COMPREHENSIVE CLIMATE ACTION PLAN

Washington-Arlington-Alexandria DC-VA-MD-WV Metropolitan Statistical Area

Prepared for the U.S. EPA as a deliverable for the Climate Pollution Reduction Grants (CRPG) Program, section 60114(a) of the Inflation Reduction Act

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Metropolitan Washington
Council of Governments

DISCLAIMER

This project has been funded wholly or in part by the United States Environmental Protection Agency (EPA) under assistance agreement 5D - 95316301 – 0 to the Washington DC Department of Energy and Environment (DOEE). DOEE engaged the Metropolitan Washington Council of Governments (COG) through a subgrant (GAN-FY23-COG-189) to develop this Comprehensive Climate Action Plan (CCAP). The contents of this document do not necessarily reflect the views and policies of the EPA, nor does the EPA endorse trade names or recommend the use of commercial products mentioned in this document.

COG is an independent, nonprofit association that brings area leaders together to address major regional issues in the District of Columbia, suburban Maryland, and Northern Virginia. COG's membership is comprised of 300 elected officials from 24 local governments, the Maryland and Virginia state legislatures, and U.S. Congress.

The Washington-Arlington-Alexandria, DC-VA-MD-WV Metropolitan Statistical Area (MSA) CCAP was developed to meet the requirements of the Climate Pollution Reduction Grants (CPRG) program, Inflation Reduction Act Section 60114(a). It does not replace or supersede the COG 2030 Climate and Energy Action Plan. Rather this plan reflects a set of evolving regional priorities for climate action that are intended for local governments and other stakeholders to use as they are continuing to evolve their own climate actions and priorities in response to a changing landscape. The actions and measures reflected within this plan are not mandates, and do not necessarily reflect new policy and regulatory actions COG members or other governments within the MSA will take.

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Photo credits: Montgomery County, DC Sustainable Energy Utility, COG

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COG deeply appreciates the contributions of the CPRG Steering and Technical Committees, COG Committees and multiple stakeholders across the MSA.

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COG would like to acknowledge the contributions of multiple COG and National Capital Region Transportation Planning Board (TPB) committees, including:

- Air and Climate Public Advisory Committee (ACPAC)
- Built Environment and Energy Advisory Committee (BEEAC)
- Chief Equity Officers Committee (CEOC)
- Climate, Energy and Environment Policy Committee (CEEPC)
- Food and Agriculture Regional Member (FARM) Policy Committee
- Metropolitan Washington Air Quality Committee (MWAQC)
- MWAQC Technical Advisory Committee (MWAQC-TAC)
- Regional Electric Vehicle Deployment (REVD) Working Group
- Regional Tree Canopy Subcommittee (RTCS)
- TPB Community Advisory Committee (TPB-CAC)
- TPB Technical Committee (TPB-Tech)

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ACRONYMS LIST

ACPAC	Air and Climate Public Advisory Committee
AFLEET	Alternative Fuel Life-Cycle Environmental and Economic Transportation
ATV	All-terrain vehicles
BAU	Business as usual
BEEAC	Built Environment and Energy Advisory Committee
BEPS	Building Energy Performance Standards
BIPOC	Black, Indigenous, and People of Color
BRIC	FEMA Building Resilient Infrastructure for Communities
CBO	Community-based organizations
CCA	Community choice aggregation
CCAP	Comprehensive Climate Action Plan
CECAP	Community-wide Energy and Climate Action Plan
CEEPC	Climate, Energy and Environment Policy Committee
CEOC	Chief Equity Officers Committee
CGA	Common Grain Alliance
CHP	Combined heat and power
CMAQ	Congestion Mitigation and Air Quality
COG	(Metropolitan Washington) Council of Governments
CPRG	Climate Pollution Reduction Grants
CSNA	Climate Solutions Now Act
DERA	Diesel Emissions Reduction Act
DEQ	Virginia Department of Environmental Quality
DOE	U.S. Department of Energy
DOEE	District Department of Energy and Environment
DPOR	Department of Professional and Occupational Regulation
EEA	Equity Emphasis Areas
EV	Electric vehicles
ESPC	Energy Savings Performance Contract
FACS	Faith Alliance for Climate Solutions
FARM	Food and Agriculture Regional Member
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GCoM	Global Covenant of Mayors
GGRA	Greenhouse Gas Reduction Act
GHG	Greenhouse gas
GWRCCC	Greater Washington Region Clean Cities Coalition
HUD	Housing and Urban Development
ILSR	Institute for Local Self-Reliance
IPCC	Intergovernmental Panel on Climate Change
IRA	Inflation Reduction Act
LIDAC	Low-Income, Disadvantaged Community

MCEC	Maryland Clean Energy Center
MDE	Maryland Department of the Environment
MEA	Maryland Energy Administration
MSA	Metropolitan Statistical Area
MWAA	Metropolitan Washington Airports Authority
MWAQC	Metropolitan Washington Air Quality Committee
NVRC	Northern Virginia Regional Commission
PACE	Property Assessed Clean Energy
PCAP	Priority Climate Action Plan
REC	Renewable energy certificate
REVD	Regional Electric Vehicle Deployment
RHE	Rockville Housing Enterprises
SELC	Southern Environmental Law Center
SEU	Sustainable Energy Utility
SOC	Standard Occupational Classification code
TPB	Transportation Planning Board
VMT	Vehicle miles traveled
WMATA	Washington Metropolitan Area Transit Authority
WSSC	Washington Suburban Sanitary Commission
WRRF	Water Resource Recovery Facility
WVSWMB	West Virginia Solid Waste Management Board
ZEV	Zero-emission vehicle

EXECUTIVE SUMMARY

PURPOSE AND SCOPE OF CCAP

Air pollution and climate change pose significant threats to communities and ecosystems worldwide, including the Washington-Arlington-Alexandria, DC-VA-MD-WV Metropolitan Statistical Area (MSA). The diverse communities in metropolitan Washington face health risks like respiratory and cardiovascular illnesses from exposure to air pollutants while climate change leads to additional risks like extreme heat, increased frequency and severity of extreme weather events, and flooding, which all pose additional risks to the safety and well-being of community members.

Considering these interconnected challenges, urgent and coordinated action by leaders is imperative to reduce air pollution and greenhouse gas (GHG) emissions to combat climate change and safeguard communities, particularly those most vulnerable to the impacts of climate change. Actions to improve air quality and reduce GHG emissions are underway, coordinated by the Metropolitan Washington Council of Governments (COG) staff and participating governments. COG, alongside Maryland, Virginia, Washington D.C., and many county and city governments within the MSA, have set ambitious goals to reduce GHG emissions. They have also created climate action plans and engaged with community members and organizations to shape the future of climate resilience and mitigation in their jurisdictions.

CCAP OVERVIEW

This Comprehensive Climate Action Plan (CCAP) presents 10 vital measures to reduce air pollution and GHG emissions in the MSA, summarized in Table 1. These measures were developed through a collaborative and iterative process with the many government offices and committees within the MSA and the states it crosses, as well as other stakeholders such as community-based organizations, private sector actors, utilities, planning boards and committees, and more. These are practical and achievable strategies spanning buildings and clean energy, transportation, waste, and land-use sectors.

GHG MEASURES

COG developed 10 GHG reduction measures for this CCAP, as presented in Table 1. These measures were developed through a collaborative and iterative process with the many government offices and committees within the MSA and the states it crosses, as well as other stakeholders like Community Based Organizations (CBOs), private sector actors, utilities, planning boards and committees, and more. These are ambitious strategies spanning buildings and clean energy, transportation, waste, and land-use sectors. Table 1 represents cumulative GHG reductions or sequestration in the short-term (2025 – 2030) and the long-term (2025 – 2050). In some instances, already existing modeling efforts from COG were used, and in other situations new modeling was conducted. When taken together, the values represent a modeled pathway to net zero emissions for the MSA.

Table 1. Summary of CCAP Measures ($MMTCO_2e$)

Sector	Measure	Cumulative 2025-2030 GHG Reductions	Cumulative 2025-2050 GHG Reductions
Buildings and Clean Energy	Accelerate the deployment of energy efficiency solutions and decarbonization of residential, institutional, municipal, and commercial buildings.	18.59	187.20
Buildings and Clean Energy	Accelerate the deployment of local renewable energy.	4.79	25.02
Buildings and Clean Energy	Study, plan for, and deploy district energy and microgrid opportunities.	0.01 - 0.38	0.25 - 0.84
Buildings and Clean Energy	Data center solutions.	3.11	45.24
Transportation	Provide and promote new and expanded opportunities to reduce VMT through public transportation, non-motorized travel, micromobility, shared travel options, and development.	0.94	2.65
Transportation	Accelerate the deployment of low- and zero- emission transportation, fuels, and vehicles.	10.7	203.37
Transportation	Accelerate the deployment of off-road/non-road electric equipment.	0.21	1.65
Waste	Reduce GHG emissions from waste and wastewater treatment.	0.07	17.42
Land Use	Accelerate the expansion of the regional tree canopy and reduce tree canopy loss.	0.18	36.00
Engagement (Cross-cutting)	Education and outreach to support measure implementation.	N/A	N/A
Other	N/A – Additional emissions changes as an outcome of the measures.	0.26	4.14
Total		**39**	**523**

Note: Scope 2 impacts from a cleaner electric grid are included in end-use sector totals for buildings and transportation. The "Other" sector includes a reduction in natural gas fugitive emissions from lower natural gas consumption, and an increase in transmission and distribution losses from more electricity consumption. These change because of measure implementation, and no mitigation strategies are directly applied to either item. In addition, these reductions do not include additional Scope 3, embodied, or life cycle GHG emissions that may occur as a result of a measure.

CO-BENEFITS

In addition to GHGs, emissions from criteria air pollutants (CAPs) also harm public health and the environment, and hazardous air pollutants (HAPs) are pollutants known to cause cancer and other serious health impacts. CAPs include ozone, particulate matter ($PM_{2.5}$, PM_{10}), carbon monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO_2), and lead. The GHG reduction measures also reduce CAPs and HAPs, which will result in additional co-benefits including improved air quality, quality job opportunities, cost savings, and enhanced community well-being across the MSA. From increasing energy efficiency in the buildings sector and developing clean energy generation to improving public transportation to planting more trees, the co-benefits these measures will provide to MSA communities, particularly to LIDACs, are estimated to be substantial.

The estimated co-benefits from successful implementation of the CCAP measures indicates human health and the economy should expect significant benefits. For example, from 2025-2050, mortality incidences will be reduced by approximately 1,000. Additionally, approximately 1.2 million fewer cases of respiratory and cardiovascular issues are expected, in addition to avoiding nearly 1 million fewer missed school/work days. The reduced mortality alone is estimated to provide an economic value of $14.6 billion, not to mention the qualitative benefits of saving a life and improving human health.

WORKFORCE

This workforce analysis provides information to help the region proactively plan for future workforce needs. The CCAP is projected to impact nearly 50 different occupations ranging from engineering, construction and skilled trades to transportation and agricultural jobs. In total, these occupations represent roughly 258,000 jobs or 7.1% of total jobs in the MSA. Overall, the COG MSA has very good equilibrium in its labor market for the CCAP occupations, with only some relatively minor shortages or surpluses (i.e., supply is within 1-2% of demand for most occupations). While overall occupations may not show shortages, certain sub-categories of activities could have shortages. Based on input from stakeholders, EV maintenance and energy auditors were two categories identified as facing shortages in the region, despite vehicle mechanics and building trade professionals overall not showing a shortage.

The rapid pace of change needed to implement the CCAP will require a significant change in the workforce and exacerbate existing challenges and barriers to attracting and retaining workers. Strategies for addressing these shortages include establishing a workforce pipeline, upskilling and reskilling workers, and coordinating with regional partners to scale existing successful programs in the region. By anticipating labor market trends, investing in workforce development, and embracing innovative workforce solutions, the region can secure the expertise needed for the CCAP.

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1 INTRODUCTION

The Metropolitan Washington Council of Governments (COG) developed this Comprehensive Climate Action Plan (CCAP) for the Washington-Arlington-Alexandria, DC-VA-MD-WV Metropolitan Statistical Area (MSA) to meet the requirements of the U.S. Environmental Protection Agency's (EPA) Climate Pollution Reduction Grants (CPRG) program. The CPRG program provides funding to states, local governments, tribes, and territories to develop plans for reducing greenhouse gas (GHG) emissions and other harmful air pollution.

The Washington, DC Department of Energy and Environment (DOEE) awarded COG a subgrant to lead the development of this CCAP and the other required CPRG planning deliverables for the MSA, including a Priority Climate Action Plan (submitted in 2024) and a Status Report (due 2027) for the MSA.

1.1. CPRG Program Overview

The Inflation Reduction Act (IRA), signed into law on August 16, 2022, directs funds to lower healthcare costs, increase America's energy security, improve the tax code, create good-paying jobs here in America, and address the existential threat of climate change by funding climate solutions. The IRA contains provisions that directly or indirectly address climate change, including reduction of U.S. GHG emissions and promotion of adaptation and resilience to climate change impacts.[1] The CPRG program, authorized under Section 60114 of IRA, provides $250 million in noncompetitive planning grants for state and local agencies, tribes, and territories to develop a PCAP, CCAP, and Status Report.

1.2. CCAP Purpose and Scope

This CCAP identifies a suite of GHG reduction measures that will provide significant (i.e., net zero) GHG reductions and other benefits to the metropolitan Washington region.

Definitions

Greenhouse Gas (GHG): GHGs include the air pollutants carbon dioxide (CO_2), hydrofluorocarbons (HFCs), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).

Greenhouse Gas (GHG) Inventory: A list of emission sources and sinks and the associated emissions quantified using standard methods.

GHG Reduction Measure: Implementable actions that reduce GHG emissions or enhance carbon removal. Measures that enhance "carbon removal" are those that increase the removal of carbon dioxide from the atmosphere through, for example, the uptake of carbon and storage in soils, vegetation, and forests (i.e., sequestration).

Benefits: Direct changes in air pollution (e.g., $PM_{2.5}$, VOCs) that result from a GHG reduction measure.

Co-Benefits: Positive effects beyond the stated goal of a GHG reduction measure (e.g., improved public health outcomes, economic benefits, increased climate resilience).

Low Income Disadvantaged Community (LIDAC): Communities with residents that have low incomes, limited access to resources, and disproportionate exposure to environmental or climate burdens.

[1] CRS. "Inflation Reduction Act of 2022 (IRA): Provisions Related to Climate Change," October 3, 2022. https://crsreports.congress.gov/product/pdf/R/R47262.

Table 2 outlines the information included in this CCAP.[2]

Table 2. Crosswalk of CPRG CCAP Requirements to Metropolitan Washington Region CCAP Section

CCAP Required Elements	Metropolitan Washington Region CCAP Section
GHG Inventory	Section 2.1
GHG Emissions Projections	Section 2.4
GHG Reduction Targets	Section 2.5
Quantified GHG Reduction Measures	Section 4
Review of Authority to Implement	Section 4 within each measure
Intersection with Other Funding Availability	Section 4 within each measure
Benefits Analysis for Full Geographic Scope and Population	Section 5
Workforce Planning Analysis	Section 6

1.3 Approach to Developing the CCAP

This CCAP covers the Washington-Arlington-Alexandria, DC-VA-MD-WV MSA, the geographic area outlined in (Figure 1).[3] The MSA crosses three states (Maryland, Virginia, West Virginia) and the District of Columbia and extends beyond COG's usual geography. Each of these states has developed its own CCAP, and those state plans, in addition to local climate action plans, provided a foundation for developing this CCAP. COG and the local governments within the MSA coordinated with state CPRG leads to align GHG reduction priorities.

[2] US EPA. "Climate Pollution Reduction Grants Program: Formula Grants for Planning," March 1, 2023. https://www.epa.gov/system/files/documents/2023-02/EPA%20CPRG%20Planning%20Grants%20Program%20Guidance%20for%20States-Municipalities-Air%20Agencies%2003-01-2023.pdf

[3] COG is comprised of 24 jurisdictions: The District of Columbia, Town of Bladensburg, City of Bowie, City of College Park, Charles County, City of Frederick, Frederick County, City of Gaithersburg, City of Greenbelt, City of Hyattsville, City of Laurel, Montgomery County, Prince George's County, City of Rockville, City of Takoma Park, City of Alexandria, Arlington County, City of Fairfax, Fairfax County, City of Falls Church, Loudoun County, City of Manassas, City of Manassas Park, and Prince William County. For more information, see https://www.mwcog.org/about-us/cog-and-our-region/local-governments/

Figure 1. Jurisdictions included in the Washington-Arlington-Alexandria, DC-VA-MD-WV MSA. Not listed but mapped jurisdictions include Arlington County (VA), City of Alexandria (VA), City of Fairfax (VA), City of Falls Church (VA), City of Fredericksburg (VA), City of Manassas (VA), and City of Manassas Park (VA).

GHG INVENTORY AND GHG REDUCTION TARGETS

COG regularly prepares a GHG inventory using mainly the ICLEI (Local Governments for Sustainability) ClearPath tool.[4] COG leveraged and expanded its existing GHG inventory and projections to cover the entire MSA. COG used the existing 2020 GHG inventory for portions of the MSA that fall within COG's geographic scope (see Figure 1). For counties and cities outside of this area, COG sought additional data sources and approaches to prepare a 2020 GHG inventory for the MSA. Additional information on the GHG inventory may be found in Section 2.1 and Appendix A.

[4] https://icleiusa.org/clearpath/

COG and many of the communities within the MSA already have established GHG reduction targets. These are described in Section 2.5 and Appendix B. COG is using a goal of net zero GHG emissions across the MSA by 2050 for the purposes of this CCAP.

GHG REDUCTION MEASURES AND THE CCAP

Many cities and counties within the MSA and the states that the MSA crosses have already engaged in significant climate planning efforts and action. Plans such as the *Metropolitan Washington 2030 Climate and Energy Action Plan,*[5] the *Tree Canopy Management Strategy,*[6] climate and energy action plans from local governments across the region, and the 2022 TPB GHG Reductions Goals and Strategies Resolution (Resolution R18-2022), provided a solid foundation of planned and ongoing actions to reduce GHG emissions for the CCAP.

To identify, prioritize, and analyze GHG reduction measures for its PCAP, COG used the process outlined in Figure 2. Stakeholder engagement activities were done continuously across all the steps discussed below.

Figure 2. COG's Process to Develop and Assess GHG Reduction Measures for the PCAP

1. Collect priority project and program ideas. COG used multiple mechanisms to collect ideas for GHG reduction priorities across the MSA. COG reviewed existing plans and climate actions across the region. COG developed and distributed a project survey to CPRG Steering and Technical Committee members to complete or share with other stakeholders (see responses in Appendix D). A public survey was conducted via COG's CPRG website and other virtual channels to collect ideas on community climate priorities (see above and Appendix E).[7] Lastly, COG presented to and held discussions with numerous stakeholders on existing COG committees and with other external stakeholders.

2. Compile ideas and develop GHG reduction measures. COG compiled existing plans and actions, along with responses to both the project and community climate priorities surveys. COG then reviewed these ideas to categorize them by relevant GHG inventory sector, identify themes, and group similar ideas to form broader GHG reduction measures. COG prepared an annotated draft list of measures. To be as inclusive as possible, COG did not explicitly cut any ideas from the initial draft measures list.

3. Prioritize GHG reduction measures. The annotated draft list of measures was shared with the CPRG Steering and Technical Committees and with other stakeholders for review through smaller discussions, webinars, and email. Specifically, COG asked for a review and feedback to identify any

[5] https://www.mwcog.org/documents/2020/11/18/metropolitan-washington-2030-climate-and-energy-action-plan/
[6] https://www.mwcog.org/committees/regional-tree-canopy-workgroup/
[7] https://www.mwcog.org/environment/programs/climate-pollution-reduction-grants-cprg-program/

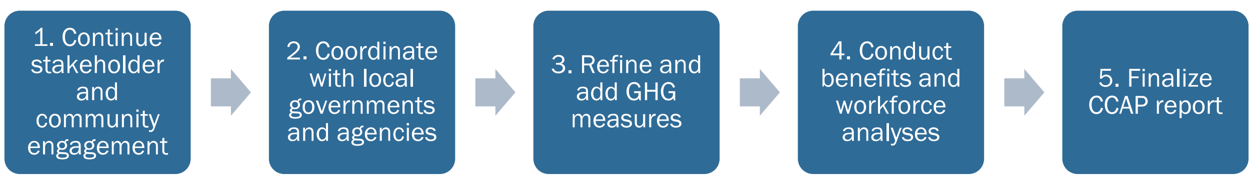
potential gaps reviewers saw in line with their priorities for funding, and to identify any potential measures to deprioritize. Using this feedback, COG finalized the list of GHG reduction measures presented in the PCAP.

4. Assess GHG reduction measures. As a next step, COG began to assess GHG reduction measures in line with PCAP requirements, such as quantified GHG reductions, authority to implement, LIDAC benefits, and other information (e.g., available funding, key implementors). COG sought input on many of these analysis elements in the initial project survey. Using the survey results, combined with other relevant information already in existing plans, and based on continued discussions with stakeholders and committees, COG assessed GHG reduction measures. Additional information on quantification of GHG reductions may be found in Appendix A.

5. Draft and Finalize PCAP. COG drafted the PCAP using information from the previous steps and shared a version with the CPRG Steering and Technical Committees for review. A version of the draft PCAP was also posted publicly online to collect other stakeholder comments and feedback. COG reviewed comments and feedback on the PCAP, addressed many of these, filled in any remaining required information, and completed the PCAP.

Following the submission of the PCAP, COG continued its climate planning efforts in anticipation of developing and submitting its CCAP. This involved multiple activities, including continued engagement with stakeholders and community members, coordinating with local governments and governmental agencies, refining measures and developing additional measures, conducting deeper analyses of benefits and workforce conditions, and finalizing the CCAP report, as illustrated in the graphic and detailed text below.

Figure 3. COG's Process to Develop and Assess GHG Reduction Measures for the CCAP



1. Continue stakeholder and community engagement. COG continued and expanded engaging with stakeholders and communities engaged during the PCAP development process to solicit ideas, share updates, and provide discussion forums to improve the CCAP.

2. Coordinate with local governments and agencies. COG continued to coordinate with local governments and governmental agencies in the region to better understand priorities, capacities, best practices, challenges, and other details relevant to forming the CCAP. COG relied on its deep history of inclusive and close collaboration with the many governments and agencies in the region to maximize communication and effective coordination.

3. Refine and add GHG measures. The final PCAP measures were presented to stakeholders and experts to further assess and refine the CCAP measures. COG and stakeholders also assessed the PCAP measures against new information, policies, data, and other factors. Using this feedback, COG finalized the list of GHG reduction measures presented in this CCAP, including the addition of two new measures: the data center solutions measure and the education and public outreach measure.

COG then updated GHG emission projections and completed net-zero GHG modeling to assess the emission reduction potential of each of the measures.

4. Conduct benefits and workforce analyses. COG next assessed the potential benefits of GHG reductions measures and assessed the workforce necessary to implement the CCAP measures. The benefits analysis focused on assessing the health outcomes related to reducing co-pollutants via the CCAP measures. The workforce analysis examines the occupations relevant to the CCAP measures and identifies potential shortages that may hinder the successful implementation of those measures and potential solutions to address shortages and other workforce challenges. Section 5 and 6 summarize the results, and further details are provided in Appendix G and Appendix H.

5. Finalize CCAP report. COG summarized all the new and updated information developed in the previous steps to develop the draft CCAP report. After sharing the draft with stakeholders and the public, COG reviewed comments and feedback on the draft CCAP, addressed many of these, filled in any remaining required information, and completed the report. The culmination of these efforts is reflected in this CCAP.

IDENTIFYING AND ENGAGING STAKEHOLDERS

Throughout the process outlined above, COG engaged with stakeholders and community representatives throughout the MSA. Engagement consisted of meetings, communications, and coordination between COG, local, and regional climate change and community leaders to ensure that both regional perspectives and local needs are reflected in the plan. Committee members, stakeholders, and community representatives engaged during PCAP and CCAP development can be found in Appendix F.

CPRG Committees

COG formed CPRG Steering and Technical Committees to advise on GHG emission reduction projects, programs, and measures. The committees are comprised of local and state government staff. Ideas suggested by these groups informed the measures included in the CCAP.

Steering Committee meetings and Technical Committee meetings were held from November 2023 through February 2024, focused on PCAP development, implementation grant evaluation criteria and to discuss prioritizing projects, programs, and measures. Additional committee meetings were held throughout 2024 and 2025 to inform the CCAP. Throughout the process, the committees emphasized the best ways to collaborate among local governments and communities. Additionally, these committees will continue to advise on the CPRG program through 2027 when the program concludes.

Other COG Committees

In addition to the CPRG Steering and Technical Committees, COG holds regular meetings with local and regional committees representing climate and environmental concerns and with industries that significantly impact GHG emissions. The CPRG was a topic of discussion at recent and ongoing meetings of these committees.

Industry, Utilities, Other Government Partners, and Stakeholders

COG also conducted a succession of meetings, conversations, and emails with stakeholders to gather information, identify priorities, and make connections to inform the CCAP. Groups engaged include utilities, regional stakeholder groups, higher education institutions' sustainability directors, environmentally focused CBOs, and others.

LIDACs
LIDAC benefits and impacts were a primary consideration for selection of regional climate pollution reduction projects, programs, and measures. Throughout the CCAP development, COG aimed for inclusivity and relationship building with sister agencies, jurisdictions throughout the MSA, tribes, industry partners, and community CBOs representing LIDACs through stakeholder engagement sessions, surveys, and meetings. During the CCAP development, COG focused on addressing environmental justice and equity concerns and supporting historically underrepresented and overburdened communities.

Recognizing that developing authentic and meaningful engagement with LIDACs relies upon dedicated outreach and time to develop relationships, COG targeted its LIDAC engagement efforts toward gathering and understanding existing priorities and issues identified through local initiatives, established engagement methods, and successful approaches. These efforts have laid the groundwork for deeper and sustained engagement of the CCAP.

PCAP engagement included contributions representing LIDAC interests from both non-governmental organizations and government representatives. Community engagement webinars, individual engagement meetings, and a Community Climate Priorities survey (described below) were offered during the development of the PCAP, centered on accessibility and inclusion. At the heart of this effort was a concise, easy-to-understand Community Climate Priorities survey created to identify the priorities most important to these communities. The survey highlighted topics such as public health, affordability, energy efficiency, transportation access, and resilience to climate impacts. By elevating these areas of concern, the initiative sought to bring forward the perspectives of groups that have historically had limited influence in planning discussions.

In addition to the CPRG Community Climate Priorities survey, COG distributed a questionnaire to local governments, state governments, and COG committees, including the Chief Equity Officers Committee, to gather information about existing outreach activities with LIDAC representatives and organizations. The questionnaire focused on understanding recent and ongoing LIDAC engagement activities at the local level over the past two years and how such engagement informs climate action plans and projects, as well as community climate and energy goals. Additionally, the questionnaire sought input on the needs and priorities identified by LIDAC community members related to GHG reduction projects and activities connected to experienced impacts of climate change. This questionnaire informed future community engagement. COG continues to coordinate with its Chief Equity Officers Committee to provide input on engagement strategies for the CCAP.

COG developed another survey entitled "Your Ideas for a Cleaner, Healthier Community," aimed at understanding community member perspectives on climate impacts of concern, energy, transportation, and other related topics. While responses were minimal, they did provide COG with additional information on priorities, challenges, and motivations, which further informed the development of the CCAP.

Tribes
There are four state recognized tribes in the MSA including the Maryland Accohannock Indian Tribe, Maryland Piscataway Conoy Tribe, Maryland Piscataway Indian Nation, and the Virginia Patawomeck

Indian Tribe. COG acknowledges that there are many indigenous people and communities living throughout the region and has worked closely with tribal representatives and organizations to ensure inclusive and equitable contributions to the CCAP. COG met with the Accokeek Foundation at Piscatawy Park, Prince George's County, and the Patawomeck Indian Tribe in Stafford, Virginia to listen to their climate, energy, and air quality interests and priorities for action.

Accokeek Foundation in Piscataway Park serves over 5,000 students annually through classroom-based programs. Areas of focus include fire ecology, invasive species, and Indigenous-led land stewardship; student-led research and a focus on breaking down the human/nature divide; and more engagement of Indigenous youth through school and community outreach. There was also a strong emphasis on healing the land from the impacts of urbanization and climate change, with a particular need for clean rivers and addressing invasive species.

The Patawomeck Indian tribal leader discussed energy and building retrofits as essential for environmental sustainability, with a desire to integrate traditional wisdom with modern technology. The tribal leader raised concerns about the potential impacts of data centers on the environment, particularly water resources, emphasizing the need for careful planning and consideration of ecological restoration efforts. Youth education is also valued, recognizing the importance of passing down wisdom teachings and embracing the value of conservation for future generations.

Community Members

To incorporate the perspective of community members across the MSA, COG disseminated the CPRG Community Climate Priorities survey to assess community-wide climate priorities during the PCAP development process. The survey was shared through multiple online channels, extending beyond formal committees to include distribution through social media, the COG CPRG and main COG websites, local representatives, and community-based/non-governmental organizations. The survey gained responses from 86 participants from 13 jurisdictions within the MSA, encompassing a diverse range of individuals, organizations, coalitions, and agencies. Participants were asked to prioritize strategies for mitigating climate change by ranking mitigation strategies. The eight strategies included in the PCAP were ranked by the community in the following order of importance:

1. Land Use
2. Energy Efficient and Clean Energy Buildings
3. Increasing Supply of On-site Clean Energy
4. Transit Options
5. Increasing Off-site Clean Energy
6. Transportation Technology
7. Waste Reduction, Composting, and Recycling
8. Carbon Removal and Sequestration

Participants were requested to reflect on specific equity priorities, barriers to action, and project ideas within the above eight strategies. Summary results are described in Appendix E.

Additionally, the draft CCAP was posted for public review and comments for 30 days in October and November 2025. COG posted the report on its website and provided physical copies at its front desk. COG provided numerous methods for people to share comments on the draft CCAP, including an online form, email, phone voicemail, and mail-in comments. COG also notified all the list servs, committees, and groups it interacted with throughout the CCAP process. These groups, and their member reach, are listed below (note that there are some duplicate people counted under more than one group). These groups had a total reach of 1,318 people.

- CPRG Steering and Technical Committee – 43 people
- CEEPC – 168 people
- BEEAC – 140 people
- ACPAC – 17 people
- MWAQC TAC – 70 people
- RTCS – 20 people
- Local government staff, from climate leaders' webinar – 22 people
- Climate Leader CBOs/NGOs – 55 people
- VADEQ and MSA leads – 5 people
- TPB Tech Oct mtg announcement – 25 attendees + 56 online streaming views
- DMV Climate Clips e-News – 631 people
- Access for All Advisory Committee – 32 people
- [Transportation] Community Advisory Committee – 24 people
- Workforce Development Panel Organizations – 10 people

COG received numerous comments through 10 submissions. Submitters were a mix of local government staff/agencies, advocacy organizations, and local citizens. Themes across the comments included requests to be more ambitious and inclusive, concerns about data centers, adjustments to technical details, and praise. COG thoughtfully considered all the comments and made some changes to the CCAP in response. COG also provided responses back to submitters both to confirm receipt of them and to provide an explanation and any changes made.

CONTINUED ENGAGEMENT

Throughout the CCAP development, COG aimed for inclusivity and relationship building with sister agencies, jurisdictions throughout the MSA, tribes, industry partners, and community CBOs representing LIDACs through stakeholder engagement sessions, surveys, and meetings. During the CCAP development, COG focused on addressing environmental justice and equity concerns and supporting historically underrepresented and overburdened communities.

During development of the CCAP, a Community Engagement Plan (CEP) was utilized to focus on diversity, equity, inclusion, and meaningful engagement with tribes and LIDACs in the MSA. This plan continues to guide COG's engagement work. Outreach to community stakeholders through ongoing and future engagements includes people and organizations that represent populations that have historically been marginalized, underserved, or left out of climate planning conversations. Through partnering with tribes, CBOs, and COG's committee of Chief Equity Officers, a conduit for input and engagement across localities and sectors, particularly among underserved community members, is being established.

COG has worked to ensure inclusive and equitable contributions to the CCAP and focused on engagement that meets people where they are. COG aimed to engage community members through various channels and integrated survey responses, feedback from listening sessions, and insights from numerous meetings to develop the CCAP Community Engagement Plan. A primary effort towards continued engagement is encapsulated in the public education and outreach measure. This measure includes actions to engage with local governments and partners to further outreach efforts and to educate stakeholders and community members in an effort to enable other CCAP measures. In addition to this measure, COG maintains relationships with numerous partners across the region, and collaboratively worked with them to continue engaging with a variety of communities and stakeholders.

2 GHG INVENTORY

2.1. GHG Inventory Development

The MSA inventory and previous COG inventories have been developed to be compliant with the U.S. Communities Protocol for Accounting and Reporting Greenhouse Gas Emissions (USCP), Global Protocol for Community Scale Greenhouse Gas Inventories (GPC), and Global Covenant of Mayors (GCoM) reporting framework. COG mainly follows the calculation guidance from USCP as the USCP identifies sources of data widely available to communities in the US. COG mainly uses ICLEI's ClearPath tool Community Scale Inventory Module for preparing GHG inventories, which is consistent with both U.S. and global accounting protocols.

The GHG inventory is a comprehensive assessment of all GHG emissions sources and sinks across the MSA. The inventory was developed using an activities-based approach, meaning emissions are calculated based on the result of activities happening in the local communities.[8] It accounts for the emissions associated with the electricity consumed within the region in addition to direct sources of emissions. The region does not have significant emissions from industrial processes, so industry is not a covered sector in this inventory. The inventory does not account for Scope 3 emissions, embodied emissions, or other life cycle emissions (e.g., emissions associated with vehicle manufacturing, emissions from concrete and other building materials production, etc.).[9]

COG made every effort to capture a complete and accurate picture of GHG trends across the MSA, while also providing for a consistent methodology that is replicable across communities and inventory years. Local results are totaled to create a picture for the whole region. A more detailed analysis of the GHG Inventory methodology can be found in Appendix A.

2.2. Inventory Results

COG developed a GHG inventory of priority sources of GHG emissions within the MSA for the year 2020 (Table 3). A detailed methodology including data resources for the preparation of this inventory are contained in Appendix A. Gross GHG emissions for the MSA were 62.2 million metric tons of

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[8] Location-based Scope 2 accounting relies on average grid emissions factors (e.g., eGRID subregions) and therefore does not explicitly account for off-site renewable energy certificates (RECs) or power purchase agreements (PPAs) held by individual large electricity consumers such as data centers. When an offtaker signs a PPA with a renewable project located within the same eGRID region, the project's zero-emitting generation is incorporated into the regional emissions factor, but the resulting emissions reductions are distributed across all load within the region. As a result, the counties hosting the offtakers do not receive specific, attributable emissions reductions from those off-site procurements under a location-based methodology.

[9] This inventory does not include embodied carbon or full lifecycle emissions associated with manufacturing, fuel production, or other upstream activities (e.g., mining for electric vehicle batteries or extraction and refining of fossil fuels). While these lifecycle emissions are important considerations, they are outside the scope of a GHG inventory focused on operational electricity use and direct emissions (Scope 1 and Scope 2 GHG emissions).

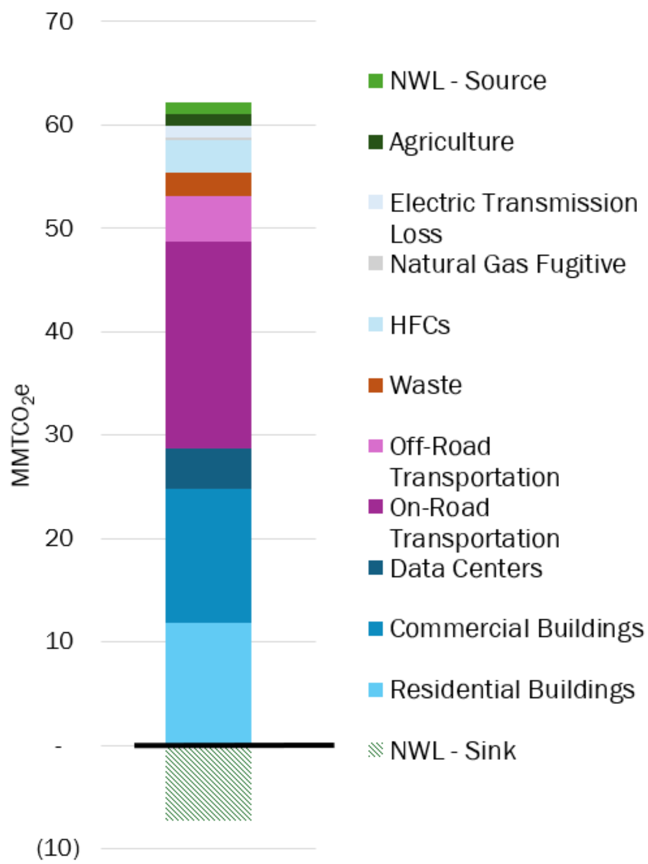
carbon dioxide equivalent ($MMTCO_2e$) in 2020. Net GHG emissions amounted to 54.9 $MMTCO_2e$ after accounting for the sequestration of GHG emissions attributed to the MSA's forests and trees.

Table 3. MSA GHG Emissions Inventory $MTCO_2e$

Emissions Type	Emissions Activity or Source	Sub-Activity Source	2020 MSA Total Emissions ($MTCO_2e$)
BUILT ENVIRONMENT			**33,296,875**
Residential Energy	Emissions from Grid Electricity	Residential Electricity	6,887,161
	Emissions from Stationary Fuel	Residential Natural Gas	4,657,398
		Residential Fuel Oil	243,916
		Residential LPG	71,933
Commercial Energy	Emissions from Grid Electricity	Commercial Electricity	9,342,352
		Data Center Electricity	3,994,792
	Emissions from Stationary Fuel Combustion	Commercial Natural Gas	3,494,491
		Commercial Fuel Oil	62,671
		Commercial LPG	30,192
Process and Fugitive Emissions	Fugitive Emissions from Natural Gas Distribution	Natural Gas Fugitive Emissions	265,916
	Other Process and Fugitive	Hydrofluorocarbon (HFCs)	3,166,081
Electric Transmission Loss	Line Loss from Electric Transmission Grid		1,079,973
TRANSPORTATION			**24,381,232**
Transportation and Mobile Emissions	On-Road Transportation (National Emissions Inventory [NEI])	On-Road Mobile Emissions	19,938,282
	Emissions from Off-Road Vehicles (NEI)	Off-Road Mobile Emissions	2,197,123
	Aviation Travel	Passenger Air Travel	2,054,479
	Rail Transportation	Rail Transportation (Diesel and Grid Electricity)	191,348
WASTE			**2,222,002**
Solid Waste	Waste Generation	Landfill Waste Generation	1,531,722
	Combustion of Solid Waste Generated by the Community	Combustion of Solid Waste	603,788
Water and Wastewater	Fugitive Emissions from Septic Systems	Septic System Emissions	67,679
	Nitrification/Denitrification Process N_2O Emissions from Wastewater Treatment	Sewer System Emissions	13,134
	Process N_2O from Effluent Discharge to Rivers and Estuaries	N_2O Effluent Discharge Emissions	5,679
LAND USE			**(4,998,981)**
Agriculture		Enteric Fermentation	493,279

Emissions Type	Emissions Activity or Source	Sub-Activity Source	2020 MSA Total Emissions ($MTCO_2e$)
	Emissions from Agricultural Activities	Manure Management	139,287
		Ag Soils	539,978
Forests and Trees Outside of Forests	Average Annual Emissions	Forests Converted to Non-Forests	458,603
		Disturbances in Forests Remaining Forests	271,565
		Loss of Trees Outside Forests	367,940
	Average Annual Sequestration	Forests Remaining Forests	(5,053,991)
		Non-Forests Converted to Forests	(93,828)
		Trees Outside Forests	(2,121,814)
GROSS GHG EMISSIONS (ALL SECTORS)			**62,170,761**
NET GHG EMISSIONS (ALL SECTORS)			**54,901,128**

Figure 4. 2020 MSA GHG Emissions by Activity



The GHG inventory represents GHG-emitting activities undertaken by residents, businesses, industry, visitors, and government located in the MSA. Approximately 46% of the MSA's gross GHG emissions come from residential and commercial building energy consumption and 39% from transportation (32% is on-road). The remainder of GHG emissions comes from other activities including solid waste, wastewater treatment, agriculture, HFCs, and fugitive emissions. GHG sequestration in natural lands offset more than 10% of gross emissions in the MSA, sequestering more than 7 $MMTCO_2e$ in 2020 (Figure 4).

Note that 2020 represents an atypical year of GHG emission levels due to the impacts of the COVID-19 pandemic. In many places, as in the metropolitan Washington region, this led to reduced GHG emissions from on-road transportation and changes in patterns in building energy use, along with other anomalies that may not be prevalent in future year inventories.

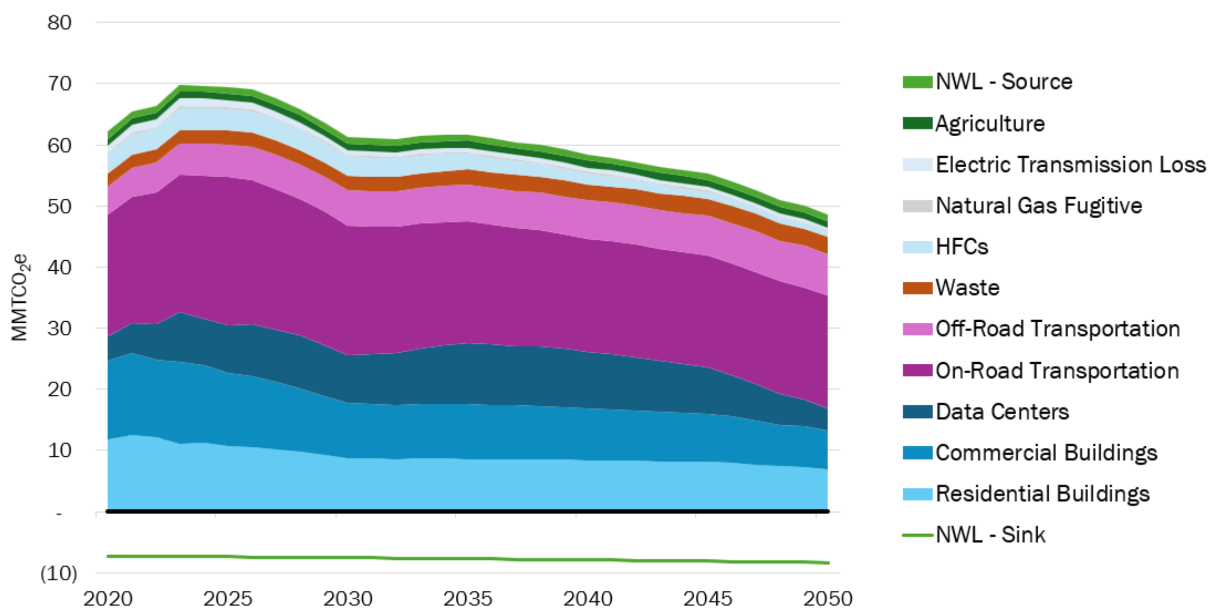
2.3. BAU Methodology and Results

Business-as-usual (BAU) projections provide a baseline scenario for future GHG emissions. BAU projections account for driving factors such as growth in population, housing and commercial development, and transportation patterns, and estimate the impact they will have on future GHG emissions. BAU projections reflect policies and practices that are currently in place, including policies for grid decarbonization. The BAU scenario serves as a basis against which to compare emission reduction benefits from implementation of GHG reduction measures. See Appendix A for a summary of BAU assumptions.

The MSA BAU scenario for this CCAP projected GHG emissions out to 2050 for each sector. Based on the assumptions used, gross emissions declined 22% between 2020-2050 (not including sequestration from natural and working lands (NWL)) and net emissions (including NWL) declined 27%. Figure 5 shows the region's anticipated BAU emissions projected out to 2050.

The year 2020 represents an atypical year of GHG emission levels due to the impacts of the COVID-19 pandemic, most notably through lower emissions in the on-road transportation sector. With a return to increased activity, notably in on-road transportation, gross GHG emissions peak in 2024. In addition, growth in data centers in the region contributes to growing emissions in the near-term.

Figure 5. MSA BAU Projections



By 2030, gross GHG emissions are back down near 2020 levels driven by an increasingly clean electric grid. State policies across the region, including the Virginia Clean Economy Act (VCEA) and renewable portfolio standards (RPS) in DC and Maryland, in addition to ongoing economic trends driving a reduction in the use of coal-fired power plants, lead to a lower carbon intensity for electricity used in the region. This results in a 42% decline in total building sector emissions from 2020 despite electricity use nearly doubling mainly due to the addition of new data centers. In addition to cleaner electricity, increasing adoption of zero-emission vehicles and improved vehicle fuel efficiency result in a 7% decline in GHG emissions from on-road transportation from 2020 to 2050. Total net emissions decline 27% from 2020 to 2050.

2.4 Near- and Short-Term Targets

The COG Board previously established specific GHG emission reduction goals of 10% below BAU projections by 2012 (bringing regional emission back down to 2005 levels), 20% by 2020, and 80% by 2050 (below the 2005 baseline). In 2019, COG became a Signatory to GCoM. Based on review of the GCoM framework of global best practices for climate planning, updated Intergovernmental Panel on Climate Change (IPCC) recommendations, and a recommendation from the COG CEEPC, the Board approved new 2030 climate goals including:

- The climate mitigation goal of 50% GHG emission reductions below 2005 levels by 2030.
- The climate resilience goal of becoming a Climate Ready Region and making significant progress toward becoming a Climate Resilient Region by 2030.

Along with the COG goals, local governments across the MSA and the states the MSA crosses have established goals. Appendix B lists existing local, regional, and state climate and energy goals and plans. For the purposes of the CCAP, COG has developed a pathway to net zero GHG emissions by 2050, reflecting increased ambition in the region. The GHG modeling for the CCAP thus assesses what it would take to achieve net zero emissions across the MSA and is described in Section 4.

3 LIDAC BENEFITS ANALYSIS

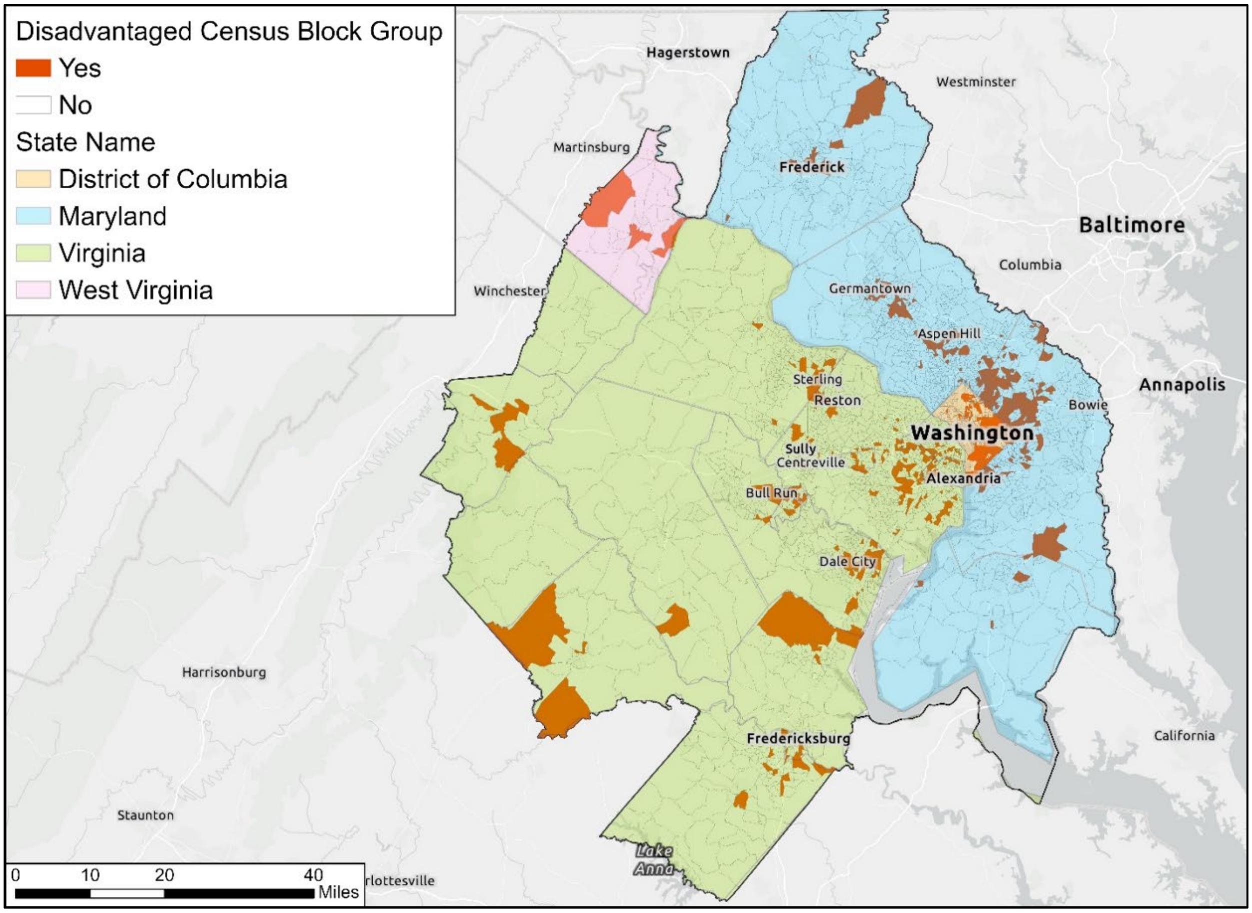
3.1 Metropolitan Washington's LIDACs

To identify communities meeting the CPRG LIDAC definition, COG used EPA's Environmental Justice Screening and Mapping Tool (EJScreen) and supplementary data. EJScreen is a tool that uses demographic, social, and environmental datasets to assess the different risks and burdens that different communities face, which enables users to identify environmental justice communities and the specific issues they face.

Communities identified as disadvantaged under the EJScreen tool for the MSA include any census block group at or above the 90th percentile for any of EJScreen's Supplemental Indexes when compared to the nation. Supplemental indices combine a five-factor demographic index that averages the percent of low income, percent unemployed, percent with limited English speaking ability, percent with less than high school education, and percent low life expectancy. The demographic index is then combined with 1 of 13 environmental indicators, such as ozone, air toxics cancer risk, hazardous waste proximity, and wastewater discharge.

COG used EJScreen to visualize and identify Census block groups that EPA designates as disadvantaged in the state (see Figure 6). In the metropolitan Washington region, 25% of the population is disadvantaged (as defined above). The percentage of disadvantaged population varies across different states: 47% of the population in DC, 28% in West Virginia, 23% in Maryland, and 21% in Virginia. A full list of the Census Block IDs that are identified as LIDACs in the MSA is included in Appendix C.

Figure 6. LIDACs in the Metropolitan Washington Region as Identified Using EJScreen



The metropolitan Washington region comprises diverse cities and counties with varying demographics such as education levels, income, and unemployment.

- Education levels vary across the MSA, with 4% of the overall population lacking a high school diploma. However, in LIDACs, this percentage is double the average at 8%.[10,12]
- Economic diversity is evident in the region's median household incomes. The average median household income across the MSA counties is approximately $125,000. However, within LIDACs, the median household income for the MSA is about 30% less on average at approximately $85,000.[11,12] Warren County (VA), the City of Fredericksburg (VA), and Jefferson County (WV) reported the lowest household median incomes at $85,096, $89,612, and $94,897, respectively.
- Overall, the unemployment rate in the MSA is 5%, although unemployment rates vary across the region. The District of Columbia experiences the highest overall unemployment rate in the region at 5%; this rises to 10% in LIDAC communities within the District.[12] Maryland experiences the

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[10] Census Bureau. American Community Survey. 2022. https://www.census.gov/data/developers/data-sets/acs-5year.html
[11] Census Bureau. American Community Survey. 2022. https://www.census.gov/data/developers/data-sets/acs-5year.html
[12] Census Bureau. American Community Survey. 2022. https://www.census.gov/data/developers/data-sets/acs-5year.html

lowest unemployment rate, at about 2% (2.1% in Prince George's County, 1.8% in Montgomery County, and 1.9% in Frederick County).[13] In Virginia, employment is 2.7% (2.4% in Loudon County, 2.6% in Prince William County, 2.3% in Fairfax County, and 2% in Arlington County).[14] The unemployment rate in Jefferson County, WV is 2.7%.[15]

The area that is comprised of the largest cluster of connected LIDACs is in Prince George's County (MD). According to the U.S. Census data, Prince George's County is 58% Black, 11% White, 4.1% Asian, and 23% Hispanic as of 2023.[16] The racial makeup of the County shows the intersectionality of socio-economic disparities and race, emphasizing the need for targeted and equitable interventions to address systemic inequalities. Prince George's County also reported the highest number of persons who have not attained a high school diploma with 13,997 persons, followed by Montgomery County (MD) with 12,957 persons, and Fairfax County (VA) with 11,256 persons. A similar pattern exists for English proficiency—Prince George's County (16,842 persons), followed by Montgomery County (9,886 persons) and Fairfax County (8,835 persons) reported the highest number of persons experiencing limited English proficiency.[17]

Additionally, as a part of its regular planning and programming, COG's Transportation Planning Board (TPB) developed Equity Emphasis Areas (EEAs)[18] throughout the COG region to elevate equity and inform future growth and investment decisions (see Figure 7 for EEAs). Analysis of the EEAs show significant overlap with LIDACs.[19]

Recognizing the disparities highlighted in the demographic information across the MSA, particularly within LIDACs and EEAs, COG emphasizes the importance of targeting climate investments in LIDAC (and EEA) community priorities. While the range of low-income, unemployed, low educational attainment, and limited English proficiency varies throughout the region, there are opportunities to positively impact many LIDACs through concentrated and focused efforts in the areas of workforce development, training, and an overall focus of green job creation and sustainable yet affordable housing. COG's LIDAC analysis provides valuable insight to support the implementation of outreach programs to meaningfully engage LIDACs using languages spoken at home, diverse imagery, plain language and other tools that meet the needs of historically underserved populations.

Consideration of LIDACs is a priority focus for COG when selecting climate pollution reduction projects, programs, and measures. Organizations representing LIDACs and local representatives who frequently work with LIDACs were engaged in the creation of the PCAP and CCAP. Furthermore, COG plans to conduct direct and comprehensive engagement with LIDACs throughout the development of the CCAP.

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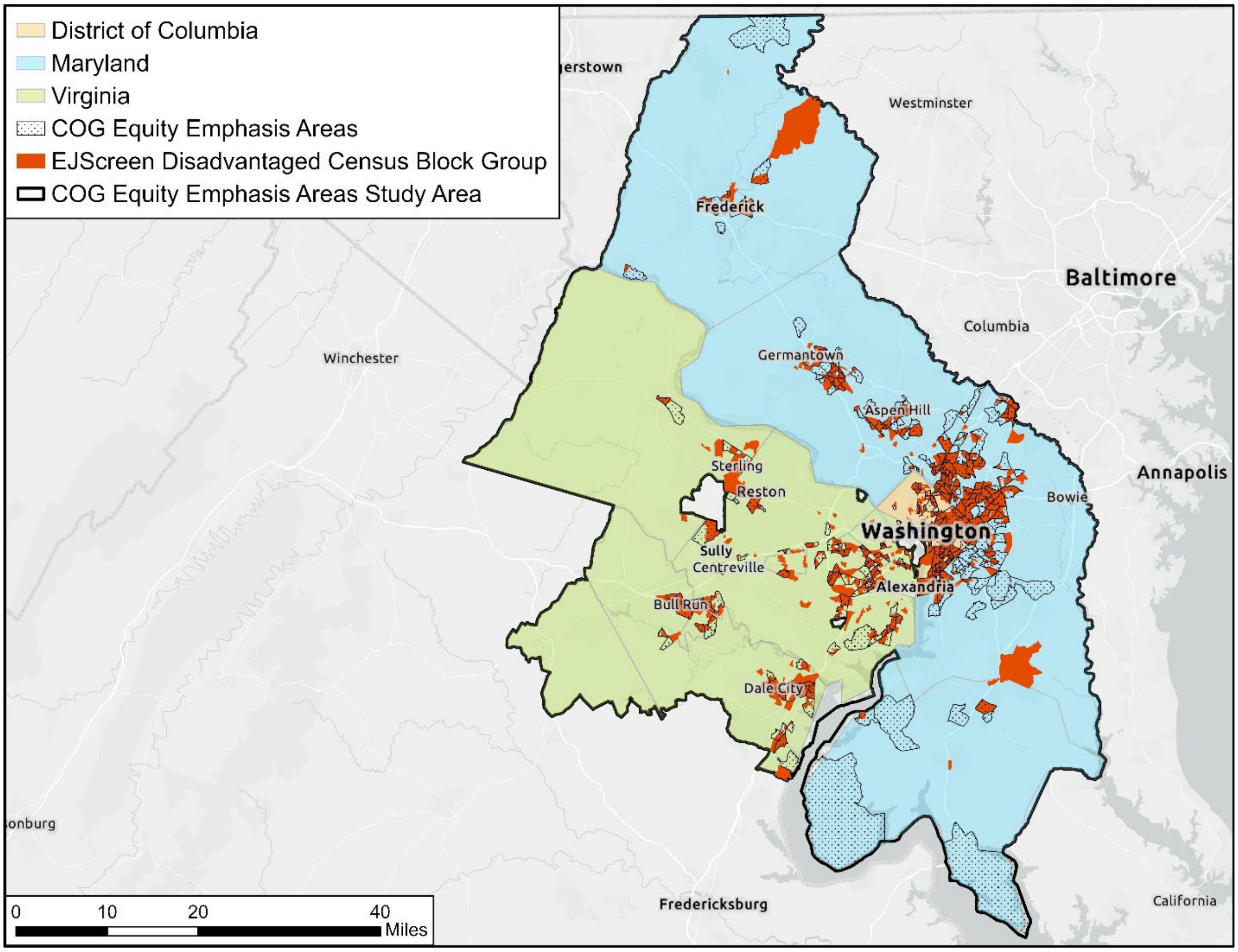
[13] Maryland Department of Labor. 2023. https://www.dllr.state.md.us/lmi/laus/
[14] Virginia Employment Commission. https://www.vec.virginia.gov/node/18241
[15] St. Louis Fed. 2023. https://fred.stlouisfed.org/series/WVJEFF7URN
[16] https://censusreporter.org/profiles/05000US24033-prince-georges-county-md/
[17] https://www.census.gov/quickfacts/fact/table/princegeorgescountymaryland/PST045223
[18] For more information, see https://www.mwcog.org/newsroom/2021/09/24/equity-emphasis-areas-a-tool-to-prioritize-and-invest-in-communities--equity/.
[19] EEAs have high concentrations of low-income individuals and/or traditionally disadvantaged racial and ethnic population groups. For more information, see here: https://www.mwcog.org/transportation/planning-areas/fairness-and-accessibility/environmental-justice/equity-emphasis-areas.

Figure 7. Overlay of COG EEAs and MSA LIDACs Identified with EJScreen



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3.2 Climate Impacts and Risks to Metropolitan Washington's LIDACs

Social systems amplify negative impacts from climate risks on Black, Indigenous, and People of Color (BIPOC) individuals and communities, income-eligible households, unhoused individuals, rural communities, and outdoor and agricultural workers.[20] Not only do these communities experience the most severe impacts of climate change, but they are also the least able to prepare for and respond to these impacts due to a lack of resources and socio-political power. According to a 2021 EPA analysis, racial and ethnic minorities are particularly vulnerable to climate change impacts, especially Black and African American individuals.[21]

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[20] Marino, E.K., K. Maxwell, E. Eisenhauer, A. Zycherman, C. Callison, E. Fussell, M.D. Hendricks, F.H. Jacobs, A. Jerolleman, A.K. Jorgenson, E.M. Markowitz, S.T. Marquart-Pyatt, M. Schutten, R.L. Shwom, and K. Whyte, 2023: Ch. 20. Social systems and justice. In: Fifth National Climate Assessment. Crimmins, A.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, B.C. Stewart, and T.K. Maycock, Eds. U.S. Global Change Research Program, Washington, DC, USA. https://doi.org/10.7930/NCA5.2023.CH20

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

Minority and low-income communities are more likely to suffer the consequences of climate change due to heightened exposure to climate risks including exposure to environmental pollution and high rates of asthma and other health issues as well as inaccessibility to resources, such as adequate infrastructure and insurance coverage. Many factors contribute to this inequality, including historical discriminatory practices in housing, education, and employment. Pre-existing health status and living conditions are two key components of climate vulnerability, which are often determined by economic power, social policies, political influence, and structural racism.[22]

Within the Washington MSA, the most prevalent climate risks are extreme heat, extreme precipitation events, sea level rise, and storm surge. These climate risks were evaluated as part of *Climate Ready DC: the District of Columbia's 2016 Plan to Adapt to a Changing Climate* (which applies specifically to DC), the Metropolitan Washington *2030 Climate and Energy Action Plan* published in 2020, and other local climate plans. Further, TPB evaluated climate risks to COG EEAs and COG's evaluation determined that communities within EEAs are particularly vulnerable to climate risks, including extreme heat, extreme weather and flooding, and sea level rise.

In DC, average annual temperatures have risen 2°F over the last 50 years and are projected to continue rising in the future. Historically, the average summer high was 87°F. By 2080, this number is projected to increase to 93°F (in a low-emissions scenario) or 97°F (in a high emissions scenario). In addition to rising average temperatures, climate change is leading to more intense and frequent heat waves. In 2012, a record-breaking heatwave hit the region and temperatures exceeded 95°F for 11 days. Currently, DC experiences 30 "dangerously hot days" (days exceeding 95°F) a year; by 2080, projections indicate that there will be 40-75 of these days. The number of extreme heat days and heat waves is projected to increase across the whole MSA as well; the number of days per year with temperatures above 95°F could reach around 40 days by 2080 under a low-emissions scenario, and around 60 days by 2080 under a high emissions scenario.[23]

The median number of extreme heat days a year in the MSA is 8.61 days; the median in LIDACs is 8.75 days, demonstrating disparities between communities. Urban heat island effects will put populations residing in urban areas at even greater risk of the health effects of extreme heat. Montgomery County mapped urban heat islands across the county to determine the communities that will be most affected.[24] More frequent and severe droughts will also impact the Potomac River and put vulnerable populations in danger due to agricultural and water system disruptions. Rising temperatures may also increase the occurrence of harmful algal blooms in freshwater and marine ecosystems in the MSA, including in the Potomac River.

Although annual amounts of precipitation have not changed significantly, seasonal precipitation rates have changed; fall and winter rates have increased while summer rates have decreased.

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[22] Patnaik, A., Son, J., Feng, A., Ade, C., 2020. Racial Disparities and Climate Change. Princeton Climate Action. https://psci.princeton.edu/tips/2020/8/15/racial-disparities-and-climate-change

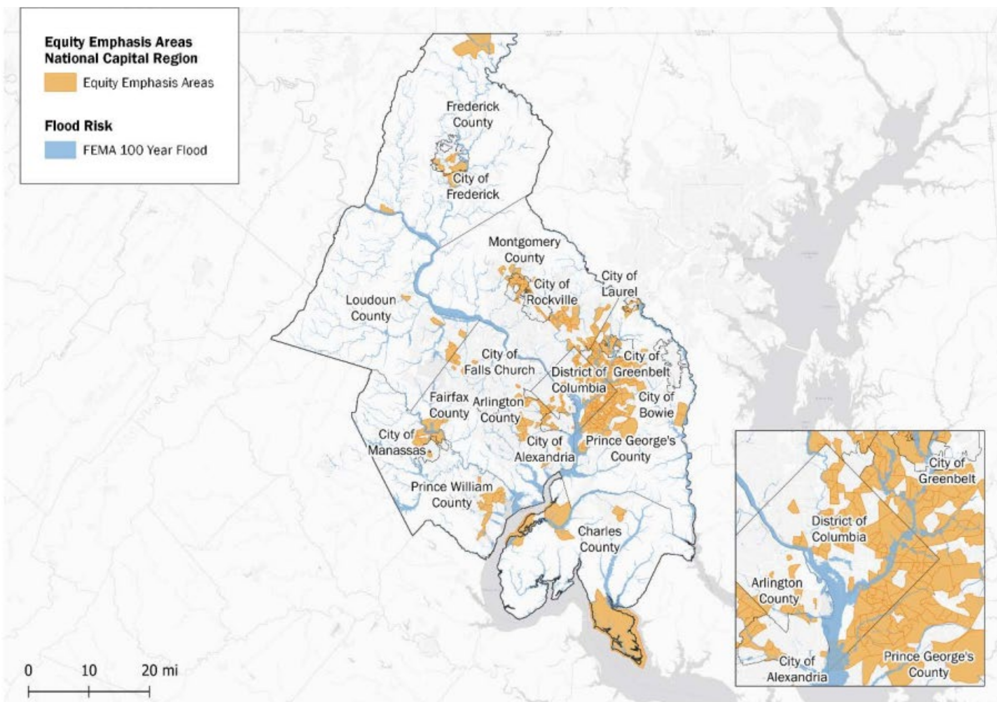
[23] A high emissions scenario refers to a Shared Socio-economic Pathway (SSP) that represents the upper boundary of radiative forcing (for example, SSP5-8.5 represents a pathway with an additional radiative forcing of 8.5 W/m^2 by 2100). Under a high emissions scenario, there is intensified exploitation of fossil fuel resources and a more energy-intensive global lifestyle (Böttinger, M. and Kasang, D. The SSP Scenarios. Deutsches Klimarechenzentrum. https://www.dkrz.de/en/communication/climate-simulations/cmip6-en/the-ssp-scenarios#:~:text=SSP585%3A%20With%20an%20additional%20radiative%20forcing%20of%208.5,CMIP5%20scenario%20RCP8.5%2C%20now%20combined%20with%20socioeconomic%20reasons.)

[24] https://storymaps.arcgis.com/stories/389babe7ce654fdd87701488ae72e8b6

Additionally, the frequency and intensity of extreme precipitation events is increasing. Today's 1-in-100-year precipitation event could become a 1-in-15-year event by late-century for the MSA.

Sea level rise is a problem for low-lying areas in the MSA, particularly in LIDACs. Water levels for the Potomac and Anacostia Rivers (which are both tidal and border LIDACs) have risen 11 inches in the past 90 years. This has resulted in a 300% increase in nuisance flooding along the riverfront. By 2080, there could be up to 3 feet and 5 inches of additional sea level rise. Coastal storms such as hurricanes also create flooding events, and climate model projections indicate that hurricanes will become more intense in the future. The threat of stronger hurricanes combined with rising sea levels puts the region at very high risk of flooding. EEAs will be more impacted by inland and coastal flooding as well. About 60% of EEAs lie in FEMA 100-year floodplains (about 1 million people total) (see Figure 8), and more than 10% of EEAs will be impacted by a 6-foot sea level rise.

Figure 8. Equity Emphasis Areas and Inland Flooding Zones for the COG region (orange areas indicate EEAs and blue areas indicate FEMA 100-year floodplains).



Source: FEMA and COG Equity Emphasis Areas

Note: The COG EEA study area differs slightly between Figure 6 Figure 7 and Figure 8 because of a change in the definition of an EEA between the 2018 data used in Figure 7 and the 2022 data

3.3 Benefits and Co-Benefits of GHG Reduction Measures to Metropolitan Washington's LIDACs

Reducing GHG emissions presents a large opportunity to advance equity, environmental justice, health, and economic outcomes in LIDACs. Through strategic interventions in sectors such as buildings, clean energy, transportation, land use, and waste management, communities can experience tangible benefits, including improved air quality, enhanced energy efficiency, increased resilience, and increased access to affordable housing and transportation. Notably, the GHG reduction measures present significant opportunities to reduce household costs and to improve quality of life through better air quality, enhanced green spaces, transit accessibility, and reduced health risks. These benefits will be reaped by all communities, but especially LIDACs and other vulnerable populations such as the elderly, pregnant women, and children.

Substantial opportunities also exist to enhance the clean energy workforce through tailored trainings, internships, and job placements by both leveraging existing programs and developing new ones. By prioritizing outreach, education, and workforce development initiatives tailored to the needs of LIDACs, climate action programs can effectively mitigate emissions while promoting social equity and building more sustainable and resilient communities. Additional information on the benefits of each GHG reduction measure for LIDACs in the MSA are presented as a part of each measure below in Section 4.

3.4 Equity, Environmental Justice, and LIDAC Priorities

Through the engagement efforts described in Section 1.3, notable emphasis was placed on equity and environmental justice, particularly concerning the needs of LIDACs. These communities are often left behind in environmental initiatives and require targeted support to address their unique needs and improve their quality of life. The most commonly noted concerns included air and water quality; public and environmental health impacts of climate change, such as from high heat days and nights; data centers affecting the overall quality of life; and the importance of ensuring that climate initiatives benefit people who have historically faced disproportionate environmental burdens.

Community engagement and empowerment emerged as significant aspects of equity impacts. Responses highlighted the community's call for public support, ensuring investment returns to communities, and involving communities in decision-making during project planning. Priorities also include a focus on addressing food security, creating employment opportunities, and supporting local environmental initiatives in historically underserved neighborhoods.

When asked which emissions reduction projects would have the most positive impact on LIDACs and historically marginalized and underrepresented communities, responses supported GHG reduction measures that align with and can be tailored to the unique needs of LIDAC communities. Specifically, communities that include people who use English as a second language; people impacted by environmental impacts on food security, communities overburdened by climate change, air quality, and transportation GHG emissions and pollution; and communities impacted by waste infrastructure such as landfills, incineration sites, and trash/recycling collection facilities.

Representatives encouraged the creation or enhancement of programs for climate-related workforce development; increasing access to electric vehicles (EVs), charging infrastructure, and public transit; decreasing vehicle miles traveled (VMT); and clean, efficient, and renewable energy such as solar and weatherization programs. Identified key strategies include:

- Promoting non-car travel, featuring expanded bike lanes, improved bus availability, and pedestrianized streets aimed at enhancing safety and accessibility;
- Locating affordable housing near transit, with an emphasis on the importance of funding for such initiatives;
- Implementing energy efficiency and electrification projects in multifamily and commercial buildings as a crucial step toward reducing energy consumption and emissions;
- Supporting local agricultural and food security initiatives such as community composting and neighborhood farming; and
- Accelerating reuse and repair initiatives, emphasizing waste reduction and promoting local employment.

4 GHG REDUCTION MEASURES

4.1 Emission Reduction Measures Summary

COG developed 10 GHG reduction measures for this CCAP, as presented in Table 4. These measures were developed through a collaborative and iterative process with the many government offices and committees within the MSA and the states it crosses, as well as other stakeholders like CBOs, private sector actors, utilities, planning boards and committees, and more. These are ambitious strategies spanning buildings and clean energy, transportation, waste, and land-use sectors.

Table 4. Summary of CCAP Measure GHG Reductions (MMTCO$_2$e)

Sector	Measure	Cumulative 2025-2030 GHG reductions	Cumulative 2025-2050 GHG reductions
Buildings and Clean Energy	Accelerate the deployment of energy efficiency solutions and decarbonization of residential, institutional, municipal, and commercial buildings.	18.59	187.20
Buildings and Clean Energy	Accelerate the deployment of local renewable energy.	4.79	25.02
Buildings and Clean Energy	Study, plan for, and deploy district energy and microgrid opportunities.	Varied based on system type, for a single generalized system ranges from 0.01 - 0.38	Varied based on system type, for a single generalized system ranges from 0.25 - 0.84
Buildings and Clean Energy	Data center solutions.	3.11	45.24
Transportation	Provide and promote new and expanded opportunities to reduce VMT through public transportation, non-motorized travel, micromobility, shared travel options, and development.	0.94	2.65
Transportation	Accelerate the deployment of low- and zero- emission transportation, fuels, and vehicles.	10.7	203.37
Transportation	Accelerate the deployment of off-road/non-road electric equipment.	0.21	1.65
Waste	Reduce GHG emissions from waste and wastewater treatment.	0.07	17.42
Agriculture and Land Use	Accelerate the expansion of the regional tree canopy and reduce tree canopy loss.	0.18	36.00

Sector	Measure	Cumulative 2025-2030 GHG reductions	Cumulative 2025-2050 GHG reductions
Engagement (Cross- cutting)	Education and outreach to support measure implementation.	N/A	N/A
Other	N/A – Additional emissions changes as an outcome of the measures.	0.26	4.14
Total		**39**	**523**

Note: Scope 2 impacts from a cleaner electric grid are included in end-use sector totals for buildings and transportation. The "Other" sector includes a reduction in natural gas fugitive emissions from lower natural gas consumption, and an increase in transmission and distribution losses from more electricity consumption. These change because of measure implementation, and no mitigation strategies are directly applied to either item. In addition, these reductions do not include additional Scope 3, embodied, or life cycle GHG emissions that may occur as a result of a measure.

The GHG reduction measures described in the CCAP may provide more than just GHG emission reductions; they will result in additional co-benefits including improved air quality, quality job opportunities, cost savings, and enhanced community well-being across the MSA. From increasing energy efficiency in the buildings sector and developing clean energy generation to improving public transportation to planting more trees, the co-benefits these measures will provide to MSA communities, particularly to LIDACs, can be accelerated through additional funding and coordination action. Implementing these measures will depend on available funding, other resources (e.g., staff time), evolving and diverse policy and regulatory landscapes across multiple states, supply chain availability, among other factors. However, COG has outlined a general timeline for CCAP implementation, milestones, and next steps below in Table 5.

Table 5. CCAP Proposed Timeline and Next Planning and Implementation Steps

Milestone	Timeframe
2025 - 2026	
Continued local and regional climate action, funding applications, and building on ongoing activities, and emphasizing CCAP measures	Throughout 2025 and 2026
Seek and secure additional funding for measure implementation; track sources that may become available from the private sector as well as public sector opportunities	2026
2027	
Deliver Status Report to EPA	Mid-2027
Continue to track progress, implement measures, and reduce GHGs at the county and municipal level.	Onward

4.2 CCAP Implementation Scenario Projections

The identified measures are intended to help provide a pathway to net zero GHG emissions for the region by 2050. Building from the BAU analysis, the potential for GHG emission reductions from each measure was assessed with the goal of creating a pathway to net zero GHG emissions by 2050. 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 9 shows the region's GHG emission projections by sector. **Compared to the 2020 inventory year, the pathway achieves a 93% reduction in net emissions by 2050**, with about 4 $MMTCO_2e$ of net GHG emissions remaining in 2050. Key assumptions, methods and data sources used to develop these quantified reduction estimates are provided in Appendix A.

The modeled pathway takes a "what would it take" approach, using aggressive assumptions and addressing multiple sources of emissions to show the level of change required to be on a path to net zero emissions. The GHG measures are intended to scale efforts and impacts over time. There are a variety of partners across all levels of government, the private sector, and non-profit space who will need to help implement these measures. These partners and their roles are outlined for each measure in the following section.

Figure 9. MSA GHG Emissions by Sector: CCAP Implementation Scenario

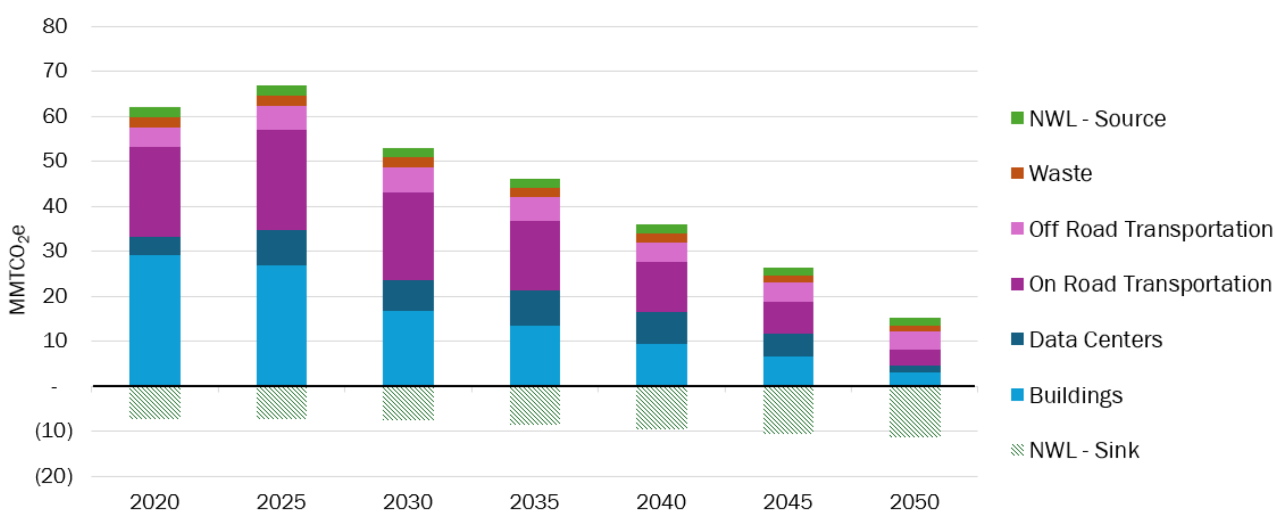


Figure 10 below presents the pathway to net zero scenario via a "wedge chart," which illustrates the impact on GHG reductions from each measure. The measures driving the largest GHG reductions for this pathway include:

1. Adoption of **zero-emission vehicles.** By 2050, nearly 80% of vehicles on the road are expected to be zero-emission vehicles. When paired with electricity powered by **clean energy**, 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 from protecting and restoring over 35,000 acres of **natural lands** and planting 3-4 million trees.
4. The deployment of **local solar** resources, which provide emission and reliability benefits as the region electrifies. By 2050, local solar capacity in the MSA is assumed to grow by 3.5 GW, up from just over 1 GW installed today.

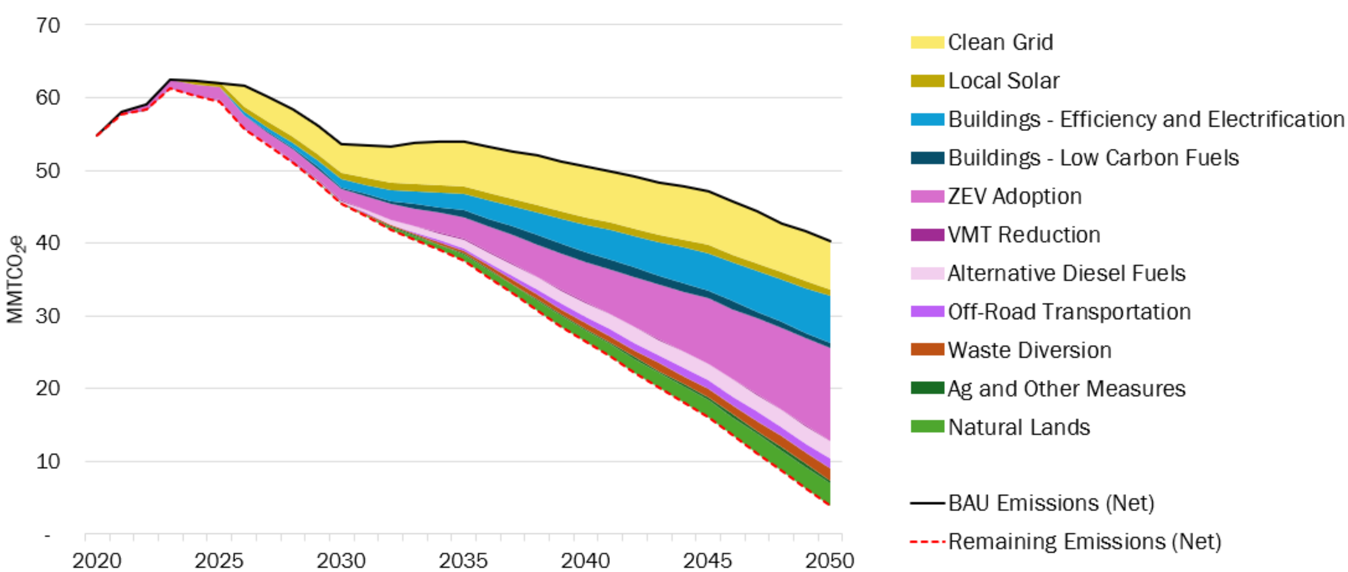
In alignment with the Maryland CCAP and the VCEA, a net zero electric grid for the region was assumed to be achieved by 2050. This is a key enabling strategy to support electrification activities within the MSA.

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 4. 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 dashed line shows the emissions under the Net Zero Scenario. The wedges in between represent the various ways to close the gap between the BAU and Net Zero Scenarios. When 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 and buildings sectors are the top drivers of emission reductions – when supported by a clean electricity grid. The significant electrification of the transportation and building sectors increases the need to support state and utilities efforts to deploy clean resources across the region to avoid increasing emissions from power plants to meet growing demand. In addition, the increased sequestration from the conservation and restoration of natural lands (e.g., forests and trees) is crucial for a net zero GHG pathway to help offset remaining emissions in later years from hard-to-abate sources.

To illustrate the role of the clean grid, the indirect (Scope 2) emission reductions from supplying clean electricity to the building and transportation sectors are shown separately in the Clean Grid wedge. The transportation and building sector wedges show the direct (Scope 1) emission reductions.

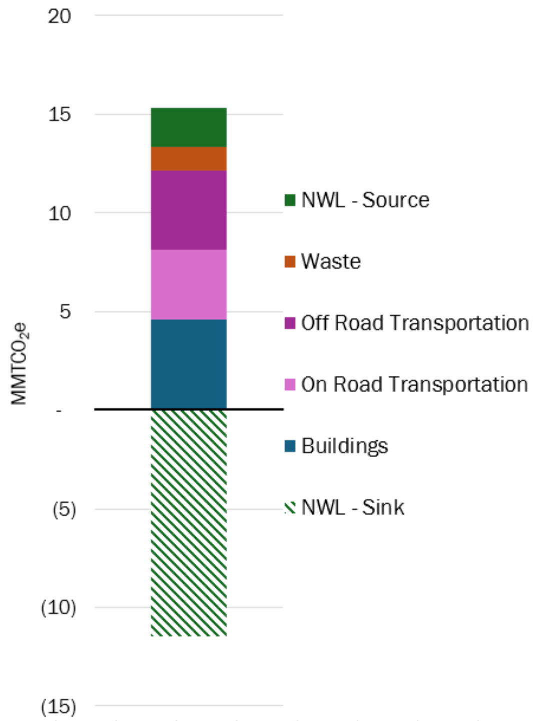
Figure 10. CCAP Measure Implementation Scenario Wedge Chart



Under this net zero pathway, GHG emissions remain in 2050 that are largely offset by sequestration from natural lands. Figure 11 depicts the GHG emissions in 2050 under this scenario, illustrating how the sinks from natural lands offset remaining emissions.

In 2050, gasoline use in on-road vehicles that have not been replaced with ZEVs drives continued emissions. Nonroad sources—landscaping equipment, construction equipment—and aviation are sources of remaining emissions in the off-road transportation sector. Remaining fossil fuel use in buildings also contributes to emissions in 2050. Additionally, waste management and agricultural activities are not fully abated by 2050.

Figure 11. GHG Emissions Remaining in 2050



Many of these remaining sources of emissions are very hard to abate; for example, some vehicles purchased today may still be on the road in 2050, and not all uses of gas for building heating or other fuels in off-road equipment will be substituted in the next 25 years.

Continued work will be needed to identify solutions with stakeholders and monitor progress for new technological solutions. In the meantime, protecting and restoring natural lands is key to achieving the net zero emissions goal.

In addition to GHG reductions, costs for the net zero pathway were also estimated. The cost assessment is designed to incorporate the following key elements to quantify total implementation costs tied to a measure, with the perspective of a societal impact, and relied on available public resources available: **capital expenses** associated with the upfront investment costs to implement a measure, including investments in infrastructure, equipment, or technology, and **operational expenses** linked to the execution of each measure. Operational expenses include recurring costs required to operate and maintain the measure, as well as any changes in ongoing expenditures or savings resulting from its implementation, such as variations in fuel and electricity use, or incentives deployed to support the measure. Table 6 below shows the total costs by sector for the net zero scenario. Measure specific cost estimates and key assumptions, methods, and data sources are provided in Appendix A.

Table 6. Total Net Costs by Sector for the CCAP Net Zero Scenario, Cumulative 2025-2050, Million 2025$

Sector	Cumulative Costs 2025-2050 (Million 2025$)
Buildings and Clean Energy	$13,249
Transportation	$231,997
Waste	$5,441
Land Use	$1,476
Total	$252,162

4.3 GHG Emissions Reduction Measures

4.3.1 Buildings and Clean Energy

ACCELERATE THE DEPLOYMENT OF ENERGY EFFICIENCY SOLUTIONS AND DECARBONIZATION OF RESIDENTIAL, INSTITUTIONAL, MUNICIPAL, AND COMMERCIAL BUILDINGS.

Decarbonizing buildings through energy efficiency, fuel switching, adaptive reuse, and other actions are a high priority for the MSA. Building energy consumption accounted for over 50% of GHG emissions in the metropolitan Washington region in 2020. This measure focuses on increasing opportunities for owners and users of all building types to access and install technologies to decrease overall energy consumption, increase energy efficiency, and reduce GHG emissions from the built environment. It covers both market rates and low/moderate income customers and private and public buildings.

QUANTIFIED GHG REDUCTIONS AND RELEVANT GHG INVENTORY SECTOR(S)

This measure will reduce GHG emissions in the buildings inventory sector. Cumulative estimated GHG emissions reduction potential for this measure are:

GHG reductions ($MMTCO_2e$), 2025-2030	GHG reductions ($MMTCO_2e$), 2025-2050
18.59	187.20

Key assumptions, methods and data sources used to develop these quantified reduction estimates are provided in Appendix A.

KEY IMPLEMENTING AGENCIES AND PARTNERS

- **State governments.** Government organizations such as the District of Columbia DOEE, Maryland Green Building Council, Maryland Department of the Environment, Maryland Energy Administration, Maryland Clean Energy Center, Virginia Department of Housing and Community Development, and others offer programs to provide funding and technical assistance for energy efficiency and electrification projects. This may include departments of energy, environment, housing, school districts, and others. Government facilities also are opportunities for building efficiency and decarbonization.
- **Local governments, including public schools.** Local departments of energy, environment, housing, school districts, and others may have additional programs and policies to provide funding and technical assistance for energy efficiency and electrification projects. Government and public facilities and sites also provide opportunities to improve regional building efficiency and reduce GHG emissions from the built environment.
- **Energy utilities.** Most utilities in the MSA serve as providers of existing energy efficiency and building decarbonization programs for ratepayers.
- **Businesses, hospitals, private schools, universities, water utilities, airports, data centers, places of worship.** These entities will implement building improvements and design/build decarbonized buildings.
- **Property owners, developers, renters.** As end users, homeowners, property owners, developers, and renters can make behavior changes and decisions that affect building efficiency. While

property owners and developers generally have more control over changes to and within buildings, especially at the time of new construction or major renovations, renters can also make behavior and other changes that will result in GHG reductions.

- **Contractors and equipment/energy service providers.** These partners provide the services and equipment to decarbonize buildings, and may include architects, engineers, energy auditors, consultants, and more. Workforce development organizations also play a key role in building the pipeline of skilled workers to serve the building sector's decarbonization needs.

IMPLEMENTATION ACTIVITIES AND MILESTONES

Actions to implement this measure could include, but are not limited to:

- Create voluntary and/or mandatory benchmarking and labeling programs for buildings.
- Strengthen green building policies and energy codes. Implementing strengthened codes, including "stretch codes," can encourage the mitigation of air pollutants from buildings.
- Conduct energy audits and site assessments. By conducting these assessments, implementers can collect information on which areas of the building inventory, if any, need additional support in achieving improved energy efficiency and decarbonization, and have the highest potential to result in energy savings.
- Facilitate net zero building development. Prioritizing low-emissions practices across the lifecycle (in construction, maintenance, and end of life) of new buildings and retrofits to existing buildings can yield more integrated emissions savings.
- Expand or create new programs and incentives for retrofits and upgrades to residential, multifamily, and commercial properties (e.g., building efficiency retrofits including window replacements, insulation, more efficient and/or electric appliances, hybrid or all-electric heat pumps or more efficient gas heat pumps).
- Implement energy efficiency and fuel switching in all buildings, particularly data centers and other large energy users (e.g., hospitals, life sciences, wastewater utilities, CHP/District Energy operators), including implementing solutions to make buildings more efficient and decarbonize buildings, including reducing the use of building-code-required back up diesel generators and transition to cleaner alternatives.
- Expand and/or create new programs for retrofits, incentives, and upgrades to municipal and government buildings, including public schools, government buildings, and operations (e.g., building efficiency and electrification retrofits, street lighting and stadium lighting retrofits, microgrids).
- Fund the deployment of microgrids.
- Plan for and address electric panel and electrical transformer upgrades in residential and commercial properties to support electrification.
- Address refrigerant use in buildings (HVAC, chillers, refrigeration) through replacement with lower global warming potential refrigerants/natural refrigerants.

Some of these activities are already underway to varying degrees across the metropolitan Washington region:

- The Maryland Climate Solutions Now Act of 2022 requires the Maryland Department of the Environment (MDE) to develop BEPS.[25] MDE must develop standards for buildings that, among

[25] https://mde.maryland.gov/programs/air/ClimateChange/Pages/BEPS.aspx

other requirements, achieve a 20% reduction in net direct GHG emissions by January 1, 2030, compared with 2025 levels for average buildings of similar construction and net-zero direct GHG emissions by January 1, 2040. Buildings subject to BEPS in Maryland are 35,000 square feet or larger (excluding the parking garage area). Owners of buildings subject to BEPS will need to report data to MDE each year beginning in 2025. Historic properties, public and nonpublic elementary and secondary schools, manufacturing, agricultural, and critical facilities are exempt.

- In January 2024, Montgomery County, Maryland issued a transmittal packet of proposed BEPS regulations to the County Council. Buildings subject to BEPS in Montgomery County are 25,000 square feet or greater and will need to meet a long-term energy performance standard based on site energy use intensity. The regulations will be considered by the County Council in 2024.[26] The DC Government also operates a BEPS program that addresses building as small as 10,000 square feet.
- Arlington has a voluntary Green Building Bonus Density Incentive Program and a Sustainable Facilities Policy for municipal buildings. Similar programs exist in other counties and cities in Northern Virginia.
- Many utilities in the region (e.g., Dominion), through existing state-wide programs (e.g., EmPOWER Maryland) offer ratepayer funded energy efficiency and decarbonization buildings programs for residential, commercial, sector-specific, and income- and age-eligible customers.

Other activities may be further behind in implementation due to limited funds, potential authority limitations, and other barriers such as lack of education/awareness and workforce and supply chain limitations. Most of the activities can be implemented or expanded in the near term.

AUTHORITY TO IMPLEMENT

Maryland, Washington D.C., and Montgomery County, Maryland have enacted legislation mandating BEPS, but Virginia law does not currently allow local governments to establish BEPS or related policies such as energy benchmarking. Energy code implementation across the region is governed by state law, which with some variations limits local governments' ability to implement codes different from that adopted at the state level. Notwithstanding the lack of home rule in Virginia to adopt local building codes, cities and counties in the Commonwealth of Virginia have—for as long as 22 years—fashioned and implemented green building incentive programs based on tiers of BEPs and performance certifications. Additionally, state RPS requirements drive the cost for RECs in each state. Thus, all activities mentioned above can be implemented or are implemented through existing voluntary or regulatory programs.

GEOGRAPHIC COVERAGE

This measure will reduce GHG emissions across the entire MSA.

FUNDING SOURCES

Example potential funding sources include:

- U.S. Department of Energy (DOE) Energy Efficiency and Conservation Block Grants
- DOE Home Efficiency Rebates and Home Electrification and Appliance Rebates
- DOE State Energy Program
- DOE and State Weatherization Assistance Programs

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[26] https://www.montgomerycountymd.gov/green/energy/beps.html

- DHHS Low Income Home Energy Assistance Program
- Washington DC Sustainable Energy Utility (SEU)
- Maryland Clean Energy Center
- MD Commercial Solar Grant Program
- MD Energy Efficiency Equity Grant Program
- MD Building Energy Performance Standards Technical Assistance Program
- MD Electrifying Community Buildings Program
- MD Clean Energy Advantage Loan
- DC Green Bank
- Montgomery County Green Bank
- Inflation Reduction Act Tax Credits (Energy Efficient Commercial Buildings Deduction (179D), and New Energy Efficient Home Credit (45L))
- VA Property Assessed Clean Energy (PACE)
- Utility Programs

LIDAC BENEFITS

These actions could contribute to reducing energy expenses for private and public entities. Indirect benefits include the creation and expansion of green energy jobs and training for auditors, construction workers, contractors, and other building trades such as HVAC suppliers and carpenters. Additionally, these measures may encourage infill development, removing blight and improving visual quality, safety, and quality of life for LIDACs. Retrofit programs typically benefit LIDACs in the urban core and in distressed areas. These measures may result in direct benefits including reduced energy costs from the implementation of energy efficiency measures and educational programs that influence user behavior and result in lower utility bills. The incorporation of microgrids may benefit LIDACs by providing alternative network sources for energy during high demand and increasing reliability. This measure will also improve local air quality, leading to a reduction in related health impacts such as asthma. Potential temporary impacts or dis-benefits for business and residential lease holders during construction include construction noise, fugitive dust, utility interruptions, and in some cases early lease termination to complete construction activities. Following construction, increased rents may be a concern.

SAMPLE METRICS FOR TRACKING PROGRESS

Potential metrics to track the progress of this measure include:

- Number of units retrofitted, disaggregated by residential, institutional, municipal, and commercial buildings
- Number of energy conservation measures installed, disaggregated by residential, institutional, municipal, and commercial buildings
- Participation rates in incentives programs, such as EmPOWER Maryland utility offerings or tax credit programs
- Square footage retrofitted, disaggregated by residential, institutional, municipal, and commercial buildings
- Number of units constructed as net zero, high efficiency or electric, disaggregated by residential, institutional, municipal, and commercial buildings

- Square footage of buildings constructed as net zero, high efficiency or electric, disaggregated by residential, institutional, municipal, and commercial buildings
- Energy use intensity (EUI) and GHG improvements (e.g., for local government buildings)
- Local electricity and natural gas consumption by jurisdiction
- Electricity and natural gas consumption by building (if in EPA Portfolio Manager)

ACCELERATE THE DEPLOYMENT OF LOCAL RENEWABLE ENERGY.

This measure aims to accelerate the development of on-site solar energy, complemented by battery storage and microgrids (where feasible), by expanding upon successful existing community-based programs (e.g., Solarize NoVA, SUN-Switch, and Capital Area Solar Switch) and introducing new initiatives and technologies, such as agrivoltaics (the co-location of agricultural production and ground-mounted solar photovoltaic systems).[27] It will provide financial and other support to install solar photovoltaic (PV) systems at single-family residential properties, including LIDAC properties, and install solar systems at public housing and affordable housing properties, and other residential and commercial buildings. Where on-site solar installation and use is not feasible, off-site solar and other renewable power resources through aggregation options such as community solar, retail choice, and community choice aggregation (CCA) could be used. This measure also includes the use of solar energy for local government operations.

QUANTIFIED GHG REDUCTIONS AND RELEVANT GHG INVENTORY SECTOR(S)

This measure will reduce GHG emissions in the buildings sector. It may also reduce emissions in the transportation sector if EVs are charged using distributed renewable energy sources. Cumulative estimated GHG emissions reduction potential for this measure are:

GHG reductions ($MMTCO_2e$), 2025-2030	GHG reductions ($MMTCO_2e$), 2025-2050
4.79	25.02

Key assumptions, methods and data sources used to develop these quantified reduction estimates are provided in Appendix A.

KEY IMPLEMENTING AGENCIES AND PARTNERS

- **State and local governments.** Governments can install and procure renewable energy on or for public facilities (including schools, municipal buildings, and other public buildings), create solar ordinances and updated zoning ordinances, and develop policies and incentive programs to support renewable energy.
- **Utilities and Regional Transmission Organizations.** As providers of large-scale renewable energy and as actors in renewable energy credit markets, utilities can work with entities to negotiate for and procure renewable energy. Utilities may also work with partners to plan for integration of distributed generation and grid modernization to serve community needs.

[27] https://www.energy.gov/eere/solar/agrivoltaics-solar-and-agriculture-co-location

- **CBOs.** Engaging with local CBOs can help ensure that on-site solar initiatives address the specific needs and concerns of local communities. These organizations can also play a role in raising awareness and promoting community participation, (e.g., in community solar programs) or build the pipeline of trained workforce to install more distributed energy generation.
- **Private sector partners.** Collaboration with private sector entities — including solar developers, financiers, building owners, installers, and technology providers — is crucial for implementing on-site solar installations. Public-private partnerships can lead to greater funding and heightened expertise for these projects.
- **Non-profit organizations.** Nonprofits can conduct community engagement, education and outreach, capacity building, research on environmental and social impacts of clean energy projects, and/or developing and installing community renewable energy projects.

COG's Commitment to Renewable Energy
Based on recommendations from the COG CEEPC, in November 2023, the COG Board endorsed a goal of 250,000 solar rooftops in the region by 2030, with additional goals that call on local jurisdictions to pursue solar installations on government facilities, explore renewable energy for 100% of government operations, and support community-wide efforts to deploy solar, including programs for low-income residents, efficient zoning and permitting processes, and incentives. Currently, there are approximately 93,000 solar energy installations in the region.
Note: This does not cover the entire CPRG MSA.
Source: www.mwcog.org/newsroom/2023/11/08/cog-board-adopts-regional-solar-energy-goals-for-2030-/

IMPLEMENTATION ACTIVITIES AND MILESTONES

Actions to implement this measure could include, but are not limited to:

- Expand the reach of existing programs, such as Solarize NoVA, SUN-Switch, and Capital Area Solar Switch programs.
- Map solar opportunities across the MSA to determine potential priorities and investments.
- Provide clean energy and microgrid feasibility assessments at key facilities (e.g., university campuses, hospitals).
- Incorporate community energy infrastructure needs, goals, and strategies in master plans, comprehensive plans, and small area plans.
- Adopt new solar-ready construction ordinances, building codes, and/or incentive programs.
- Provide or promote incentives to encourage installation of solar in the community and for battery storage.
- Install renewable energy systems on schools and municipal infrastructure.
- Implement battery storage pilot initiatives at public facilities.
- Provide technical assistance and support for negotiating and navigating power purchase agreements, CCA, and community solar.
- Examine the possibility of regional demand aggregation.
- Initiate cooperative purchasing initiatives or energy purchasing consortia.
- Develop new state or local policies to help overcome barriers to CCA adoption.
- Leverage existing cooperative purchasing programs, such as the Mid-Atlantic Purchasing Team and COG Cooperative Procurement Program, to fast-track local implementation.
- Establish PPA(s) to provide clean electricity to local government facilities, potentially aggregating demand with other local jurisdictions or large local businesses to reduce costs.

- Implement and share best practices from CCA and retail choice aggregation pilot programs, where applicable.
- Advocate for increased percentages of clean energy in state RPS programs.
- Coordinate with utilities to speed up interconnection agreement processing time and ensure equitable costs for transmission upgrades for residents installing solar.
- Provide financial and other support to install solar PV systems at single-family residential properties, including LIDAC properties, public housing and affordable housing properties, and other residential and commercial buildings.
- Implement large-off site solar procurement projects supplying the wholesale PJM electricity market.

Many of these activities are ongoing and will continue to be implemented throughout the region but need to be scaled. Other activities, such as developing new policies to overcome CCA adoption barriers, still need to be implemented and depend on existing authorities. Some of these planned activities can commence in a shorter timeframe, contingent upon available resources (e.g., regional solar opportunity mapping), whereas others may take more time (e.g. adopting solar-ready ordinances) and may be location-dependent.

AUTHORITY TO IMPLEMENT

The authority to implement on-site renewable energy falls on state and local governments in partnership with utilities and the private sector. Programs like Solarize NoVA, SUN-Switch, and Capital Area Solar Switch operate at the building scale, and the implementation authority for voluntary participation rests with individual building owners. On-site solar development is pursued where feasible, but off-site options, such as community solar, retail choice, and CCA, come into play when on-site solutions are not viable. The authority for off-site renewables, particularly community solar, is governed by state law. Utilities in the metropolitan Washington region can offer voluntary renewable energy certificate (REC) purchases (the cost of which is driven by different state RPS requirements), while community solar, retail choice, and CCA require specific state legal authorizations, each addressed by Maryland, DC, and Virginia laws in their respective domains. Retail choice, allowing customers to choose alternative energy suppliers, is currently authorized in Maryland and DC but not in Virginia, except for large electricity users. CCA, allowing local governments to seek energy supplies independently, is legally authorized in Maryland and Virginia, and is subject to state legal provisions similar to those for community solar.

GEOGRAPHIC COVERAGE

This measure will reduce GHG emissions across the entire MSA.

FUNDING SOURCES

Example funding sources include:

- DOE State Energy Program
- Washington DC SEU
- Montgomery County Green Bank
- MD Commercial Solar Grant Program
- VA PACE
- VA Clean Energy Innovation Bank
- VA Grid Reliability Improvement Program

- VA Community Access to Renewable Energy Funding

LIDAC BENEFITS

Transitioning from fossil fuels to renewable energy would provide benefits such as improved indoor air quality and local air quality, as well as reduced energy bills. Secondary benefits may include site remediation to create spaces for off-site solar development and a competitive market for users who have expanded choices for energy suppliers. In addition, potential health benefits include reduced cases of asthma and upper respiratory disease, and associated effects from diseases such as obesity, diabetes, and chronic infections related to reduced outdoor activities. Job creation and training in the renewable energy space could benefit LIDAC members.

SAMPLE METRICS FOR TRACKING PROGRESS

- Number of solar rooftops
- Amount of distributed solar capacity installed
- Amount of distributed solar capacity installed in LIDACs
- Size of the current solar workforce

STUDY, PLAN FOR, AND DEPLOY DISTRICT ENERGY AND MICROGRID OPPORTUNITIES.

This measure focuses on targeted and strategic uses of district energy systems, with the opportunity to deploy clean energy sources (e.g., renewable gas generated from a landfill or solid waste operations, solar, waste heat recovery, combined heat and power), and potentially pair with microgrids. District energy systems deliver hot water, steam, or chilled water from a central plant(s) to multiple buildings via a network of pipes to meet thermal end uses like space heating, domestic hot water, air conditioning or industrial process heating or cooling.

For large energy users (e.g., data centers, water utilities) and campuses (e.g., hospitals, higher education facilities), district energy offers an opportunity for energy efficiency, GHG reductions, and resiliency. Microgrids can provide a form of energy resilience and independence due to their ability to "island" from the larger grid. This is especially important for critical infrastructure, post-disaster community needs, or proximity to 24/7 large energy users when energy is needed during blackouts or other interruptions in service. These opportunities could be targeted in LIDAC areas and form the basis of community resilience hubs and provide needed community facility investment.

QUANTIFIED GHG REDUCTIONS AND RELEVANT GHG INVENTORY SECTOR

This measure reduces GHG emissions from the buildings sector. The potential GHG reduction benefits of district energy systems and microgrids in the metropolitan Washington region is highly dependent on the specific application of the system(s). In 2011, COG worked with FVB Energy Inc to study potential benefits and costs of generalized example district energy systems in the region. The GHG reductions presented below in Table 7 represent the application of various generalized example district energy system types to a comparison building. Calculations based on the FVB study are presented in Appendix A, along with key study assumptions and data sources.

Table 7. Cumulative GHG Reductions for Example Generalized District Energy System Types (MMTCO$_2$e)

System Type	2025-2030	2025-2050
Boilers and Chillers	0.03	0.25
Engine CHP	0.33	0.72

System Type	2025-2030	2025-2050
Turbine CHP	0.18	0.38
Combined cycle CHP	0.38	0.84
Biomass Boiler	0.13	0.70
GSHP	0.01	0.30
Waste Heat	0.09	0.51

KEY IMPLEMENTING AGENCIES AND PARTNERS

- **State and local government agencies.** Government public buildings are community-focused buildings that can serve as microgrid or resilience hub host sights. State and local governments play a role in planning, development, permitting, and other phases of implementation. They may also be the beneficiaries of investments such as resilience hubs and critical sheltering. Local governments may need to plan for capital budgeting and procurement.
- **Public Service Commissions, Utilities, Energy Suppliers.** Participation and/or approval by energy utilities (e.g., Pepco) and their regulators is critical for microgrid owners and operators. Further, utilities and energy suppliers will need to fuel district systems running on clean or renewable gases.
- **Private sector.** Support from the private sector, including key implementers and partners mentioned above, will be required for feasibility assessments, construction planning and development, and potential operations and maintenance. Key industry stakeholders will be important to supply new sources of zero-emission fuels, such as renewable gas or hydrogen. Financing partners are also important.

IMPLEMENTATION ACTIVITIES AND MILESTONES

Actions to implement this measure could include, but are not limited to:

- Support the identification and selection of high energy users and critical infrastructure for combined heat power (CHP), district energy and/or microgrid implementation.
- Decarbonize existing CHP systems.
- Explore or transition to renewable natural gas (RNG), hydrogen, or other low carbon fuel solutions for energy sourcing and generation.
- Engage with private sector partners interested in solar, biofuel, CHP, district energy and microgrid implementation solutions.
- Engage with LIDACs where resilience hubs are most needed and engage with the community on what resources they need.
- Conduct site feasibility assessment and pre-construction planning.
- Partner on grant applications or provide contract support for project planning, feasibility, and implementation support.
- Support state incentives and opportunities to help facilitate district energy and microgrid development.
- Support the development of microgrids.
- Coordinate with state and local governments to reduce barriers to deployment.
- Work closely with regulators and utilities to deploy solutions.
- Conduct pilot programs to demonstrate the viability and utility of resilience hubs.

The accomplishments of CEEPC and its members have also earned the region recognition as a White House Climate Action Champion. This designation made its members eligible for targeted federal technical assistance and grant funding from 2014–2016. One way COG leveraged this opportunity was to conduct local clean energy infrastructure assessments at six sites across the region to determine the feasibility of microgrids, CHP, geothermal, or net zero energy development. Two examples of progress at these sites include the Falls Church School Campus (geothermal energy) and the Washington Hospital Center (microgrid deployment).

Montgomery County has installed a microgrid project at the County's Public Safety Headquarters as part of a comprehensive effort to ensure the resiliency of critical public services during major electric distribution system outages. The project installed a microgrid featuring 2 MW of solar PV canopies mounted over a parking lot and an 800-kW CHP system and reduces GHG emissions of 5,900 metric tons annually.[28] Montgomery County has also installed a microgrid at the County's Correctional Facility, which will reduce GHG emissions by more than 950 tons annually.[29] In addition, Montgomery County has created Brookville Smart Energy Bus Depot, an integrated microgrid and electric bus charging infrastructure project. Montgomery County also developed a microgrid-powered resilience hub at the Montgomery County Animal Services and Adoption Center.[30] Montgomery County Green Bank created a privately-owned resilience hub in an EEA by electrifying an affordable high-rise apartment building and installing a 159kW solar PV system.[31]

Arlington County's Community Energy Plan (CEP) includes a goal to ensure Arlington's energy resilience and includes policy actions that focus on developing resilient energy infrastructure, enhancing energy assurance, and assessing microgrid opportunities for critical services. Under the CEP, in 2023, Arlington County completed its Energy Assurance Plan, which advanced a microgrid and resiliency hub feasibility study and implementation as priority actions, with a focus on primary needs of LIDACs. Maryland has been extending programs to incorporate resiliency projects, e.g., MEA introduced in 2020 the Resilient Maryland Program to provide funding for projects to increase microgrids and other distributed energy resources to improve energy resiliency.

NVRC commissioned a study on the legal viability of district energy systems in 2011, and many of these conclusions and opportunities still stand.[32] The study concluded that: there are clear existing paths for public and/or private establishment, ownership and operation of district energy systems; district energy systems will likely be subject to complex legal frameworks; depending on the ownership arrangements and system characteristics, the operation may be subject to limitations of powers of localities under the "Dillon Rule", to State Corporation Commission Regulation, and land use and environmental regulations; the Code of Virginia provides paths to development of district energy systems, but could be amended to provide more clarity about how district energy systems can be developed and operated.

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[28] Microgrids Public Safety Headquarters (montgomerycountymd.gov)

[29] Microgrids Montgomery County Correctional Facility (montgomerycountymd.gov)

[30] https://www.mymcmedia.org/elrich-announces-new-resiliency-hub-at-animal-shelter/

[31] Montgomery County Green Bank. https://mcgreenbank.org/first-privately-owned-resilience-hub-and-electrification-project-at-hampshire-towers-apartments/

[32] NVRC. https://www.novaregion.org/DocumentCenter/View/3050/NVRC-McGuire-Woods-District-Energy-White-Paper-Au?bidId=

AUTHORITY TO IMPLEMENT

Where microgrids or district energy systems interconnect with and/or displace infrastructure owned by energy utilities franchised under state law, utility participation and/or permission is typically required, which will also involve state regulatory commissions. It may be necessary to amend some state laws to implement this measure. Where municipally owned utilities are involved, the authority typically resides within the local government. In certain situations, such as greenfield development, microgrid/district energy projects could be developed without utility involvement, though it is more likely that interconnection agreements would be encouraged if not required.

GEOGRAPHIC COVERAGE

The actions within this measure are focused on the entire MSA area, but opportunities are focused in areas of high energy use, such as in high density data center populations (e.g., Loudoun and Prince William counties), schools and universities (e.g., University of Maryland), and hospitals.

FUNDING SOURCES

Example potential funding sources include:

- Energy Efficiency and Conservation Block Grants
- MEA Resilient Maryland Program
- MD Solar Access Program
- MD Commercial Solar Grant Program
- DOE Grid Innovation Program
- DOE Smart Grid Grants
- Private sector energy performance contracts
- VA Grid Reliability Improvement Program
- VA Community Access to Renewable Energy Funding

LIDAC BENEFITS

This measure directly benefits DC and ancillary service networks within the system as the improvements are focused on large system users such as public and private hospitals, schools, institutions and other large facilities. Secondary or co-beneficiaries include LIDACs due to the reduction of GHG emissions and other air toxins surrounding the fossil fuel facilities, expanded job opportunities and training in the areas of maintenance and system network upgrades, and overall system reliability through the introduction of microgrid components.

SAMPLE METRICS FOR TRACKING PROGRESS

- Number of approved/installed projects
- Capacity of microgrid capacity installed

DATA CENTER SOLUTIONS.

Data centers are buildings containing computer servers, storage and network equipment that provide online services and support for the digital economy such as social media, video streaming, cloud storage and increasingly artificial intelligence (AI) and quantum computing. The metropolitan Washington region has become the world's leading hub for data centers, driven by favorable incentives and zoning policies, access to land and electric power, an extensive underground fiber optic network, and proximity to federal agencies. Loudoun County, Virginia, is home to the highest concentration of data centers globally. In 2023, data centers consumed around 25% of total building electricity use in the MSA, resulting in 8% of the region's gross GHG emissions according to BAU estimates.

While data centers are a key driver of rising energy demand in the region[33], they also generate significant economic benefits to localities, including tax revenue and job creation. Loudoun County's ~200 data centers and the data center ecosystem provide more than 15,000 jobs in Loudoun County and generate almost half of the county's property tax revenues.[34]

The goal of this measure is to provide a suite of actions that localities can leverage going forward to maintain these economic advantages while addressing concerns regarding how to balance rising electricity consumption with local and regional GHG emissions reduction goals. Data center owners and operators, such as Amazon, Microsoft, and Google (who collectively own over half of hyperscale data centers[35]) and utilities such as Dominion Energy and Northern Virginia Electric Cooperative (NOVEC) (which are the primary electric utilities serving Northern VA) will be critical drivers and partners for implementing the actions outlined in this measure.

This measure is intended solely as an informational resource to support local governments as they consider policies, programs, and partnerships related to data center development. The actions described here are not mandates, nor are they designed to create new policy or regulatory requirements for data center owners, operators, utilities, or other private entities. Instead, they represent a menu of voluntary options that localities may choose to incorporate into their planning, permitting, and economic development approaches. Localities across the MSA vary widely in their priorities, infrastructure capacity, available resources, and policy and regulatory frameworks. The actions outlined here are meant to be flexible tools that can be adapted to local contexts rather than prescriptive standards; adoption of any action is at the full discretion of each locality.

Implementation of many of these actions relies on collaboration with data center owners and operators, developers, and electric utilities, who have autonomy over their internal operations, procurement choices, and energy management practices in line with existing regulations, policies and voluntary commitments. While localities may encourage or incentivize certain practices, they cannot—and this measure does not attempt to—require private entities to undertake any specific action.

This measure and information Appendix I aims to help local governments and other stakeholders:

- Better understand the evolving landscape of data center energy use and emissions.
- Consider approaches that align data center growth with local climate, resilience, and economic goals.
- Build a toolkit of strategies that can be tailored to local needs and capacities.

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[33] See PJM 2025 Load Forecast: https://www.pjm.com/-/media/DotCom/library/reports-notices/load-forecast/2025-load-report.pdf

[34] Those are permanent jobs in and around the data centers and include their customers and their vendors: https://loudounpossible.com/data-centers

[35] Cloud data centers get bigger, denser amid AI building boom: https://www.utilitydive.com/news/cloud-ai-data-center-aws-microsof-google-oracle/743290/

QUANTIFIED GHG REDUCTIONS AND RELEVANT GHG INVENTORY SECTOR(S)

The total electricity consumed by data centers is held constant between the BAU and CCAP Implementation Scenario; this measure quantifies potential reductions from cleaner electricity supplied by the grid. In addition, due to the lack of information on existing fuel use for backup power, this measure also does not quantify the impact of cleaner backup power solutions. Key assumptions, methods and data sources are provided in Appendix A.

GHG reductions ($MMTCO_2e$), 2025-2030	GHG reductions ($MMTCO_2e$), 2025-2050
3.11	45.24

Uncertainties in Data Center Estimates. The projections presented in this plan for data center GHG reductions represent a first draft and attempt at estimating the GHG emissions impacts and opportunities for reductions in the MSA. These estimates were developed based on available and reputable data sources as described in Appendix A. However, there is a high degree of uncertainty in the estimates, driven by limited available data and the fact that the data center industry is rapidly evolving and developing. It will be important to continue to refine and update the estimates and supporting data presented within this plan to capture changes in, for example, planned square footage of data centers and energy use intensities over time which have a large impact on projected GHG emissions.

Data Center Types at a Glance

Emissions from data centers come from the use of fossil fuels to generate electricity. That electricity is either grid-supplied or generated onsite through backup power (typically diesel generators). In theory, reducing these emissions is simple: Sourcing carbon-free power for electricity supply would eliminate GHG emissions from data center operations. However, developing such resources at the pace and scale required presents a significant challenge, largely due to the high reliability requirements for data centers.

There are over 300 data centers within a 50-mile radius of Washington, DC, about 200 of which are in Loudoun County.[36] Data centers can be as small as an IT closet in an office building or over a million square feet. The electricity demand from data centers varies depending on their size and use. The concentration of data centers in the region, including the recent development of large hyperscale facilities, has led to significant increases in energy demand. This measure focuses on mitigation actions to support energy efficiency and emission reductions from those with the largest impacts – colocation and hyperscale data centers.

From 2010-2018, most servers could be found in Internal, Edge, or Enterprise data centers. In 2023, hyperscale and colocation data centers accounted for almost 80% of data server energy

[36] United States Data Centers - Providers Map in United States: https://www.datacenters.com/locations/united-states

use[37]. Hyperscale data centers are built by companies that deploy internet services and platforms at massive scale and can exceed 100,000 square feet. The development of more powerful microchips in recent years has led to higher power demand in a smaller footprint, resulting in some hyperscale facilities using hundreds of megawatts of electricity – enough to power hundreds of thousands of homes.

Hyperscale data centers are experiencing rapid growth. Distinct clusters emerge for colocation and hyperscale data center locations as data centers strategically position themselves close to their clients and cloud services users to ensure high availability and low response times. Factors such as proximity to population centers, electricity cost, network infrastructures, and local utility prices influence their location choices. Virginia hosts the highest electricity demand associated with data centers in the U.S., serving as the primary hub for both colocation and hyperscale data centers, followed by California and Texas.[38]

Data centers developers and owners/operators are a critical partner for implementing the actions outlined in this measure, and some of the region's data centers are already applying best practices to maximize energy efficiency and manage energy demands. Currently, data centers across the MSA have earned 44 ENERGY STAR ratings and two have been awarded Designed for ENERGY STAR status, with the majority located in Loudoun County. In addition, 24 have been certified by LEED and 5 by Green Globes.[39] ENERGY STAR certified data centers score in the top quartile in power efficiency compared to similar sized data centers across the country. To manage costs, many colocation and hyperscale data centers are designed to be highly efficient but may not apply for certification programs.

STATUS OF LOCAL ACTION

With the rise in data center development proposals – hyperscale ones in particular – counties in the region have begun to review their zoning and permitting processes to address community concerns and provide direction for data center growth in their communities.

Edge data centers are smaller facilities that are located closer to end users at the edge of a networks to provide internet connectivity and access to cloud computing.

Enterprise data centers are owned or leased by a single organization and used to support that organization's IT needs.

Internal data centers are integrated into larger buildings and managed by businesses with their own IT systems.

Colocation data centers provide space, power, cooling, and connectivity for the servers and other hardware of multiple organizations. These facilities are also referred to as multi-tenant data centers.

Hyperscale data centers are usually built by or for one organization to meet the specific technical, operational, and pricing requirements of a hyperscale customer.

[37] Lawence Berkeley National Laboratory. (2024). 2024 United States Data Center Energy Usage Report. Retrieved from https://eta-publications.lbl.gov/sites/default/files/2024-12/lbnl-2024-united-states-data-center-energy-usage-report.pdf?utm_source=substack&utm_medium=email

[38] Lawence Berkeley National Laboratory. (2024). 2024 United States Data Center Energy Usage Report. Retrieved from https://eta-publications.lbl.gov/sites/default/files/2024-12/lbnl-2024-united-states-data-center-energy-usage-report.pdf?utm_source=substack&utm_medium=email

[39] COG. (2025). Metropolitan Washington Data Center Green Building Database Summary. Retrieved from https://www.mwcog.org/events/2025/9/24/climate-energy-and-environment-policy-committee/

The counties that are early movers in this are Fairfax County, which adopted a new Data Center Zoning Ordinance Amendment in 2024, and Loudoun County, where the Office of Planning and Zoning is in the process of updating the policies, standards, and locations for data center development. Phase 2 of Loudoun's process, expected to be completed in 2026, will focus on establishing policy guidance and use-specific zoning standards for data centers and utility substations to address concerns related to land use, compatibility, aesthetics, infrastructure and natural and environmental resources. Loudoun County is also collaborating with the Data Center Coalition, the National Renewable Energy Laboratory (NREL), and other regional partners to build on existing successes and identify strategies to manage and reduce energy and water use by data centers.

Table 8 below outlines ongoing processes to navigate significant data center growth in select localities as of today. This space is continually evolving.

Table 8. Summary of Locality Data Center Actions

County	Permitting Overview	Workgroups / Task Forces
Loudoun County	March 2025: removed by-right development; all new data centers require a special exception. Ongoing: Comprehensive Plan and Zoning Ordinance Amendment to update the policies and standards for data center and electrical substation uses.[40]	None
Fairfax County	Sept 2024: adopted data center zoning ordinance amendment, which created stricter by-right standards, including size limits, noise studies, setbacks, and building aesthetic requirements.[41]	None
Prince William County	By-right development allowed in the Data Center Opportunity Zone Overlay District (DCOZOD) (est. 2016); outside the overlay, special use permit is required.[42]	None

[40] Loudoun County Government. (2025). Data Center Standards & Locations. Retrieved from https://www.loudoun.gov/5990/Data-Center-Standards-Locations
[41] Fairfax County Government. (2024, March 20). Board of Supervisors approves new data center zoning ordinance amendment. Retrieved from https://www.fairfaxcounty.gov/news/board-supervisors-approve-new-data-center-zoning-ordinance-amendment https://www.fairfaxcounty.gov/news/board-supervisors-approve-new-data-center-zoning-ordinance-amendment
[42] Prince William County Government. (2022, January 20). Frequently asked questions (FAQ) about data centers. https://www.pwcva.gov/assets/2022-01/Frequently%20Asked%20Questions.1.20.22.pdf https://www.pwcva.gov/assets/2022-01/Frequently Asked Questions.1.20.22.pdf

County	Permitting Overview	Workgroups / Task Forces
	Ongoing: Review of policy proposals for enhanced design and sustainability guidelines.[43]	
Frederick County	In September 2025, the County Council approved Bill 25-09, which creates a critical digital infrastructure (CDI) overlay zone.[44]	Data Centers Workgroup published a report with recommendations, including CDI zones and sustainability measures.
Prince George's County	No revisions yet.	Qualified Data Center Task Force established in 2025 to evaluate potential risks, community benefits, and revenue potential from data centers.

Implementation Activities and Milestones

This measure includes several actions that data centers can take to improve energy efficiency, use clean energy, and reduce emissions from onsite backup power. Many of these actions can be encouraged by localities through the permitting process or reporting or meeting efficiency standards and using clean energy. The key drivers of data center energy use are servers/IT equipment and cooling systems. The actions below are grouped into five categories: 1) IT Equipment Efficiency, 2) Building-level (cooling and power systems efficiency), 3) Energy Use and Procurement, 4) Data Tracking and Reporting, and 5) Engagement and Advocacy.

IT EQUIPMENT EFFICIENCY

- Encourage including efficient equipment in procurement processes, such as ENERGY STAR IT equipment.
  - ENERGY STAR servers use 30% less energy than regular servers on average when power management is enabled while typically providing better performance per watt, leading to fewer servers being needed.
  - ENERGY STAR certifications available: computer servers, storage, switches/routers and uninterruptible power supplies. Many of these products can also be found on the EPEAT registry which covers additional environmental and sustainability product criteria beyond energy use.

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[43] Prince William County Government. (n.d.). DPA2021-00020: Data Center Opportunity Zone Overlay District comprehensive review. Retrieved from https://www.pwcva.gov/department/planning-office/data-center-overlay-district-comprehensive-review/
[44] Frederick County Council. (2025). Bill No. 25-09: Critical Digital Infrastructure Overlay Zone. Retrieved from https://www.frederickcountymd.gov/DocumentCenter/View/357520/Bill-No-25-09

- Metrics used for these efforts are based in part on efficiency measurements using the Standard Performance Evaluation Corporation's (SPEC) Server Efficiency Rating Tool (SERT) for computer servers and the Storage Networking Industry Association's (SNIA) Emerald tool for storage products.
    - Sample procurement language can be found here.
- Encourage the adoption of higher utilization levels in IT hardware when possible.
- Encourage data center operators to continue leveraging free IT equipment return and/or recycling programs offered by major IT vendors (HPE, Dell, Oracle, IBM, Cisco, etc.).
- In addition, hyperscale data centers can use AI to optimize energy use by determining when to use certain AI models.[45]

Servers and IT equipment on average drive about 60-70% of data center power demand, with that share increasing in newer hyperscale and colocation data centers. Encouraging data centers to identify savings opportunities through IT equipment upgrades is a relatively straightforward method to help reduce energy demand.

Reducing the IT power requirements results in a multiplier effect through savings on infrastructure power: every unit of IT power saved reduces infrastructure power to energize and cool the IT equipment. Data center owners and operators can take advantage of not only higher efficiency IT equipment, but also data center management strategies such as utilization, consolidation, and computer server workload virtualization to prevent excessive IT energy consumption.

BUILDING-LEVEL (MECHANICAL AND ELECTRICAL)

- Encourage implementing best practices for cooling & air management, including:
    - Free air cooling through air economizers. Direct free air cooling uses outside air to directly cool equipment. This is very efficient but requires careful air quality and temperature management. Indirect free air cooling uses outside air to cool water or other fluids, which are fed into various forms of heat exchangers in the data center. This requires protecting equipment from outside environmental factors.
    - In-row, overhead, or rear door refrigerant-based heat exchangers, which are typically more energy efficient than traditional air cooling and can be implemented cost-effectively in traditional enterprise and colocation data center facilities.
    - Hot aisle/cold aisle arrangements should always be implemented when cooling with any air-based approach. Hot aisle and cold aisle containment separates the hot air released from servers from the cool air used to cool the data center.

Servers and computer chips generate heat, resulting in significant cooling needs for the building and equipment. Cooling systems often drive 30-40% of data center energy demand. At the building level, data center cooling systems can be either air-cooled or water-cooled. Evaporative cooling systems use water evaporation to cool air, and while very energy efficient, consume significant amounts of water. Considerations for cooling systems include cost and complexity to implement, load availability, space configurations, future energy needs, and energy efficiency.

[45] Li, et al. (2024). SPROUT: Green Generative AI with Carbon-Efficient LLM Interference. Retrieved from https://aclanthology.org/2024.emnlp-main.1215.pdf 5.pdf

- Encourage onsite energy efficiency improvements, including:
  - Raising the chilled water temperature.
  - Evaluating chillers for replacement.
  - Encourage monitoring systems for real-time management and efficiency (including Data Center Infrastructure Management (DCIM) software), reviewing operation and efficiency on a regular basis, and staff training.
- Implement best practices for power infrastructure and uninterruptible power supplies (UPS).
- Collaborate with liquid-cooled data centers during the site selection process to consider access to recycled wastewater. Using non-potable water for data center cooling processes or using closed-loop cooling systems will limit the impact on local drinking water supplies.[46]

ENERGY USE AND PROCUREMENT

- Encourage onsite solar.
  - Given the amount of renewables needed to meet a data centers' electricity demand, it is generally not feasible or cost-effective for data centers to deploy onsite solar to meet all of their electricity demand. Powering a 100 MW hyperscale data center would require nearly 1,500 acres of solar -- roughly 1,100 football fields -- and that power would need to be generated 24/7 (which solar alone cannot provide). However, onsite solar could be included as part of the permitting process to provide community benefits to help meet local goals for clean energy development.
- Encourage offsite clean energy procurement.
  - Hyperscale data centers require vast amounts of electricity, making it challenging to meet their full energy demand with onsite renewable generation alone. Offsite clean energy procurement—such as power purchase agreements (PPAs) or co-located renewable projects—offers a scalable approach to significantly reduce emissions while supporting regional clean energy development. Offsite procurement can be located locally, within the same grid region, or in other regions; however, using this report's activities-based GHG accounting approach, emissions are attributed to the electricity consumed by data centers. Locating clean energy within the same grid region, such as PJM, is critical to lowering regional emission factors. Offsite renewables within PJM can reduce grid-average emissions over time, while co-located generation can directly power data centers with clean electricity. Data centers often pursue renewable energy procurement across the country to support

Data centers in the PJM region are increasingly using offsite procurement and co-located clean energy projects to meet corporate sustainability goals. Federal Energy Regulatory Commission and PJM both have ongoing stakeholder discussions to address challenges to rapid clean energy deployment. Solutions being explored include reforming the interconnection process, modernizing transmission planning, and considering nuclear restarts or siting clean energy near high-demand areas. Local governments can monitor PJM stakeholder processes and support policies that accelerate clean energy deployment, helping meet rising data center demand while reducing regional emissions. For example, in 2024 Microsoft and Constellation Energy announced a 20-year PPA to restart the Three Mile Island nuclear plant in Pennsylvania, which—pending regulatory approvals and PJM interconnection agreements—could offset electricity use across Microsoft's PJM-region data centers and serve as a model for similar projects.

[46] What Is Closed-Loop Cooling, and When Should Data Centers Use It? https://www.datacenterknowledge.com/cooling/what-is-closed-loop-cooling-and-when-should-data-centers-use-it-

corporate sustainability goals, but using generation outside PJM may not reduce regional emissions (per activity-based accounting). Emphasizing PJM-located generation ensures tangible regional environmental benefits.
    - Localities can explore mechanisms to encourage data centers to source clean energy through their planning and permitting processes.
- Encourage options to reduce emissions from backup power and increase efficiency.
    - Replace diesel generators, the main source of direct air pollution from data centers, with natural gas generators, which have lower GHG intensity and offer other air quality benefits. As there is overlap between the locations of existing data centers and LIDACs, this would result in improved air quality in LIDACs.
        - With technology advancements, in the long term, large battery storage systems could provide cost-effective on-site backup power for data centers.
    - Deploying CHP systems can increase the energy efficiency and reliability of data centers by providing a reliable power supply and efficiently utilizing waste heat, either in combination with absorption chillers to provide additional cooling and/or to supplement district heating efforts. They can even be used as a primary energy generation source, turning a utility feed into a backup power option and removing the need for diesel generators and storage.
- CHP plants can also be paired with fuel cells to realize even greater efficiencies and can use hydrogen blends and/or pure hydrogen in place of natural gas if available. CHP and fuel cells can both play a primary role in microgrid deployments as they can produce constant power which can allow electric grid connections to become secondary or backup electricity options and potentially open grid demand response or load sharing opportunities.
- Collaborate with utilities to encourage participation in demand response programs.
    - Research suggests that targeted amounts of data center load flexibility, or the ability to scale back operations during times of grid stress, can help bring data centers online while minimizing the additional infrastructure costs and GHG emissions associated with increasing periods of stress on the grid[47]. Data center load flexibility could also be incentivized through the permitting process, with preference for permitting data centers that are capable of load flexibility.
    - Data centers could also host grid-scale batteries onsite to provide grid services. Options like on-site CHP plants mentioned above or future development of small modular nuclear reactors may allow for new forms of interactivity between data centers and the electric grid.
- Conduct feasibility studies for district energy.
    - District energy systems carry hot water, steam, and/or water through insulated pipes to provide energy for nearby buildings. High quality waste heat from data centers could potentially contribute to these systems as a base heating resource.
    - In the Northern Virginia region, most data centers use air-cooled HVAC units that produce relatively low-temperature waste heat. Successful integration into district energy systems is more feasible with liquid-cooled or water-cooled data center systems, while air-cooled

[47] Norris, T. H., T. Profeta, D. Patino-Echeverri, and A. Cowie-Haskell. 2025. Rethinking Load Growth: Assessing the Potential for Integration of Large Flexible Loads in US Power Systems. NI R 25-01. Durham, NC: Nicholas Institute for Energy, Environment & Sustainability, Duke University. https://nicholasinstitute.duke.edu/publications/rethinking-load-growth

systems may require booster stations or other modifications that could reduce energy efficiency.
  - Feasibility studies should assess the temperature and quality of available waste heat, explore co-location or complementary heat sources, and determine whether district energy integration is practical and beneficial for specific sites.

DATA TRACKING AND REPORTING

- Encourage data center operators to report water and energy consumption and benchmark their performance. Key metrics to do so are power usage effectiveness (PUE) and water usage effectiveness (WUE), in additional to total consumption of electricity (MWh) and water (gallons). Additional metrics may also be helpful for understanding the resource intensity and infrastructure needs for large loads.
  - Leverage Maryland and DC BEPS reporting requirements to track data center energy consumption and emissions. The Maryland BEPS covers buildings 35,000 square feet or more. DC has a phased approach starting with buildings over 50,000 square feet reporting data in 2021, then those over 25,000 square feet in 2028, and expanding to cover those over 10,000 square feet in 2034[48]. In Maryland, healthcare facilities, federal buildings, and critical infrastructure facilities may apply for exemption to the BEPS program.
- Encourage data centers to achieve ENERGY STAR certification and track certifications over time.
- Encourage existing data centers to conduct comprehensive energy assessments to identify key areas of energy use.
- Encourage data centers to report the amount of renewable energy directly tied into operations, either through on-site installations or off-site power purchase agreements within same service territory.

ENGAGEMENT AND ADVOCACY

- Examine and/or implement new policies in localities where applicable.
  - Develop or identify sample guidance and use-specific zoning and permitting standards/ordinances for new data centers and utility substations to address concerns related to land use, compatibility, noise, aesthetics, infrastructure, natural and environmental resources, and to encourage community benefits.
- Encourage reporting of PUE where able and set maximum PUE design targets for new data center builds and retrofit/operating targets for existing data centers.
  - Educate local government staff, providing background materials on data centers to support discussion related to planning and zoning changes.
- Coordinate between localities to advocate for changes at the state, regional, and federal level.

Power Usage Effectiveness (PUE): A metric used to evaluate the efficiency of energy usage that can be measured by *Total Facility Energy (kWh) / IT Equipment Energy (kWh)*

Water Usage Effectiveness (WUE): A metric used to evaluate the efficiency of water usage that can be measured by *Total Site Water Usage (liters) / IT Equipment Energy (kWh)*

The closer the PUE value is to 1.0, the more efficient the data center is in utilizing its power solely for IT equipment. WUE value of 0 indicates no water usage. Importantly, additional IT equipment energy use lowers PUE, so adding more IT capacity in a data center, all else equal, can lower PUE scores while increasing energy use.

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[48] Latest BEPS Standards and Compliance Rules - Building Innovation Hub

- Add select data center items to legislative agendas.
- At the state level, track Virginia's and Maryland's legislative agendas and coordinate regional advocacy to support select bills, especially around data reporting and tracking of energy and water use.
- At the state level, intervene as appropriate in utility proceedings related to ratepayer impacts from meeting data center energy demand.
- At the broader regional and federal level, identify opportunities to participate in PJM or FERC stakeholder discussions, particularly related to accurate forecasting of data center load and potential ratepayer impacts.
- Support local jurisdictions with data driven decision-making (e.g., including data center estimates in future community-wide GHG inventories).
- Continue exploring partnership opportunities with industry organizations for anonymized and aggregated data collection.

KEY IMPLEMENTING AGENCIES AND PARTNERS

REGULATING AGENCIES

- **FERC.** Regulates electricity and transmission of electricity in interstate commerce, the development of reliability standards and national energy infrastructure, including natural gas pipelines and more.
- **Virginia State Corporation Commission, Maryland Public Service Commission.** The regulatory bodies that acts as a State Public Utility Commission and regulate utility rates.
- **State Air Emission Regulators.** VA's Department of Environmental Quality (DEQ), Maryland's Department of the Environment (MDE), and DC's DOEE play key roles in issuing water permits, requiring certifications, or conducting environment impact assessments for data centers, as well as issuing air quality permits for fossil fuel-powered backup generators. In Maryland and DC, these agencies also implement the building energy performance standards.

IMPLEMENTING AGENCIES

- **Federal government agencies.** Several federal agencies play a role in developing best practices for and certifying data centers. EPA's ENERGY STAR program certifies data centers that meet high standards for energy efficiency and provides resources on efficient equipment. DOE works with national laboratories, including Lawrence Berkeley National Laboratory and the National Renewable Energy Laboratory, to conduct research on data center energy use and identify solutions and best practices.
- **PJM, the regional transmission organization.** PJM develops load forecasts for the region and is actively working to adapt to expected data center growth by accelerating interconnection processes, planning for new transmission infrastructure, and addressing the unique challenges posed by co-located data center generation.
- **Local government and regional agencies.** Localities, COG, and the NVRC play an important role in facilitating regional coordination, leading community engagement and outreach, and compiling GHG inventory data. Local planning and zoning departments play a key role in managing and regulating data center development, including updating policies and standards for data center uses.
- **Data center developers, owners, and operators.** Data center owners and operators make key facility development, operation, and maintenance decisions, and are responsible for ensuring facility reliability and security. This group ultimately decides how their data centers are designed,

if they include any of the above efficiency improvements, and what data is collected and/or reported.

- **Electric, water, and gas utilities.** Utilities are responsible for supplying the energy and water data centers use for their operations.
- **Energy developers.** Energy developers will build the assets to provide utilities and data centers with needed energy.
- **Other partners.** Certification programs (e.g., LEED), industry groups (e.g., Data Center Coalition), and others will be key partners to enable the implementation of the measure.

AUTHORITY TO IMPLEMENT

Data center owners, operators, and developers have autonomy over their internal operations, procurement choices, and energy management practices in line with existing regulations, policies and voluntary commitments. The strategies outlined in this measure are voluntary options and rely on collaboration with these private entities.

At the jurisdictional level, the District of Columbia and Maryland have established statutory authority to implement building-level data tracking and reporting requirements. Under their respective Building Energy Performance Standards (BEPS) programs, certain data centers will be required to report energy use and emissions beginning in 2025, with Maryland allowing potential exemptions for emergency backup generation. These requirements apply only within those jurisdictions and reflect authority expressly granted under their state or district laws.

Current Virginia law does not authorize local governments to establish BEPS programs or comparable mandatory energy reporting or tracking requirements unless the Commonwealth first adopts a statewide policy enabling them to do so. As a result, Virginia localities cannot require energy benchmarking, reporting, or related standards for data centers at this time. However, Virginia localities may choose to encourage enhanced energy efficiency, transparency, and data tracking through voluntary, non-regulatory mechanisms. These may include offering incentives such as expedited permitting, recognition programs, or other facilitative measures for data centers whose proposed designs or operational commitments align with preferred sustainability practices. Localities may also be able to collect certain energy- or design-related information through existing development review or permitting processes, as allowable under current law.

Overall, implementation of the actions in this strategy depends on the voluntary participation of data center owners and operators and, where applicable, the existing legal authority of District, Maryland, and Virginia jurisdictions. This measure is intended to serve as a resource that localities can adapt to their needs and legal context, rather than as a set of enforceable requirements.

GEOGRAPHIC COVERAGE

This measure applies to the full MSA, particularly counties where data centers are or will be present.

FUNDING SOURCES

Example potential funding sources include:

- DOE Grid Resilience and Innovation Partnerships (GRIP) Program grants
- DOE Accelerating Speed to Power Funding

- Cooling Operations Optimized for Leaps in Energy, Reliability, and Carbon Hyperefficiency for Information Processing Systems (COOLERCHIPS) Funding
- The Maryland Energy Administration offers grant programs to data centers located in or being constructed in the state with a minimum data floor facility size of 2,000 square feet to support projects that reduce electrical usage and improve PUE.

LIDAC BENEFITS

This measure identifies strategies for data centers to reduce electricity consumption at both the IT equipment and building levels, and use clean energy, which can help mitigate environmental and social impacts to LIDACs. Large energy loads like data centers can increase regional electricity demand, which may indirectly influence residential rates through higher wholesale energy or capacity market prices or through grid upgrades needed to maintain reliability.[49] Reducing electricity consumption can help limit these potential indirect impacts and mitigate increased energy burden for LIDAC households. Lower energy use or localized clean energy also reduces emissions from fossil fuel power generation, improving local air quality and health outcomes—particularly respiratory conditions such as asthma—in communities near power plants.

Onsite diesel backup generators can be a significant source of local air pollution, which disproportionately affects nearby LIDACs. Encouraging a transition to cleaner alternatives, such as battery storage or natural gas generators (particularly Tier 4 generators), can reduce pollutant emissions and improve health outcomes. Additional potential impacts include noise from generators, changes in local traffic or land use, and ensuring that economic benefits from data center development reach LIDAC residents through workforce or community programs.

SAMPLE METRICS FOR TRACKING PROGRESS

The following metrics can only be reported if information is able to be collected from data centers:

- PUE
- WUE
- % of year using free air cooling when applicable
- % of electricity offset by clean energy procurements
- Capacity (kW) of onsite solar hosted by data centers

COG and localities can collaborate to collect the following metrics:

- Energy use from data centers covered by BEPS (only applies to MD/DC)
- Number of data centers achieving various energy efficiency certifications (e.g., ENERGY STAR)
- Data center electricity GHG emission estimates to incorporate into local and regional greenhouse gas inventories, inclusive of any registered carbon offsets.

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[49] New data center development can indirectly influence electricity costs for residential ratepayers. Large loads may increase regional demand, potentially raising wholesale energy and capacity market prices. In organized electricity markets, additional generation may be needed to ensure reliability, and associated costs—along with necessary transmission or distribution upgrades—can be allocated across all ratepayers. The magnitude of these effects depends on market structure, cost allocation rules, utility contracts with large customers, and whether new generation is fossil-fuel or renewable-based.

4.3.2. Transportation

The transportation sector contributed 39% of gross GHG emissions in the MSA in 2020, of which 82% is from on-road transportation and the remaining 18% is from off-road transportation (including construction vehicles, rail, and passenger air travel). The COG region is expected to add about 1.4 million people (a 25% increase) and 900,000 jobs by 2050. At the same time there is expected to be a 12.3% increase in VMT by residents in the region.[50] Population growth and increased VMT are even greater for the whole of the MSA, and vehicle trips are expected to continue to be the predominate mode of transportation in a BAU scenario. As such, it is key to expanding access to transit options beyond single occupancy vehicles to increase the mode share for public and active transportation.

As the federally mandated MPO for the National Capital Region, the TPB is responsible for producing the region's Metropolitan Transportation Plan and Transportation Improvement Program. In June 2022, the TPB adopted a Resolution on the Adoption of On-Road Transportation Greenhouse Gas Reduction Goals and Strategies (TPB Resolution R18-2022). As part of that resolution, the TPB adopted a set of priority strategies to reduce GHG emissions from on-road transportation including:

- Improve walk/bike access to all high-capacity transit stations.
- Increase walk/bike modes of travel, e.g., complete the National Capital Trail Network by 2030.
- Add additional housing near high-capacity transit stations and in COG's Regional Activity Centers.
- Reduce travel times on all public transportation bus services.
- Implement transportation system management and operations improvement measures at all eligible locations by 2030.
- Convert private and public sector light-, medium-, and heavy-duty vehicles, and public transit buses to clean fuels by 2030.
- Deploy a robust region-wide EV charging network (or refueling stations for alternative fuels) for light, medium, and heavy-duty vehicles.

The resolution also included a set of strategies to be explored in coordination with local and state levels:

- Take action to shift growth in jobs and housing from locations currently forecast to locations near high-capacity transit stations and in COG's Regional Activity Centers to improve the jobs-housing balance locally.
- Make all public bus transportation in the region fare-free by 2030.
- Make all public rail transportation in the region fare-free by 2030.
- Price workplace parking for employees – only in Activity Centers by 2030 and everywhere by 2050.
- Convert a higher proportion of daily work trips to telework by 2030 and beyond.
- Charge a new fee per VMT by motorized, private, passenger vehicles in addition to the prevailing transportation fees and fuel taxes.

[50] TPB. Visualize 2045. 2022. https://visualize2045.org/wp-content/uploads/2022/09/Viz2045Final-Report-6-15-22_hyperlinked_.pdf

- Charge a “cordon fee” (i.e., commuter tax) per motorized vehicle trip for all vehicles entering Activity Centers by 2030.

TPB’s action to adopt GHG goals and strategies specific to the on-road transportation sector were informed by the TPB’s Climate Change Mitigation Study of 2021 (CCMS) and a questionnaire of TPB members that was conducted in February and March 2022. The strategies that were studied in the CCMS and later considered by the TPB for adoption are not an exhaustive list of all possible GHG reduction strategies for the on-road transportation sector. As noted previously, documents such as the Metropolitan Washington 2030 Climate and Energy Action Plan and climate action and energy plans from local governments were consulted to identify planned and ongoing actions to reduce GHG emissions. Additionally, strategies that were designated “for further study” by the TPB were designated as such because they were not supported by a majority of members at that time; however, that would not preclude a jurisdiction with implementation authority from implementing one or more of those strategies. A study on those strategies is expected to be completed in June 2024.[51]

The GHG reduction measures included below for the transportation sector reflect these already established goals and strategies and completed and ongoing studies to support them.

PROVIDE AND PROMOTE NEW AND EXPANDED OPPORTUNITIES TO REDUCE VMT THROUGH PUBLIC TRANSPORTATION, NON-MOTORIZED TRAVEL, MICROMOBILITY, SHARED TRAVEL OPTIONS, AND DEVELOPMENT.

This measure aims to reduce VMT by offering robust, reliable, and safe travel options. It will provide and promote new and expanded opportunities to reduce VMT through public transportation, non-motorized travel, micromobility, shared travel options, and transit-oriented development. These options include active transportation methods (e.g., bicycling, walking), public transportation (e.g., trains, buses), shared transportation (e.g., carpools, vanpools), and micromobility (e.g., shared bicycles and scooters). Other opportunities for teleworking and telehealth will also reduce VMT. Land use and transit-oriented development changes, such as infill housing, also are a part of this measure to help reduce the length of trips and create more opportunities for alternatives to driving.

Public transportation not only reduces GHG emissions but also improves air quality and makes communities more livable, sustainable, and economically competitive. By attracting businesses, residents, and visitors, well-developed transit systems spur economic growth and development. Public transportation also increases the connectedness of communities, increasing quality of life and economic opportunity by increasing property values and access to jobs, public facilities, and resources.

QUANTIFIED GHG REDUCTIONS AND RELEVANT GHG INVENTORY SECTOR

This measure will reduce GHG emissions in the transportation sector. Emissions from the land use sector may also be impacted because of changes in development. Cumulative estimated GHG emissions reduction potential for this measure are:

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[51] https://www.mwcog.org/documents/2024/10/18/implementation-considerations-for-on-road-greenhouse-gas-emissions-reduction-strategies/

GHG reductions ($MMTCO_2e$), 2025-2030	GHG reductions ($MMTCO_2e$), 2025-2050
0.94	2.65

Key assumptions, methods and data sources used to develop these quantified reduction estimates are provided in Appendix A.

KEY IMPLEMENTING AGENCIES AND PARTNERS

- **Local governments and municipalities.** Responsible for land use planning and comprehensive planning; transportation planning, development, and operations, including local transit; program development and administration (e.g., travel demand management programs), and local policies. Will support infrastructure investment and implementation, including pedestrian and cyclist infrastructure.
- **State Departments of Transportation.** Will be key partners in transportation infrastructure planning, development, and operations, such as rail and changes to roads to prioritize bus transportation along state routes, as well as policies related to toll roads and interstate corridor charging and fueling infrastructure.
- **Regional planning organizations and commissions.** Plan for, evaluate, and in some cases fund transportation infrastructure investments and programs. This includes COG, TPB, Northern Virginia Transportation Authority (NVTA), National Capital Planning Commission (NCPC), and other regional planning agencies across the MSA.
- **Regional and local transit agencies.** Transit agencies like WMATA, Maryland Transit Administration (MTA), and Northern Virginia Transportation Commission (NVTC) will be critical to implementing programs and policies.
- **Transit advocates and NGOs.** NGOs and advocates can play a supporting role in education and outreach related to this measure and can also help connect and engage with grassroots organizations and LIDACs.
- **Private sector partners.** Private sector partners, such as landowners, developers, and businesses play a key role in development decisions and design that affect the viability of using alternatives to driving. Business can also implement telecommute and other policies that help manage travel demand. Public-private partnerships can lead to greater funding and heightened expertise for these projects.

IMPLEMENTATION ACTIVITIES AND MILESTONES

Actions to implement this measure could include, but are not limited to:

- Implement infrastructure improvements to support non-motorized travel (e.g., roadway designs that make walking and biking safer, adding bicycle and pedestrian pathways, adding, and expanding sidewalks, improving crosswalks, completion of the National Capital Trail Network and other paved and unpaved trails for bicycle use). *
- Enhance micromobility options, including expanding shared bike, e-bike, and scooters. *
- Improve first-mile last-mile connections to transit (e.g., shuttles, bicycle storage, bicycle and pedestrian connections to transit, on-demand transit). *
- Provide improvements and enhancements in public transit service (e.g., operational and service enhancements, bus and rail maintenance and investments to improve reliability and quality of service, low-income/free fare products, and bus rapid transit). *

- Support land use policies that encourage development near high-capacity transit stations and within activity centers, including design that supports walking, biking, and transit. *
- Provide transit capital investments to enhance and expand public transit service (e.g., expansion of bus, rail, and bus rapid transit infrastructure; bus stop improvements such as benches and bus shelters, mobility hubs that bring together transit, bike sharing, transit station improvements for operational efficiency, and other options). *
- Implement or expand policies that promote car/ride sharing and reduce vehicle travel, such as through reduced parking minimums, parking pricing, and congestion pricing, as well as HOV-3 free and other policies to encourage ride sharing.
- Implement incentives that encourage use of sustainable modes, such as incentives for purchasing e-bikes, or incentives for ridesharing and using transit, reduced or fare-free transit.
- Implement policies and incentives to manage travel demand, such as those that promote or require telework policies, employer-based trip reduction, ride matching, and vanpool formation.

Note: Strategies with an * generally fall within the GHG reduction strategies that were adopted by the TPB in June 2022 and are included in the quantified GHG reductions.

AUTHORITY TO IMPLEMENT

The actions associated with making changes to increase pedestrian and bicycle infrastructure can be administered by local and state jurisdictions. Policies that impact land use can similarly be administered by local jurisdictions though zoning codes and potential changes and developers can act on where to build based on these policies. Actions related to public transportation may need approvals from regional or state transportation agencies to be implemented and will need higher levels of authority depending on the scope and scale of changes to public infrastructure. Additional agencies and approvals will be needed for any actions related to charges such as congestion pricing and VMT pricing. Employers also play a key role in providing company policies to allow teleworking. Of note, for this region there is a relatively high number of federal workers, so changes in employee telework policies will be tied in part to federal agency employee policies.

GEOGRAPHIC COVERAGE

This measure will reduce GHG emissions across the entire MSA.

FUNDING SOURCES

Example potential funding sources include:

- Federal Transit Administration (FTA) Grants – Urbanized Area Formula Program
- FTA – Bus and Bus Facility Grants
- FTA – Capital Investment Grants
- Federal Highway Administration (FHWA) Carbon Reduction Program
- FHWA Congestion Mitigation and Air Quality Improvement (CMAQ) Program
- FHWA Highway Safety Improvement Program (HSIP)
- FHWA Surface Transportation Block Grant (STBG) Program
- Virginia Department of Rail and Public Transportation
- Virginia Commuter Assistance Program
- Virginia Ridership Incentive Program
- MD Community Development Block Grant Program

- MD Bikeways Grant Program
- MD Recreational Trails Program
- DC Transportation Alternatives Program

LIDAC BENEFITS

The actions in this measure aim to improve public transit service through enhanced and increased service along with prioritizing designated service types within LIDACs. Improving public transit service in the urban core and along commuter routes could encourage increased transit use because of reduced commute times from home to workplace and last mile service. Priorities include the enhancement of bus and rail service which could better serve LIDACs using Virginia Railway Express (VRE) and MARC regional rail service in addition to commuter bus and local WMATA bus and rail service in addition to other regional transit service such as Montgomery County's RideOn bus service. Expanding and improving bus transportation will benefit LIDACs as many transit-dependent and low-income transit riders use bus systems.[52]

LIDAC members located in the urban core or near congested highways across the MSA experience significant traffic, noise, pollution, and safety related effects. Suburban and rural areas face another set of barriers that increase pollution due to increased commute times and congestion, resulting in increased transportation GHG emissions. Increasing the use of public transportation and accessible and safe transportation options such as walking and biking can positively impact LIDACs by reducing transportation costs and improving health through active transportation alternatives.

This measure also includes transit-oriented development (TOD) considerations. However, TOD development historically leads to gentrification when supportive policies are not implemented to protect underserved homeowners and renters. This measure will require partnership among municipalities, transit agencies, and the development community to truly benefit LIDACs.

SAMPLE METRICS FOR TRACKING PROGRESS

- VMT and VMT per capita
- Mode share for public and active transportation (e.g., percent of workers commuting by single occupant vehicle, rideshare, transit, bike, walk, telework)
- Transit ridership for bus and rail transit
- Active transportation and micro mobility uptake
- Percent of businesses that adopt hybrid or fully remote work policies
- Mode share for public and active transportation of all trips

ACCELERATE THE DEPLOYMENT OF LOW- AND ZERO- EMISSION TRANSPORTATION, FUELS, AND VEHICLES.

This measure aims to accelerate the deployment of low-emission and zero-emission transportation, fuels, and vehicles across all on-road sectors including light-, medium-, and heavy-duty vehicles. This includes both personal vehicles and private and public fleets, including school and municipal bus

[52] Shuling Wu & Jennifer D. Roberts (2023) Transit justice: community perceptions and anticipations of a new light rail transit line in Prince George's County, Maryland, United States, Cities & Health, 7:6, 1012-1028, DOI: 10.1080/23748834.2022.2133573

fleets, and supports the deployment of charging and fueling infrastructure. To support the deployment of EVs, a robust network of EV charging must be widely available, reliable, and easy to use for residents and businesses, especially in communities and multifamily settings. Beyond EVs, this measure also allows for flexibility in the use of green hydrogen, biodiesel, and other renewable or low-carbon fuels where options are not available or feasible, particularly for medium- and heavy-duty vehicles and buses.

QUANTIFIED GHG REDUCTIONS AND RELEVANT GHG INVENTORY SECTORS

This measure reduces GHG emissions from the transportation sector. The increase in EV adoption may also impact GHG emissions in the buildings sector depending on how chargers are tied to the built environment. Cumulative estimated GHG emissions reduction potential for this measure are:

GHG reductions ($MMTCO_2e$), 2025-2030	GHG reductions ($MMTCO_2e$), 2025-2050
10.70	**203.37**

Key assumptions, methods and data sources used to develop these quantified reduction estimates are provided in Appendix A.

KEY IMPLEMENTING AGENCIES AND PARTNERS

- **COG** can support the aggregation of demand via the COG Cooperative Purchasing Program and local EV buying co-ops. This effort can also be supported by **Clean Cities Coalitions and Washington Area New Dealers Association (WANADA). TPB** can coordinate efforts in the region and has set priority actions that are reflected in this measure.
- **Local and regional transit agencies.** Transit agencies are also key implementors in the transition of public transit fleets and clean fuel and EVs. They also coordinate on implementing charging/fueling infrastructure.
- **State and local governments (including public schools).** State and local agencies can transition municipal fleets to EVs, or low-carbon fuel vehicles supported by the adoption of green fleet policies and plans and provide incentives or policies to support EV adoption. State agencies, with federal funding, are building out EV charging networks. Local governments can also implement community-wide buying co-ops for EVs for public and private fleets as well as personal vehicles and provide education to residents and businesses about EVs and EV charging. Governments can also install charging equipment on municipal properties, including through partnerships with utilities and the private sector.
- **Utilities.** Provide incentives for transitioning to clean fuel vehicles and installing EV charging (e.g., both Pepco and Dominion Energy offer support for rideshare and electric bus charging infrastructure in the region). Public Utility Commissions (PUC)/ Public Service Commissions (PSC) will coordinate on the relevant regulations for implementation. Water utilities can transition their fleets to low-emission vehicles.
- **Private sector actors.** For-hire vehicle operators such as Uber and Lyft or ridesharing companies such as Zipcar, can procure and offer alternative fuel vehicles and provide EV charging infrastructure. Other private sector actors, such as developers, can include EV charging and EV-ready parking in the construction projects to expand the charging network.
- **Vehicle manufacturers.** Auto manufacturers can add new low emissions vehicles to their product offerings.

- **Grocery stores, shopping plazas, and gas/charging and fueling stations.** These entities can work with state and local governments to bring publicly accessible charging and biofuel or hydrogen fueling stations to the region.

IMPLEMENTATION ACTIVITIES AND MILESTONES

Actions to implement this measure could include, but are not limited to:

- Implement systems to manage and use data on vehicle registrations and charging infrastructure (e.g., uptime) and fueling stations.
- Support cooperative purchasing and community buyer co-ops, as well as ride share and car share that accelerate the use of low- or zero-emissions vehicles.
- Pass and implement ordinances that mandate or incentivize clean fuel infrastructure into development.
- Create and implement clean vehicle and clean fuel procurement policies.
- Plan for, develop, and procure EV charging networks, such as Alternative Fuel Highway Corridors. Also, develop biofuels infrastructure and markets.
- Develop incentive programs for EV chargers in multifamily, public and commercial, and rental properties.
- Create incentives and programs for EV and low-emissions vehicles. Incentives can include direct financial incentives or exemptions to certain restrictions (such as DC's driving restriction exemption, HOV lane exemptions in Maryland and Virginia, or emissions testing exemption in Virginia).
- Develop corridor specific and local hydrogen fueling stations, including focused on serving medium and heavy-duty vehicles. Work with fleet owners and truck dealers to accelerate the adoption of hydrogen vehicles.
- Provide funding to support the conversion of private and public sector light-, medium-, and heavy-duty vehicles, and public transit buses to clean fuels, and for the necessary supportive infrastructure.
- Provide workforce training (e.g., through the Electric Vehicle Infrastructure Training Program) and upskilling of current trades for installation and maintenance of EV charging and fueling infrastructure.
- Conduct regular analysis of the state of clean fuel infrastructure to address any gaps in charging/refueling needs that may hamper the rate of transition.
- Explore innovations in charging such as vehicle-to-grid regenerative power and solar tie-in to EV infrastructure.
- Consider providing funding to improve the development of battery-operated equipment.
- Consider proper disposal/end of battery life management systems.
- Provide funding to support the conversion of private and public sector light-, medium-, and heavy-duty vehicles, and public transit buses to clean fuels and for the necessary supportive infrastructure.
- Support grid connection upgrades and infrastructure improvements that support affordable, adequate, reliable, and resilient power supply for private and public sector light medium, heavy-duty vehicles, and public transit buses utilizing clean fuels.

All these implementation activities and milestones support the TPB's adopted priority strategies (June 2022) to convert private and public sector, light-, medium-, and heavy-duty vehicles, and public transit buses to clean fuels and to deploy a region-wide robust EV charging network (or refueling stations for alternative fuels) for light-, medium-, and heavy-duty vehicles.[53] COG is already taking action to support these priorities. In the summer of 2023, a new Electric Vehicle Deployment Clearinghouse was unveiled.[54] A REVD Working Group was also established and is developing a Regional Electric Vehicle Infrastructure Implementation Strategy.[55]

AUTHORITY TO IMPLEMENT

Local jurisdictions have the authority to purchase vehicles for their fleets; such purchases have already been started across the MSA. In some instances, purchasing or procurement policies may need to be adjusted to prioritize low and no emissions vehicles. Private and personal purchasing of low and no emissions vehicles does not have any statutory limitations. Local zoning or code changes may need to be made for charging and fueling infrastructure, and authority to implement varies across the MSA. States are also using transportation funds to support the planning for and development of EV charging infrastructure. Municipalities and residents may need to coordinate with PUCs and PSCs on regulations regarding the siting of public charging infrastructure, charging resale statues, and other issues as appropriate.

GEOGRAPHIC COVERAGE

This measure will reduce GHG emissions across the entire MSA.

FUNDING SOURCES

Example potential funding sources include:

- IRA – Alternative Fuel Vehicle Refueling Property Tax Credit
- FHWA National Electric Vehicle Infrastructure Formula Program (NEVI)
- FHWA Charging and Fueling Infrastructure Discretionary Grants
- EPA Clean School Bus Program
- EPA Diesel Emissions Reduction Program (DERA)
- EPA Clean Heavy-Duty Vehicle Program
- FTA Low or No Emission Grant Program
- Maryland EV Excise Tax Credit Program
- Utility incentive programs, such as EmPOWER Maryland
- MD Electric Vehicle Supply Equipment Rebate Program
- Montgomery County EV Purchasing Co-op Dealership Incentives

LIDAC BENEFITS

This measure includes considerations for incentivizing the sale of EV and low emission vehicles and creating EV infrastructure such as charging stations. Possible direct benefits to LIDACs include reduction in $PM_{2.5}$ and ozone and related health impacts such as asthma. The inclusion of incentives for EV infrastructure at multi-family, public, commercial, and rental properties will expand the presence of EV vehicle use beyond suburban or more wealthy urban neighborhoods. These

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[53] June 2022 TPB meeting recap: Plan update, new climate goals approved - TPB News - News | Metropolitan Washington Council of Governments (mwcog.org)
[54] COG unveils Electric Vehicle Deployment Clearinghouse - News Highlight - News | Metropolitan Washington Council of Governments (mwcog.org)
[55] Regional Electric Vehicle Deployment Working Group | Metropolitan Washington Council of Governments (mwcog.org)

measures would benefit LIDACs throughout the MSA region by reducing overall transportation costs. EV network design and thoughtful consideration of charging station placement are key to ensuring that communities are not left out of the EV network.

Members of LIDACs have historically benefited little from EV programs due to the high capital costs to purchase them. However, programs and incentives that expand the use of EV ride sharing or car sharing can bring benefits to LIDACs. Cooperative purchases for heavy-duty and school bus fleet conversions would also reduce local GHG emissions in LIDACs. Indirect benefits to LIDACs include workforce development and training, but existing jobs for internal combustion engine maintenance may start to dissipate.

SAMPLE METRICS FOR TRACKING PROGRESS

- Number of EVs, and low-carbon fuel vehicles registered (or purchased for local government or public fleets)
- Number of publicly accessible charging stations installed by type (e.g., Level 2 or DC Fast Chargers)
- Uptime hours for public charging stations
- Number of alternative fuel stations
- Quantity of biofuels consumed annually
- Number of maintenance/repair workers trained

ACCELERATE THE DEPLOYMENT OF OFF-ROAD/NON-ROAD ELECTRIC EQUIPMENT.

This measure focuses on accelerating the widespread adoption of electric and/or battery operated off-road/non-road electric and other low-emission equipment through education and awareness campaigns and by implementing a comprehensive framework of incentives and assistance programs to make purchase of new equipment or retrofit of existing equipment more accessible and appealing. This equipment includes lawn and landscaping equipment, construction equipment, recreational vehicles like all-terrain vehicles (ATVs), marine vessels, locomotives, and more. It also includes transitioning government owned and operated equipment to electric.

QUANTIFIED GHG REDUCTIONS AND RELEVANT GHG INVENTORY SECTOR

This measure reduces GHG emissions from the transportation sector. Cumulative estimated GHG emissions reduction potential for this measure are:

GHG reductions ($MMTCO_2e$), 2025-2030	GHG reductions ($MMTCO_2e$), 2025-2050
0.21	1.65

Key assumptions, methods and data sources used to develop these quantified reduction estimates are provided in Appendix A.

KEY IMPLEMENTING AGENCY(IES) AND PARTNERS

- **State and local government agencies.** Local governments can create financial incentives for residents to purchase electric lawn care equipment and for construction companies to purchase electric or retrofit existing construction equipment. They can also work with the private sector to educate consumers. Government agencies can put in place procurement policies for, or contract for, electric-powered off-road equipment and partner with the private sector on upstream programs.

- **Private sector (including retailers, landscaping companies, etc.).** Share information on equipment, join roadshows to demonstrate and give consumers access to equipment and information about retrofit programs. Also procure and use electric or battery-operated equipment.
- **Businesses and residents.** Buy and use electric and other low emission equipment.
- **Local and regional transit agencies.** Key implementors in transitioning equipment to electric.

IMPLEMENTATION ACTIVITIES AND MILESTONES

Actions to implement this measure could include, but are not limited to:

- Provide education and outreach campaigns to introduce new products or technologies to consumers and users (e.g., conduct a “roadshow”).
- Expand or create new incentives and technical assistance programs to promote and spread the use of electric equipment.
- Fund the improvement of battery-operated equipment, e.g., increasing the lifespan of battery powered equipment can enable commercial and public entities to adopt battery powered equipment.

There are already examples of available incentives for this measure that could be expanded upon. For example, the City of Bowie, Maryland has implemented a rebate for electric lawn care equipment for residents. Furthermore, the DC SEU has implemented a rebate for electric lawn mowers. Because this technology is readily available and programs already exist, this measure could be implemented in the near term.

AUTHORITY TO IMPLEMENT

Because these actions are typically incentive based rather than regulatory, the authority of state and local agencies to mount voluntary programs is typically within their charters. Actions such as regulating air pollution emissions from off-road equipment for the purposes of complying with ambient air quality standards under state implementation plans or similar regulatory actions are not anticipated in this measure.

GEOGRAPHIC COVERAGE

The actions within this measure are focused on the entire MSA.

FUNDING SOURCES

Example potential funding sources include:

- U.S. EPA Clean Diesel Grant Program/Diesel Emissions Reduction Act
- USDA Rural Energy for America Program Renewable Energy Systems & Energy Efficiency Improvement Loans & Grants

LIDAC BENEFITS

In the short term, benefits may be isolated to business owners and program participants who can afford the upfront costs of transitioning to electric and/or battery-operated equipment. However, as programs gain traction and awareness spreads, LIDACs may become more engaged in the process.

Benefits for LIDACs may include reduced operational expenses in the long term for business owners and localized health benefits resulting from reduced GHG emissions and toxins and reduced noise pollution.

SAMPLE METRICS FOR TRACKING PROGRESS

- Dollars of incentives used
- Number of pieces of electric equipment or electric off-road vehicles procured by local government or the private sector
- Number of engines repowered or replaced
- Annual quantity of diesel fuel reduced

4.3.3. Waste

REDUCE GHG EMISSIONS FROM WASTE AND WASTEWATER TREATMENT.

The waste sector, which includes waste landfills, waste incineration, and wastewater treatment facilities, generates high potency GHG emissions. To address emissions from the waste sector within the metropolitan Washington region, this measure aims to prevent, reduce, and divert waste and to reduce emissions at landfills, solid waste incinerators, drinking water treatment plants, drinking water distribution facilities, and wastewater treatment plants. It also includes harnessing landfill gas (LFG) to generate electricity and heat. This measure covers both inorganic and organic waste.

QUANTIFIED GHG REDUCTIONS AND RELEVANT GHG INVENTORY SECTOR(S)

This measure reduces GHG emissions from the waste sector. GHG emissions from buildings and transportation may also decrease if LFG can be collected and used to generate electricity and heat. Cumulative estimated GHG emissions reduction potential for this measure are:

GHG reductions ($MMTCO_2e$), 2025-2030	GHG reductions ($MMTCO_2e$), 2025-2050
0.07	17.42

Additional indirect GHG emissions reductions may be realized, including reduced energy consumption to process and transport waste and reduced maintenance and operations activities and inputs (e.g., chemicals). Key assumptions, methods and data sources used to develop these quantified reduction estimates are provided in Appendix A.

KEY IMPLEMENTING AGENCY(IES) AND PARTNERS

- **Local government departments of public works, resource recovery, and/or water.** Oversees landfills, solid waste management and recycling, wastewater treatment operations and facilities.
- **VA Department of Professional and Occupational Regulation (DPOR).** Oversees the Board for Waterworks and Wastewater Works Operators and On-site Sewage System Professionals, which licenses wastewater treatment facilities.
- **MD Department of the Environment.** Handles solid waste management and recycling in the state. MDE also oversees the Board of Waterworks and Waste System Operators, which sets standards for wastewater treatment plant operators.
- **Washington Suburban Sanitary District (WSSC Water).** Provides water and wastewater treatment services for Prince George’s and Montgomery County in Maryland.

- **WV Solid Waste Management Board (WVSWMB).** State agency charged with helping local Solid Waste Authorities achieve their recycling goals through technical assistance and grants.
- **WV Department of Environmental Protection.** Oversees the Division of Water and Waste Management, which permits wastewater treatment facilities.
- **Additional state government agencies.** The Virginia Department of Environmental Quality, DC Water, and other agencies, where appropriate, will provide guidance and resources for implementation of this measure.
- **Local governments.** General oversight and policy implementation.
- **Private sector.** Including Solid Waste Authorities and privately-owned sanitation centers and wastewater treatment plants, and waste-related businesses support local and state governments in waste and wastewater treatment collection and management.

IMPLEMENTATION ACTIVITIES AND MILESTONES

Proposed actions within this measure focus on increased access to composting, waste diversion practices, waste-to-energy facilities (such as water pollution treatment plants for biowaste), methane capture technology, and food waste reduction programs. These actions and programs will reduce waste sector emissions and provide multiple benefits to communities, including reduced air pollution and improved waste management in LIDACs. Actions to implement this measure could include, but are not limited to:

- Expand and offer new programs to implement waste prevention, recovery and recycling for food waste and other organics. This will include promoting the source reduction of food scraps, edible food recovery and increased recycling of food scraps, along with other organics, through composting, anaerobic digestion, and animal feed operations.
- Expand existing programs or establish new ones to enable using organic waste for compost, including yard trimmings and food waste, for curbside pickup. Collected organic waste will then be brought to a composting site, such as the Prince George's County's Organic Composting Facility in Maryland or Prince William County Balls Ford Road Composting Facility in Virginia, instead of being sent to landfills or waste-to-energy facilities such as the Covanta Fairfax incinerator. Prince William Landfill is being developed into an Eco-park to capture methane and conduct anaerobic digestion of organic waste. Compost can then be used to produce soil additives for growing foods and plants. Compost can be collected curbside in City or County-provided composting bins, as proposed below.
- Provide residential compost bins. Provide free compost bins to residents, like how many Cities and Counties provide residents with recycling bins. Residents can pick up a compost bin at a city or County sanitation center. They can use the bins at home to participate in a city or County-run curbside composting program, as described above, or to start their own at-home composting operation.
- Encourage commercial composting. Establish an educational program to encourage businesses, including restaurants, universities, multi-resident buildings, and other entities to compost organic and food waste. Training and educational materials could highlight incentives such as GHG emissions reductions and cost-savings on waste hauling costs. Cities and Counties could provide training materials for businesses and potentially subsidize the cost of on-site composting vessels. Pairing this with additional investment in industrial composting facilities and an expanded compost collection program would further incentivize commercial composting.

  - Provide commercial composting facilities with necessary. For example, de-packaging equipment to handle expired processed foods and Receiving Buildings with bio-filters to reduce volatile organic compounds.
- Invest in industrial composting facilities. Invest in organic and food composting operations at existing and new solid waste facilities, including composting, mulching, and landfill facilities. Current composting facilities in the metropolitan Washington region include the Prince George's County's Organic Composting Facility in Maryland and the Prince William County Eco-Park in Virginia. Enhancing composting operations across the region would build capacity for a residential curbside composting program, as well as composting from commercial stakeholders with larger quantities of organic waste.
  - Support new infrastructure and transportation options for moving compost and organic waste to treatment or processing facilities.
  - Support recycling activities including feeding animals and anaerobic digestion with beneficial use of digestate/biosolids.
  - Obtain and use new cold storage systems to reduce food waste.
  - Conduct waste education and public service campaigns. Educate the public to promote behavioral changes that encourage waste diversion at the source. Establish a public service campaign and disperse educational materials that encourage households to reuse and buy in bulk. Include education that focuses specifically on limiting single-use materials and food waste. Additionally, educate businesses on how they can reduce waste in their operations or implement composting systems, as described in the above action.
- Improve practices and technologies to increase waste reduction, reuse/recovery, and recycling for all waste streams.
  - Product innovation and policy. Enact policies to ban or tax wasteful single-use packaging (e.g., plastic bags, plastic straws, polystyrene). Additionally, establish a program, potentially a grant, to promote research and develop new product designs to replace wasteful products sold and used in industrial processes in the region.
  - Establish landfill waste transfer stations and convenience centers. Establish government owned waste transfer stations that will service homeowners, small haulers, and large haulers. Waste collected at this facility will be transferred to other jurisdictions for processing, recovery, and disposal. The facility will incorporate a public convenience center, which will assist with reuse and waste diversion initiatives. This action is being explored especially in Charles County, Maryland as their landfill nears capacity.
- Monitor, manage, and capture methane from landfills, food scrap/aerobic compost digester systems, and wastewater treatment plants for beneficial use.
  - Use methane capture technology. Introduce methane capture technologies, such as anaerobic digesters or LFG collection systems, via regional pilot or demonstration projects. Ensure project data can be easily tracked and monitored, and that projects can be scaled up if deemed effective.
  - Develop LFG-to-energy projects. Expand LFG treatment centers at landfills so that captured LFG can be converted into fuel for vehicles, electricity, and heating systems, rather than burned off.
  - Develop wastewater heat exchange projects.
- Promote the electrification of the transportation sector to move food waste. Implement waste to energy equipment at regional wastewater treatment plants through available anaerobic digestion technology

- Produce power for renewable fuel production, enhance power reliability for wastewater treatment plants, reduce biosolids production and prevent sanitary sewer overflows to improve water quality and protect public health.

There are limited barriers to implementing this measure and with proper funding and support many actions could be implemented soon.

AUTHORITY TO IMPLEMENT

The implementing authorities for this measure are state and county government agencies (e.g., Public Works, Department of the Environment, etc.) in partnership, where applicable, with private utilities, landfills, and composting facilities. Public waste management, demonstration projects, waste-related policies, and public education campaigns can all be carried out under the existing powers of local governments. Support from the private sector, including key implementers and partners mentioned above, will be required for projects that expand to private landfills and wastewater treatment centers.

GEOGRAPHIC COVERAGE

The actions within this measure are focused on the entire MSA.

FUNDING SOURCES

- EPA Solid Waste Infrastructure Recycling Grant Program
- USDA Solid Waste Management Grants
- EPA Consumer Recycling Education and Outreach Grant Program
- USDA Rural Energy for America Program Renewable Energy Systems & Energy Efficiency Improvement Guaranteed Loans and Grants
- VA DEQ Litter Prevention and Recycling Grants
- MD Wastewater Treatment Plants Fund

Benefits of Addressing Food Waste
Reducing, rescuing, and repurposing food waste can provide broader benefits to the region beyond GHG reductions. Addressing food challenges can bring health and nutritional benefits to LIDACs and reduce GHG emissions associated with food production and transportation, among many other benefits. Within the metropolitan Washington region, some jurisdictions have implemented the first stage of food waste prevention education campaigns (e.g., Montgomery County's Food Is Too Good To Waste campaign).

LIDAC BENEFITS

Using new and innovative technologies to manage longstanding community facilities such as landfills and treatment plants, which are often sited near low-income and overburdened areas, may result in not just a reduction of GHG emissions but also of odor, eye irritants, fugitive dust, sewer overflows, sewage backups, and other nuisance incidents that directly impact homes and businesses surrounding these locations. Exposure to hazardous materials may also be reduced. Expanding composting and other food waste reduction programs at the neighborhood and commercial level may spur the implementation of urban farming, community gardening, food distribution, farmers markets, and other programs which support farm to table programs, reduced organic waste, and other activities which may benefit LIDACs. Local farming, gardening, and composting programs also reduce the amount of organic waste from food in landfills, therefore reducing methane gas emissions, improving air quality in surrounding neighborhoods, and reducing overall GHG emissions.

SAMPLE METRICS FOR TRACKING PROGRESS

- Weight of waste diverted from landfills or waste-to-energy facilities.
- Weight of waste composted.
- Number of people reached via waste diversion education programs and public service campaigns (e.g., clicks, views, webinar attendees, flier passed out).
- Weight of biosolids diverted from land application.
- Amount of GHG reductions.

4.3.4. Land Use

ACCELERATE THE EXPANSION OF THE REGIONAL TREE CANOPY AND REDUCE TREE CANOPY LOSS.

Trees and the canopy they create provide numerous environmental, economic, and social benefits. For example, tree canopy is important for mitigating the urban heat island effect and protecting communities from the increased temperatures that are a result of climate change and can reduce the cost of energy because of reduced need for air-conditioning. Trees and other plants are also carbon sinks, removing CO_2 from the atmosphere and sequestering it in their structures. Trees also provide adaptation benefits by storing stormwater and surface water runoff in the surrounding soil, particularly in upstream areas. Trees reduce the occurrence and severity of flood events and prevent erosion.[56] This measure focuses on increasing tree canopies in urban and rural settings and preventing additional tree canopy losses. It involves planning, implementation, and management efforts on both private and public lands and working with community organizations and property owners to identify and implement strategies to increase tree canopy. Expanding green spaces in addition to tree canopy has the potential to increase sequestration potential of the land use sector.

QUANTIFIED GHG SEQUESTRATION AND RELEVANT GHG INVENTORY SECTOR

This measure reduces GHG emissions from the land use sector. Cumulative estimated GHG sequestration potential for this measure is:

GHG sequestration ($MMTCO_2e$), 2025-2030	GHG sequestration ($MMTCO_2e$), 2025-2050
0.18	36.00

Key assumptions, methods and data sources used to develop these quantified reduction estimates are provided in Appendix A.

KEY IMPLEMENTING AGENCIES AND PARTNERS

- **State department or divisions of natural resources or forestry.** Maintain and provide technical expertise and services for the maintenance and care of trees and other natural lands.
- **Chesapeake Tree Canopy Network.** Provides a platform for partners to share knowledge and best practices.

[56] World Resources Institute. 5 Reasons Cities Should Include Trees in Climate Action. 2022. https://www.wri.org/insights/urban-trees-city-climate-action

- **COG Regional Tree Canopy Subcommittee (RTCS).** A subcommittee dedicated to the management of both the tree and forest canopy. COG and its municipal partners are currently working to determine an implementation path for its integrated urban tree canopy management approach.
- **Local governments.** Local governments operate various programs that enhance tree canopy by planting, maintaining, and monitoring the health of trees on public land and operating programs to incentivize private landowners to plant trees.
- **Community organizations.** Local organizations can help inform the strategic placement of trees to benefit LIDACs.
- **Private landowners.** They can choose to voluntarily increase tree canopy on their land.

IMPLEMENTATION ACTIVITIES AND MILESTONES

Actions to implement this measure could include, but are not limited to:

- Utilize data and mapping tools to identify priority planting areas and track local and regional tree canopy coverage. Implement programs and tools to assist in care and maintenance of trees.
- Implement and expand partnerships with educational organizations to enable students to plant, monitor, and maintain trees. Teaching students how to manage trees (especially in LIDACs) can increase the public awareness of the benefits of tree canopy and expand capacity to plant and monitor trees.
- Support community gardens and small-scale urban agriculture.
- Review and strengthen local tree canopy-related policies and ordinances. Ensure that local policies are aligned to enable implementers to accelerate the expansion of tree canopy.
- Expand existing programs (e.g., the West Virginia Forestry Stewardship Program) or create new incentivizes for planting trees and forestry management on private land, communities, and developments.
- Fund investments on private land. Provide plans and funds to increase tree canopy in public lands such as in parks and forests, as well as on and around public schools, libraries, and government owned buildings and on publicly owned sidewalks that support safe access to transit and active transportation (e.g. walking, biking and micromobility).
- Adopt and implement policies that stimulate use of green infrastructure such as green roofs, green walls, green common areas. Design and install green infrastructure to supplement urban canopy in heat-intensive or vulnerable areas.
- Apply green infrastructure to trails, walkways, streets, and roads, integrating green with built infrastructure.

Many of these activities are ongoing but could be expanded or started in the coming years. COG has taken actions to promote increased tree canopy across the MSA. COG's *Tree Canopy Management Strategy*[57] describes the state of urban forest programs in the COG region as of 2018. COG's RTCS is recommending a tree canopy goal of 50% for the COG region as well as goals by land use type.

Programs such as Arlington County's Land Disturbance Activity Ordinance and Programs have resulted in nearly 170 Green Roofs, and the Green Streets Program has resulted in 14 completed projects.

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[57] https://www.mwcog.org/documents/tree-canopy-management-strategy/

Beyond the COG region, states across the MSA have also focused on goals and actions to increase and maintain tree cover. For example, the Virginia Department of Forestry's 2019 strategic plan has six strategic goals, that focus on protecting the forest resources and the community members of the Commonwealth from wildfire and reduce impacts to the forest from other threats and increasing the social, environmental, and economic benefits provided by trees and forests, among other priorities.[58]

AUTHORITY TO IMPLEMENT

Implementation authority for tree canopy expansion, preservation, or development on public land typically falls within the powers of the owning jurisdiction (e.g., a state natural resources or forestry agency). Public space tree planting and tree canopy maintenance falls to the owning jurisdiction. For private-owned land, consent of or actions from the landowner would be needed, and applicable covenants and zoning restrictions would need to be honored. Any applicable environmental regulations would also apply (e.g., managing stormwater and runoff). Smart growth and green development incentive programs are deployed by numerous cities and counties within COG, as well as local government programs for green infrastructure.

GEOGRAPHIC COVERAGE

The actions within this measure are focused on the entire MSA area.

FUNDING SOURCES

Example potential funding sources include:

- USDA Natural Resources Conservation Service (NRCS) Healthy Forests Reserve Program
- National Forest Foundation Grant Programs
- U.S. Forest Service Urban and Community Forestry Grant
- MD Community Tree Planting and Education Grant Program
- MD Forest Legacy Program
- MD Forest Conservation and Management Program
- VA Trees for Clean Water Grant Program
- VA Forest Pest Treatment Cost-Share Programs
- Va Community Forest Revitalization Program
- DC Casey Trees Tree Rebate Program
- Local government capital improvement program funds
- Foundation Grants

LIDAC BENEFITS

On average, LIDACs have less tree canopy than other areas, particularly urban settings (Figure 12). Increasing the tree canopy can provide cooling and stability benefits in areas within the urban core that are subjected to heat island effects. The regional tree canopy also provides health and aesthetic benefits to LIDAC communities. This measure will have a positive impact for LIDACs in the urban core where parks and green spaces have been preserved, and in rural and suburban settings where growth boundaries have been implemented to protect green space and tree canopy. Educational programs and participation opportunities for adults, teens, and children, including environmental stewardship experiences, can lead to greater awareness and further action in the community.

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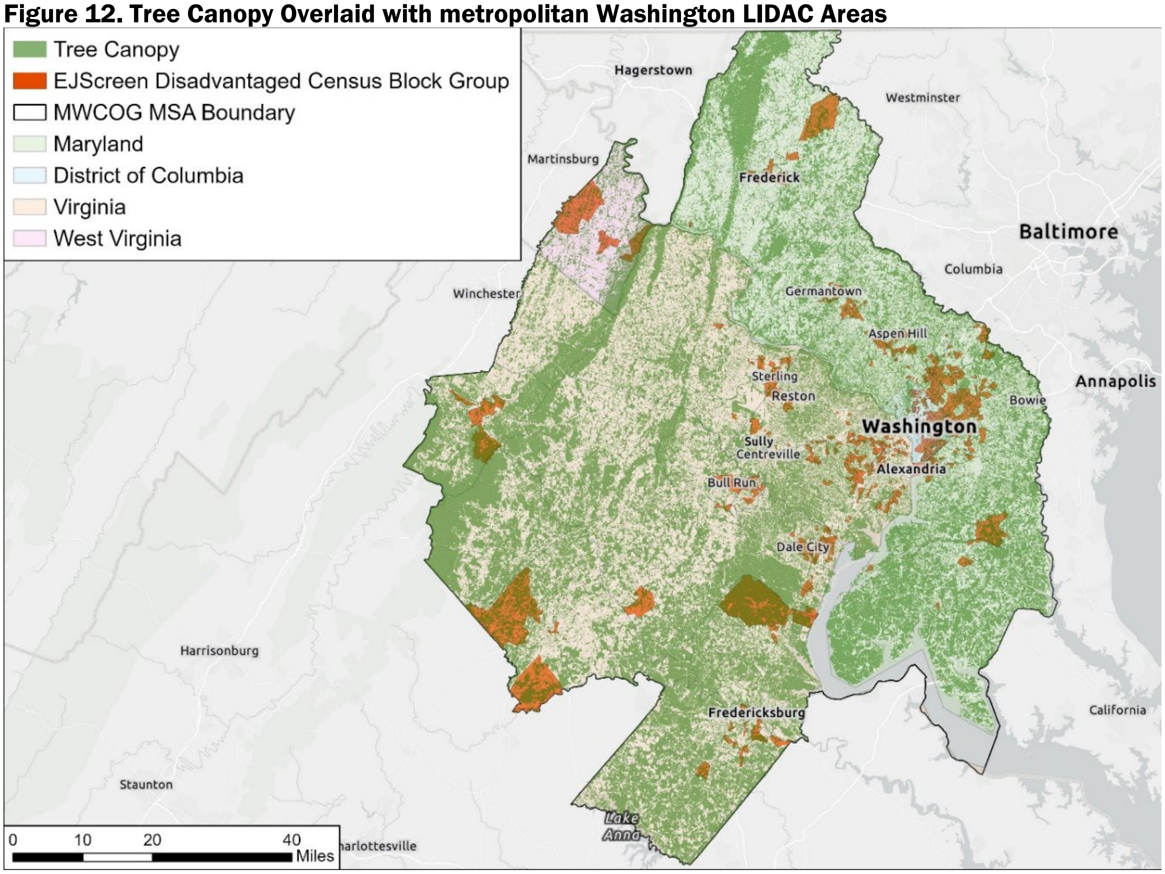
[58] https://dof.virginia.gov/strategic-plan/

Training and employment opportunities for both planting and maintenance of urban forests may benefit LIDAC members in terms of employment, training, and expanded canopy coverage as canopy restoration programs become more prevalent in cities and urban neighborhoods.

Figure 12. Tree Canopy Overlaid with metropolitan Washington LIDAC Areas



SAMPLE METRICS FOR TRACKING PROGRESS

- Number of priority planting areas identified and addressed
- Tree canopy cover area
- Number of trees planted
- Number of new tree planting programs

4.3.5. Cross-cutting Enabling Actions

CONDUCT EDUCATION AND PUBLIC OUTREACH TO SUPPORT MEASURE IMPLEMENTATION

The measures in this CCAP require education and public outreach to support their implementation. Through listening sessions, localities and CBOs expressed a desire for coordination, resources, and best practices to conduct education and public outreach across the region. This measure aims to enhance the effectiveness and efficiency of community and government education pathways to enhance the public's understanding of climate change risks and opportunities and to engage local partners to further outreach and education goals. For localities and CBOs, this measure provides guidance on how to effectively engage the public in climate, energy, and air quality planning, with additional emphasis on communities most vulnerable to climate impacts.

By establishing best practices for inclusive and equitable community engagement, this measure outlines how to initiate a climate conversation in communities, engage local stakeholders, ensure information accessibility, and foster shared ownership and collective action.

QUANTIFIED GHG REDUCTIONS AND RELEVANT GHG INVENTORY SECTOR(S)

This measure will not directly result in GHG reductions. But it will support the other measures and their associated GHG reductions.

KEY IMPLEMENTING AGENCIES AND PARTNERS

- **State governments.** Government organizations such as the District of Columbia DOEE, Maryland Department of the Environment, Virginia DEQ, and others may conduct outreach and public engagement activities to inform the public, partners, and other stakeholders.
- **Local governments.** Local governments and local departments of energy, environment, housing, and others frequently develop educational materials and provide outreach support to local residents and partners. These existing efforts can also partner with COG and state government organizations to collaborate, share experiences and best practices, and develop more informed and targeted efforts within local communities.
- **Utilities.** Utilities, particularly energy utilities, have significant power to educate and engage broad swaths of the MSA. Most utilities already conduct education and outreach efforts related to energy efficiency, smart technology solutions, health and safety, and other topics pertinent to CCAP measures. They can leverage these existing programs to spread awareness among its user base and to better understand their challenges and priorities related to climate.
- **Public schools and libraries.** The mission of schools and libraries is to serve and engage their communities and to provide educational services across a broad range of topics. Therefore, they are natural partners for education and outreach efforts related to climate change. Schools and libraries also serve as safe spaces for community organizing and offer excellent venues for outreach, speaking events, workshops, and more.
- **CBOs.** CBOs play a significant role in raising awareness and promoting community participation (e.g., in community solar programs). Engaging with CBOs can help ensure that the specific needs and concerns of local communities are informed and can catalyze community engagement to support climate implementation efforts.
- **Non-profit organizations and environmental/climate organizations.** Nonprofits and climate/environment organizations can conduct community engagement, education, outreach, and capacity building efforts on a wide range of topics related to climate action implementation. Environmental and climate organizations can prioritize climate topics and focus on education, advocacy, and mobilizing efforts.

IMPLEMENTATION ACTIVITIES AND MILESTONES

Actions to implement this measure could include, but are not limited to:

- Identify outreach methods that prioritize in-person engagement as well as using social media.
- Develop climate communications outreach materials, templates, or guidance that can be leveraged to engage communities across the region.

- Identify and engage with people or organizations that are trusted messengers in their communities.
- Build a network of CBOs, EJ organizations, and other community climate leaders to create support systems, knowledge sharing, and expand engagement capacity.
- Build trust and credibility by supporting CBOs and trusted messengers in person and by attending events.
- Share neutral data sources and analyses on issues that are top concerns for residents.
- Demonstrate the ease and impact of smaller climate actions.
- Offer incentives/rebates/giveaways; transportation, childcare, and participation support.
- Personalize messaging and place emphasis on the climate impacts your community cares about

AUTHORITY TO IMPLEMENT

Local governments and CBOs have the primary ability to implement the public education and outreach measure on the ground in communities. Many of the activities outlined, such as developing materials, hosting events, and engaging residents, can be initiated in coordination with communities. In some cases, successful implementation may require coordination across multiple departments, including media and marketing, as well as executive leadership.

GEOGRAPHIC COVERAGE

This measure will be implemented across the entire MSA.

FUNDING SOURCES

Example potential funding sources include:

- NOAA Chesapeake Bay-Watershed Education and Training (B-WET) program
- Chesapeake Bay Trust Environmental Education Grant Program
- VA Department of Conservation and Recreation (DCR)'s Watershed Educational Programs Project
- EmPOWER MD energy efficiency and conservation funds
- Private funds and philanthropies, e.g., the Burroughs Wellcome Fund Climate Change and Human Health Seed Grants
- Corporate partnerships, e.g., Pepco Sustainable Communities Grant

LIDAC BENEFITS

LIDAC areas have historically been overlooked, underrepresented, and underinformed; this measure can start to overcome these challenges by directing efforts to engage and educate LIDAC areas as well as other areas in the region. Providing additional information, education, and resources to LIDAC community members will help increase the community's understanding of critical issues as well as programs and policies that attempt to overcome those issues. Furthermore, beyond education and awareness, engaging with LIDAC community members increases the understanding that local government, CBOs, NGOs, businesses, and other organization have of LIDAC challenges, priorities, and other factors, and can enable these organizations to better implement CCAP measures to address LIDAC needs. Such efforts are likely to provide benefits to LIDAC areas related to awareness, education, capacity building, workforce development, and civic engagement.

Key benefits include:

- **Accessible Outreach:** LIDAC residents receive information in clear, convenient ways through in-person engagement, social media, and easy-to-use materials.
- **Trusted Connections:** Partnering with CBOs and community messengers ensures LIDAC voices are heard and respected, building credibility and stronger networks.
- **Inclusive Participation:** Incentives, childcare, and transportation support make it easier for LIDAC residents to participate in climate programs and decision-making.
- **Empowered Communities:** Transparent data, personalized messaging, and incremental climate actions help LIDAC households reduce costs, improve health, and see direct benefits.

SAMPLE METRICS FOR TRACKING PROGRESS

Potential metrics to track the progress of this measure include:

- Number of events held
- Number of event participants
- Number of localities engaged
- Number of partner organizations engaged
- Number of partner organization events held
- Number of survey responses received
- Number of outreach materials developed and distributed
- Number of social media interactions (e.g., reposts, likes, comments)
- Number of website interactions (e.g., site visits, downloads)
- Percentage of events held in LIDAC areas
- Percentage of public engaged that live in LIDAC areas

ADDITIONAL CROSS-CUTTING SUPPORT FOR MEASURES

All the GHG reduction measures identified above may be enabled or enhanced through other cross-cutting actions, such as:

- **Building the clean energy workforce.** An expanded and well-trained workforce is critical to implement the breadth and depth of GHG reduction measures in this plan, beginning with education for building owners, architects, designers, and contractors to influence climate-facing development from the design phase. This also includes developing new programs or expanding existing ones to provide training, paid internships, and job opportunities for a clean energy workforce. Some of these opportunities should be focused in LIDACs to bring benefits to these communities.
- **Leveraging or establishing umbrella organizations to support centralized resources.** Deploying shared resources and funding through a centralized program for implementation-ready projects or pooling resources to accelerate climate action for a set list of climate actions and technologies that benefit multiple jurisdictions can create administrative and other efficiencies. Providing technical assistance can assist stakeholders in completing projects.
- **Financing clean energy.** Clean energy financing and incentives to increase clean energy, energy efficiency, and fuel switching will accelerate the deployment of GHG reduction measures by overcoming capital and funding barriers. Clean energy financing mechanisms may include green banks, green financing, commercial PACE programs, interest rate buy downs, grant or rebate programs, a revolving loan fund (e.g., green bonds, clean energy loans), Energy Savings Performance Contract (ESPC), as well as grants and rebates.

5 BENEFITS ANALYSIS

In addition to GHGs, emissions from criteria air pollutants (CAPs) also harm public health and the environment, and hazardous air pollutants (HAPs) are pollutants known to cause cancer and other serious health impacts. These CAPs and HAPs, collectively referred to as co-pollutants, are often emitted alongside GHGs during fossil fuel combustion from sources such as power plants, factories, and vehicles. These pollutants, unlike GHGs, do not primarily contribute to climate change, but affect human health and the environment. Like a GHG inventory, tracking these co-pollutants in an inventory over time provides an understanding of what pollutants are being released, how much, and their key sources. These two categories of air pollutants affect human health and the environment:

- **CAPs** include ozone, particulate matter ($PM_{2.5}$, PM_{10}), carbon monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO_2), and lead.
- **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 NO_x, they create ozone, a CAP. Some VOCs are HAPs, such as benzene or formaldehyde.

Ammonia (NH_3) contributes to the formation of $PM_{2.5}$, a CAP, when it reacts with other pollutants like NO_x and SO_2.

Table 9 provides a summary of co-pollutant emissions in the region by sector and pollutant, with a focus on criteria air pollutants. The data is compiled from EPA's 2022 Emissions Modeling Platform.

Table 9. Co-pollutant Emissions by Sector and Pollutant (MT)

Category	CO	NO_x	VOC	PM_{10}	$PM_{2.5}$	SO_2	NH_3
Agriculture	6,090	1,267	39,006	2,694	669	28	11,153
Industry	249	-	4,914	9,375	1,480	-	-
Mobile	89,706	8,583	7,986	795	410	29	563
Stationary	5,518	2,163	755	697	689	31	184
Waste	645	25	278	106	90	43	311
Other	283	7	209	4,412	1,133	1	-
Total	**102,490**	**12,045**	**53,149**	**18,078**	**4,471**	**132**	**12,211**

RESULTS

This section presents the quantified outcomes of co-pollutant changes and associated health benefits for the MSA building from the modeling conducted for the net zero CCAP Implementation Scenario. The MSA-wide summary results provide an aggregated view of total emissions reductions and health impacts across all sectors. Sector-specific analyses detailing the contributions of individual sectors to both pollutant reductions and public health improvements can be found in Appendix G. Table 10 and Table 11 show the cumulative reductions by pollutant and sector. Table 12 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 was 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 EVs are used and VMT decreases, emissions of HAPs 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.[59]

In addition to health benefits from air pollution removals, the NWL 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 NWL, EPA's i-Tree Landscape Module was used to estimate ecosystem services provided by increased tree cover. By 2050, the modeled tree canopy expansion could result in avoided runoff benefits reaching over $15 million/year. The results of the air pollutant removals are included in Table 10.

Table 10. Cumulative Changes in Co-Pollutant Emissions (MT) by Pollutant, 2025-2050

Pollutant	Cumulative Reductions from Change in Energy Use (MT)	Removals from NWL (MT)
NO_x	131,811	19,335
SO_2	2,842	10,647
PM_{10}	22,843	47,178
CO	350,534	3,809
Lead	0.7	0

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[59] https://www.lung.org/clean-air/outdoors/what-makes-air-unhealthy/buildings

Table 11. Cumulative Co-Pollutant Reductions (MT) by Pollutant and Sector, 2025-2050

Sector	Pollutant	Cumulative Reductions (MT) (2025-2050)
Waste	NO_x	230
Buildings	NO_x	123,636
On-Road	NO_x	432
Off-Road	NO_x	7,513
Buildings	SO_2	1,428
On-Road	SO_2	1,231
Off-Road	SO_2	183
Waste	PM_{10}	98
Buildings	PM_{10}	9,388
On-Road	PM_{10}	13,065
Off-Road	PM_{10}	291
Waste	CO	4,314
Buildings	CO	102,023
On-Road	CO	242,997
Off-Road	CO	1,200
Buildings	Lead	0.7

Note: Lead could not be calculated for all sectors.

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 12 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., PM, SO_2, NO_X, VOCs) on public health outcomes and monetizes these benefits using peer-reviewed concentration-response functions and economic valuation methods.

Table 12. Cumulative Monetary Health Benefits and Incident Reductions, 2025-2050

Health Impact	Cumulative Monetary Benefits (2025-2050), Million $	Cumulative Incidence Reduction (2025-2050)
Mortality	$ 10,072 – $ 19,115	690 – 1,309
Hospital Visits	$10	1,895
Missed School/Work or Restricted Activity	$ 471	940,281
Cardiovascular Conditions	$ 33	451
Respiratory Conditions	$ 486	738,822

6 WORKFORCE PLANNING 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. Appendix H provides more detail on the workforce analysis approach and methodology, including employment trends, gap analysis data, and the skills and training assessment.

This workforce analysis provides information to help the region proactively plan for future workforce needs. The CCAP is projected to impact nearly 50 different occupations ranging from bus drivers to the building trades. In total, these occupations represent roughly 258,000 jobs or 7.1% of total jobs in the MSA.

The workforce gap analysis uses data on projected growth, separations, and hires to estimate the shortage or surplus of workers for each occupation. 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; it is a starting point to identify current areas of shortages and to identify areas for future collaboration and planning to ensure workforce readiness. As measure implementation occurs across sectors, workforce needs will grow for hands-on positions within waste, construction, plumbing, and carpentry, and existing workers may need to undergo additional training (e.g., electricians that can install EV chargers and HVAC technicians that can install heat pumps).

GAP ANALYSIS TAKEAWAYS

Overall, the COG MSA has very good equilibrium in its labor market for the CCAP occupations, with only some relatively minor shortages or surpluses (i.e., supply is within 1-2% of demand for most occupations).

The largest shortage projected for COG in 2025 is 563 workers for the laborers and freight, stock, and material mover occupations within the waste sector. This represents 2.1% of the total laborers and freight, stock, and material movers in the MSA. The next several occupations with the greatest projected shortages in 2025 are all related to the construction industry and are needed to implement measures within the buildings and clean energy sector (see Table 13). The two occupations with the largest shortages do not require advanced degrees or a high level of technical knowledge, suggesting that education and intensive technical training are not necessary to close these gaps.

Workforce surpluses in the region for the CCAP occupations are also relatively minor (see Table 14). The greatest workforce surplus is within the waste sector, specifically among heavy and tractor-trailer truck drivers, with a projected surplus of 204 workers. This represents 1% of the total workforce in that occupation. While some occupations have surpluses, they still might not all have the technical skills to perform CCAP-related measures that are more novel or niche, e.g., for EVs, energy auditing, and solar PV installations. Part of the solutioning framework is to connect individuals with technical skills to upskilling opportunities that will prepare them to support the implementation of the CCAP.

Table 13. Occupations with the Largest Workforce Shortages in 2025

SOC Code	Occupation	Relevant Sector	Potential Workforce Shortage	Shortage as Percent of Total Employment
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	Waste	-563	2.1%
47-2061	Construction Laborers	Buildings and Clean Energy	-231	0.9%
47-2152	Plumbers, Pipefitters, and Steamfitters	Buildings and Clean Energy	-110	1.2%
47-2031	Carpenters	Buildings and Clean Energy	-82	0.5%
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	Buildings and Clean Energy	-34	0.2%
47-3012	Helpers--Carpenters	Buildings and Clean Energy	-31	4.8%

Table 14. Occupations with Largest Workforce Surplus in 2025

SOC Code	Occupation	Relevant Sector	Potential Workforce Surplus	Surplus as Percent of Total Employment
53-3032	Heavy and Tractor-Trailer Truck Drivers	Waste	204	0.9%
17-2051	Civil Engineers	Buildings and Clean Energy, Transportation	204	2.3%
13-1041	Compliance Officers	Buildings and Clean Energy	190	1.4%
17-2199	Engineers, All Other	Buildings and Clean Energy	148	1.6%
47-2111	Electricians	Buildings and Clean Energy, Transportation	88	0.5%
37-3011	Landscaping and Groundskeeping Workers	Land Use	85	0.4%
53-7081	Refuse and Recyclable Material Collectors	Waste	81	3.1%
47-3013	Helpers--Electricians	Buildings and Clean Energy, Transportation	77	4.1%

While informative, the quantitative supply/demand balance is limited to the reported occupation levels and may mask challenges to worker retention and issues specific to certain employers or specific jobs within a broader occupation.

To provide additional context, COG conducted stakeholder outreach to supplement the gap analysis and to collect information on successful sample programs in the region. Discussion questions with stakeholders included whether there was a gap for particular jobs in a sector and barriers to attracting or retaining workers. Some key takeaways on challenges and needs are summarized below:

- Shortages specific to EV maintenance technicians and energy auditors were identified.
- Strict job requirements can present a challenge; flexibility in hiring practices is needed to attract and retain talent.
- The need for comprehensive solutions to worker retention, including addressing issues related to high housing and childcare costs in the region.
- Ensuring equitable access to training programs, which may include flexible structures such as internship programs or alternative pathways to certification that do not require traditional education. On-the-job training and practical experience can be valid qualifications in some cases.
- Future discussions are needed with employers in key occupations to learn what their specific challenges are to meet the increased pace and scale of activity to support CCAP implementation.

SOLUTIONING FRAMEWORK

Although workforce shortages are relatively minor today, the rapid pace of change needed to implement the CCAP will require a significant change in the workforce and exacerbate existing challenges and barriers to attracting and retaining workers. Strategies for addressing these shortages include establishing a workforce pipeline, upskilling and reskilling workers, and coordinating with regional partners to scale existing successful programs in the region. By anticipating labor market trends, investing in workforce development, and embracing innovative workforce solutions, the region can secure the expertise needed for the CCAP.

Upskilling and Reskilling

When possible, it is advantageous to pair occupations experiencing workforce shortages and surpluses that have transferable skills. Reskilling and upskilling workers from occupations where there are surpluses to occupations with shortages can provide opportunities for individuals to develop professionally, expand their skill sets, and cement employment opportunities. An example of a potential pairing includes pivoting some of the heavy and tractor trailer truck drivers, with a surplus of 204 jobs, into industrial truck and tractor operators, with a shortage of 19 jobs. Additionally, landscaping workers can be transitioned to construction laborers, where there is a shortage. These skill transfers can often be accomplished with minimal additional training, whereas others may take more investment in training. When pathways to pivot careers are provided to employees, this may fill necessary gaps and provide workers with access to growing fields. Adjustments in career paths should provide workers with net benefits such as greater opportunities for professional growth and increased pay if possible.

A focus for the region is ensuring that workers are trained with the necessary skills to implement CCAP measures. Many of the occupations with labor surpluses require advanced degrees such as engineering, or specialized expertise such as electrical work. However, these degrees/certifications do not guarantee that workers are prepared to perform technical audits and processes needed for CCAP implementation, highlighting an opportunity for alternative career pathways for some of these specific gaps. While regional training programs currently available for energy auditing, rooftop solar installation, and EV maintenance are limited, the region is actively working to expand stakeholder partnerships in addition to online and in person training opportunities. Some EV examples within the region include:

- **Greater Washington Region Clean Cities Coalition (GWRCCC):** Brings together the alternate fuel and EV industry for trainings and job fairs.
- **Electrical Vehicle Infrastructure Training Program (EVITP):** A national online program, also offered in person in the COG region by the local chapter of the International Brotherhood of Electrical Workers (IBEW).
- **Montgomery College Automotive Electrical Systems Specialist Certificate:** A program that prepares students for the National Institute for Automotive Service Excellence (ASE) L-3 Light Duty Hybrid/Electric Vehicle technician certification exam.

These programs often require a baseline of technical knowledge and are focused on upskilling or reskilling workers. Within the EV industry, many current programs are reaching out to certified electricians, autobody shops, mechanics, and vocational tech high school automotive graduates to encourage these individuals to increase their technical expertise in automotive electrical systems.

Following a similar format to these opportunities in the EV space, the region is working to diversify educational opportunities for rooftop solar installation and energy auditing in a range of formats across higher education institutes, community organizations, and professional development groups. This is a successful model that can be expanded and improved upon across the region to ensure equitable access to these programs.

Early Career Professional Development

It will also be important to target youth and early career programs to introduce occupations with current and projected shortages. The greatest projected shortage is within labor intensive positions for freight, material moving, and construction. These positions often require minimal formal education and can be learned on the job. In addition to these entry level roles, there are several skilled trades with shortages with require some technical training or apprenticeship experience. These occupations include plumbers, pipefitters, steamfitters, carpenters, and roofers.

There are a wide variety of training programs available throughout the region for construction and trade occupations, such as laborers, electricians, and HVAC and heat pump installation, repair, and maintenance. A variety of institutions offer training in these occupations, including community colleges, career and technical education providers at both the high school and post-secondary level, apprenticeships, and private training providers. In addition, farming occupations have a fair number of training programs and are concentrated in the counties with the largest agricultural sectors, such as Loudoun, Fauquier, and Culpeper.

Many high schools across the region already offer relevant career development resources and expose students to the range of career paths they could take to support the energy transition, but there is room to expand high school workforce education programs across the region and ensure they provide information about the variety of alternative career pathway options and the various compensation levels and stability that they may provide.

Workforce Partners and Training Resources

There are a range of existing job initiatives and workforce development resources across the region that pertain to occupations impacted by the CCAP, some of which are listed below. This list is intended to show the range of stakeholders actively working in the region that localities and other implementers could work with moving forward; they will be vital resources for training and employment opportunities.

- **Workforce development programs:** These programs offer trainings, job fairs, career advice, and additional resources to facilitate employment. They also connect employers with community members seeking work opportunities. Examples include:
    - Emerald Cities Collaborative
    - Virginia Career Works
    - Fauquier County's Career Center
    - Civic Works
    - City of Bowie Maryland Workforce Development Program
    - GRID Alternatives Workforce Development Program
    - Employ Prince George's
    - WorkSource Montgomery
    - District of Columbia Sustainable Energy Utility (DC SEU)
- **Local universities and community colleges:** Facilitate educational opportunities to increase technical skill sets needed for CCAP implementation. Provide students with certifications and licenses needed for career advancement. Examples include:
    - Northern Virginia Community College
    - University of District of Columbia
    - Montgomery College
    - Prince George's Community College
    - Laurel Ridge Community College
- **Local High Schools:** Encourage students who are not seeking four-year higher education institutions to consider technical and trade opportunities. Connect existing students with local community colleges and apprenticeships to support their transition after graduating.
- **Economic development offices:** Promote local employment and connect employers with community priorities and needs.
- **Utilities:** Provide guidance to COG on workforce gaps and available jobs for community members.

APPENDIX A. GHG INVENTORY, BUSINESS-AS-USUAL PROJECTIONS, AND GHG REDUCTION MEASURE QUANTIFICATION

GHG Inventory

For the CPRG, COG produced a 2020 GHG inventory for the MSA. COG leveraged and expanded its existing GHG inventory and projections for the COG region to cover the entire MSA. COG used the existing 2020 GHG inventory for portions of the MSA that fall within COG's geographic scope. To incorporate counties and cities in the broader MSA COG region, COG sought additional data sources and approaches to prepare a 2020 GHG inventory for the full MSA.

COG completes GHG community-scale inventories for all 24 local government members, northern Virginia, and metropolitan Washington. COG makes every effort to capture an accurate picture of GHG trends for each of its local government members, while also providing for a consistently applied methodology across all its members' communities. Local inventory results are added together to get the total regional GHG emissions. The emissions attributed to the additional MSA jurisdictions have been incorporated into COG's 2020 inventory for the CPRG project.

COG GHG inventories are compliant with both the U.S. Communities Protocol for Accounting and Reporting Greenhouse Gas Emissions (USCP) and Global Protocol for Community-Scale Greenhouse Gas Inventories (GPC). COG inventories use public data readily available on a consistent basis. While both accuracy and consistency are important to GHG inventories, consistency is given a higher priority. COG used global warming potential (GWP) factors from the Intergovernmental Panel on Climate Change Fourth Assessment Report (IPCC AR5).

The inventory follows an activities-based approach, meaning emissions are calculated based on the result of an activity happening in a community. An example of this is that solid waste emissions are calculated based on the tonnage of trash the community sends to a landfill(s). Simply because they do not have a landfill within their jurisdiction's boundaries, does not mean that they are not contributing to landfill emissions.

The broad categories of emission types covered by COG's GHG inventory work include the built environment (including some process and fugitive emissions), transportation and mobile emissions, waste (solid waste and wastewater), and some land use (agriculture, forests, and trees outside of forests). Most of these sectors, except land use, are required elements to be compliant with the USCP and GPC.

The gases calculated within these inventory records include carbon dioxide (CO_2), methane (CH_4), Nitrous oxide (N_2O), Hydrofluorocarbons (HFCs), and Perfluorocarbons (PFCs).

CLEARPATH

ICLEI's ClearPath is an online tool for preparing local GHG inventories, forecasts, climate action plans, and monitoring reports. The tool is consistent with both US and global accounting protocols. COG uses the Community Scale Inventory Module to support completing its GHG inventory work for its members and the region. Some of the tool's calculators are used to calculate emissions as inventory records are created, while in other instances, emissions are calculated outside the tool and recorded in the inventory record.

COVID-19 IMPACTS

The COVID-19 pandemic has had far-reaching impacts on the global economic and social system. Pandemic impacts on GHG emissions are largely due to reduced economic and travel activity. Globally, the pandemic impacted GHG emissions by 4-5% in 2020. The state of Maryland estimates the pandemic had a 4% impact on GHG emission reduction in 2020. COG estimates the pandemic had a 4-6% impact on metropolitan Washington's 2020 GHG emissions.

The pandemic impacted the anticipated reduction in a few key sectors of metropolitan Washington's 2020 GHG emissions inventory. Emissions from the built environment were lower than projected for 2020, in part due to the pandemic; however, the grid getting cleaner and weather impacts also played a role. Emissions from the transportation sector were lower than previously projected for 2020 because less people were on the roads and flying during the height of the pandemic. Finally, solid waste emissions were lower overall than projected for 2020. However, waste that would have been generated and collected from businesses were generated within individual residences during the height of the pandemic and thus it did not make a significant impact on overall GHG emissions in 2020.

BUILT ENVIRONMENT

Residential and Commercial Electricity

Residential Electricity accounts for emissions resulting in electricity use in residential buildings. Commercial Electricity accounts for emissions resulting in electricity use in commercial, government, industrial, data centers, and other non-residential buildings and facilities. The Residential and Commercial Electricity emission calculations for the COG member jurisdictions follow the USCP recommended methodology as outlined in Appendix C, BE.2.1 from Version 1.2 of the Protocol. COG annually collects aggregated account and consumption data from the electric utilities that serve metropolitan Washington for residential and commercial electricity consumption in (kWh).

Calculations of Residential and Commercial Electricity emissions for the additional MSA jurisdictions also follow the USCP recommended methodology as outlined in Appendix C, BE.2.1 from Version 1.2 of the Protocol. The residential electricity methodology estimates consumption in kilowatt hours (kWh) by multiplying the estimated number of households using electricity with per household electricity consumption data. The Energy Information Administration (EIA) has readily available electricity energy intensity data for the South Atlantic region and the US Census Bureau American Community Survey (ACS) has readily available data on number of households using electricity. The Commercial Electricity methodology estimates consumption by calculating the percent of commercial square footage using electricity. Values for commercial building square footage using electricity are scaled locally by multiplying the local jurisdictional commercial square footage by the percentage of commercial building square footage using electricity in the broader South Atlantic region. These values, in turn, were multiplied by the electricity energy intensity in kilowatt hours per square foot ($kWh/ft.^2$) to get total electricity consumption in kWh per additional MSA jurisdiction.

Utility data provided for the commercial sector includes electricity consumption for data centers and electric rail. Electricity consumption from these two subsectors were subtracted from the total commercial electricity consumption to isolate other commercial electricity consumption. Electricity consumption from data centers are subsequently broken out from other commercial buildings based on data center square footage. See the Data Center and Rail BAU section of this appendix for more detail about this methodology. These data center inventory estimates are draft and the methodology is subject to change for final publication of the CCAP.

Electricity consumption data and EPA eGRID emission rates are used to calculate emissions. EPA eGRID Subregions leveraged to complete the MSA inventory include RFC East (RFCE), RFC West (RFCW), and SERV Virginia/Carolina (SRVC).

Residential and Commercial Natural Gas

Residential and Commercial Natural Gas consumption accounts for combustion emissions from stationary fuel applications, such as boilers and furnaces. The Residential and Commercial Natural Gas emission calculations for the COG member jurisdictions follow the USCP recommended methodology as outlined in Appendix C, BE.1.1 from Version 1.2 of the Protocol. COG annually collects aggregated account and consumption data from the natural gas utilities that serve metropolitan Washington, which is used to complete emission calculations using this methodology.

Calculations of Residential Natural Gas emissions for the additional MSA jurisdictions follow the USCP recommended methodology as outlined in Appendix C, BE.1.2 from Version 1.2 of the Protocol. This methodology estimates residential utility natural gas consumption in therms by multiplying the estimated number of households using utility natural gas in each jurisdiction with per household natural gas consumption data for the South Atlantic region. The EIA Residential Energy Consumption Survey (RECS) has readily available utility natural gas energy intensity data for the South Atlantic region and the ACS has readily available data on number of households using utility natural gas.

Calculations of Commercial Natural Gas emissions for the additional MSA jurisdictions follow the USCP recommended methodology as outlined in Appendix C, BE.1.3 from Version 1.2 of the Protocol. The Commercial Natural Gas methodology estimates consumption by calculating the percentage of square footage using natural gas. Values for commercial building square footage using utility natural gas are scaled locally by multiplying the local jurisdictional commercial square footage by the percent of commercial building square footage using utility natural gas in the broader South Atlantic Region. These values, in turn, were multiplied by the natural gas energy intensity in therms per square foot (therms/$ft.^2$) to get total natural gas consumption in therms per additional MSA jurisdiction.

Residential Fuel Oil and LPG

Fuel oil accounts for both distillate fuel oils and kerosene used in stationary applications. Liquefied Petroleum Gas (LPG) refers to a group of hydrocarbon gases derived from crude oil refining or natural gas processing. Propane is the most common LPG. The Residential Fuel Oil and LPG emissions calculations follow the USCP recommended methodology as outlined in Appendix C, BE.1.2 from Version 1.2 of the Protocol. This methodology estimates residential fuel oil and LPG consumption in gallons by multiplying the estimated number of households using fuel oil or LPG as a home heating fuel in the region and each jurisdiction with the respective residential fuel oil or LPG energy intensity data for the region. Gallons are used to estimate emissions.

Local data on households and consumption related to fuel oil and LPG is not readily available for all MSA members. However, the EIA RECS has readily available fuel oil and LPG energy intensity data for the South Atlantic region and the ACS has readily available data on number of households using fuel oil and LPG as a home heating fuel.

Commercial Fuel Oil and LPG

The Commercial Fuel Oil and LPG emissions calculations follow the USCP recommended methodology as outlined in Appendix C, BE.1.3 from Version 1.2 of the Protocol. These methodologies calculate percent of square footage using fuel oil or LPG. Values for commercial building square footage using fuel oil or LPG are scaled locally by multiplying the local jurisdictional commercial square footage by the percentage of commercial building square footage using fuel oil or LPG in the broader South Atlantic Region. These values, in turn, are multiplied by the fuel energy intensity in gallons per square foot (gallons/ft^2) to get total fuel oil or LPG consumption in gallons per locality and region. Gallons are used to estimate emissions.

The number of commercial buildings and total square footage for each MSA jurisdiction is readily available from the CoStar Commercial Property Records. There is not readily available data on stationary fuel use for these buildings. The EIA does have data available for larger regions on total commercial buildings and square footage; number and square footage of buildings using fuel oil or LPG; and energy intensity. EIA's South Atlantic Region in the Commercial Building Energy Consumption Survey (CBECS) includes DC, MD, VA, DE, WV, NC, SC, GA, and FL.

Natural Gas Fugitive Emissions

Natural Gas Fugitive Emissions accounts for emissions resulting from local natural gas system losses within the community. The Fugitive Emissions from Natural Gas emission calculations use a ClearPath calculator. The fugitive emissions are calculated based on a leakage rate for total annual natural gas consumption. The ClearPath calculator uses a leakage rate of 0.3%. Data from the Metropolitan Washington Annual Utility survey needs to first be collected and analyzed for the inventory year prior to completing these steps.

Hydrofluorocarbon Emissions

Hydrofluorocarbons (HFCs) are a type of GHG and are comprised of several organic compounds composed of hydrogen, fluorine, and carbon. HFCs are produced synthetically and are commonly used in air conditioning and refrigerants. HFC emissions in this inventory represent GHG emissions from substitutions for Ozone depleting substances. The U.S. EPA annual inventory reports on GHG emissions calculates nationwide emissions for substitutes for Ozone depleting substances. Total U.S emissions from substitutes for Ozone depleting substances are scaled locally by population to estimate regional values. Local data on substitutes for Ozone depleting substances is not available. It would take extensive research and local surveys to develop this data.

Electric Transmission and Distribution Losses

Electric Power Transmission and Distribution Losses (T&D) emissions account for electricity lost to heat when transmitted through power lines. The Electric Power T&D Losses emission calculations follow the USCP recommended methodology as outlined in Appendix C, BE.4.1 from Version 1.2 of the Protocol. The calculations factor in total MSA electricity consumption and grid emission factors by eGRID subregion (RFCE, RFCW, and SRVC) as well as a 5.3% T&D grid loss rate.

TRANSPORTATION AND MOBILE EMISSIONS

On-Road and Off-Road Mobile Emissions

On-Road Mobile Emissions represent exhaust and evaporative emissions of carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4) from on-road passenger and freight motor vehicles. The mobile off-road equipment data category includes all mobile source emissions that do not operate on roads, excluding commercial marine vehicles, railways, and aircraft. The MSA inventory uses EPA's National Emissions Inventory (NEI) data for on-road mobile emissions and Off-road mobile emissions estimates. COG region inventories typically use EPA MOVES model for these calculations; however, data and modeling are not available for the full MSA.

Passenger Air Travel

Passenger air travel emissions account for commercial aircraft emissions from major commercial airports serving the MSA. The Passenger Air Travel emission calculations generally follow the USCP recommended methodology as outlined in Appendix D, TR.6.D from Version 1.2 of the Protocol. COG's approach uses the best available data to estimate air travel passenger emissions by airport and includes personal travel and business travel by people who live, work, or were visiting an MSA jurisdiction. This includes all air passengers leaving from Ronald Reagan Washington National Airport (DCA) and Washington Dulles International Airport (IAD). COG estimates air travel passenger emissions for air passengers leaving from Baltimore-Washington International Thurgood Marshall Airport (BWI) by allocating emissions by the percentage of passengers traveling from COG member jurisdictions to the airport.

To estimate emissions per airport, national aircraft emissions are downscaled based on the local to national ratio of revenue passenger miles for BWI, DCA, and IAD. This approach does not account for aircraft emissions and air passengers that are, for instance, flying into IAD and taking a connecting flight elsewhere. For all originating air passengers departing from the region's three commercial airports – BWI, DCA, IAD – the biennial Washington-Baltimore Regional Air Passenger Survey provides readily available origin-destination data for base and forecast years. There is also readily available data on commercial aircraft emissions and passenger miles travelled for the airports serving the region through EPA and the Bureau of Transportation Statistics, respectively.

Commuter Rail

Commuter Rail Transportation calculates emissions resulting from Maryland Transit Administration (MTA) MARC and VRE trains carrying commuters from Maryland and Virginia. The Commuter Rail Transportation emission calculations generally follow the USCP recommended methodology as outlined in Appendix D, TR.4 from Version 1.2 of the Protocol. In this approach, emissions are calculated from annual diesel consumption of commuter rail operators.

Diesel consumption of commuter rail systems (code CR) is readily available via the Federal Transit Administration's (FTA) National Transit Database. MTA reports diesel consumption for their full commuter rail operations, some of which occur outside the MSA. MTA annual diesel consumption is attributed to the MSA by the percent of stations located in the MSA – 63 percent of MTA's MARC stations are in the MSA.

WASTE

Solid Waste

Landfill Waste Generation accounts for the emissions resulting from waste generated by the community in a year and disposed of at a landfill. The Landfill Waste Generation emission calculations follow the USCP recommended methodology as outlined in Appendix E, SW.4 from Version 1.2 of the Protocol. The calculations are based on tons of municipal solid waste (MSW) from local jurisdictions going to a landfill and whether the receiving landfills have methane capture. The EPA FLIGHT Tool was used to identify whether a landfill that regularly receives MSW from the region has methane collection. COG also gathered information on landfill methane collection efficiency from jurisdictions or landfill operators.

The Combustion of Solid Waste accounts for the emissions resulting from the tons of MSW generated by the community in a year and disposed of at a waste-to-energy (WTE) facility. The Combustion of Solid Waste Generated by the Community emission calculations follow the USCP recommended methodology as outlined in Appendix E, SW.2.2 from Version 1.2 of the Protocol.

The best available MWS data from local and regional sources was used to calculate these emissions. Unlike other activities in this inventory, there is no regional, state, or federal source of MSW data that comprehensively reports data in the way needed for GHG inventory calculations.

Wastewater

Septic Systems Emissions account for the fugitive emissions resulting from the physical settling and biologic activity during the treatment process in septic tanks. The Fugitive Emissions from Septic Systems calculations follow the USCP recommended methodology as outlined in Appendix F.WW.11 from Version 1.2 of the Protocol. The methodology estimates GHG emissions based on the population served by septic.

Sewer System Emissions accounts for N2O emissions during the treatment process at wastewater treatment plants (WWTPs). The Nitrification/Denitrification Process N2O Emissions from Wastewater Treatment calculations follow the USCP recommended methodology as outlined in Appendix F.WW.7 from Version 1.2 of the Protocol. The methodology estimates GHG emissions based on the population served by sewer.

N2O Effluent Discharge Emissions account for the emissions resulting from treated wastewater that flows out of a treatment facility and is discharged into waterways. The Process N2O from Effluent Discharge to Rivers and Estuaries calculations follow the USCP recommended methodology as outlined in Appendix F.WW.12 from Version 1.2 of the Protocol. The methodology estimates GHG emissions based on the population served by sewer and daily Nitrogen loads. Data inputs on Nitrogen loads are downloaded from EPA Chesapeake Bay Program's Chesapeake Assessment Scenario Tool (CAST). This data represents a simple average of the annual loads recorded by the Bay Program.

The Regional Wastewater Flow Forecast Model (RWFFM) and COG Cooperative Forecasts are leveraged to estimate populations served by sewer and septic. For jurisdictions not included in COG's Cooperative Forecast, population data is acquired from the ACS.

LAND USE

Agriculture

Emissions from agricultural activities include enteric fermentation, manure management, and ag soils. Enteric fermentation accounts for the methane produced from animal digestion in cows, sheep, goats, swine, and horses. Manure management accounts for emissions from management systems that stabilize or store livestock manure. Ag soils account for nitrous oxide (N2O) emissions from animals, crop production, and fertilizer application.

Agricultural sources and activities relevant to the MSA were calculated using EPA's State GHG Inventory Tool. MSA data inputs into the EPA's State GHG Inventory Tool are pulled at the county-scale from CAST. CAST is a web-based nitrogen, phosphorus, and sediment load estimator tool that streamlines environmental planning in the Chesapeake Bay watershed.

Forests and Trees Outside Forests

Forests and trees outside of forests sequester CO_2 during photosynthesis and act as a carbon sink. If removed, they can be a source of emissions. ICLEI's Land Emissions And Removals Navigator (LEARN) tool estimates the local GHG impacts of forests and trees outside of forests. This tool provides information on land cover, including forest cover and change. Forested areas are defined as greater than 1-acre while trees outside forests are individual trees or trees in small patches less than 1-acre. LEARN combines methods outlined in the U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions Appendix J with national and regional data sources to derive a first-order approximation of annual GHG impacts over a given time period. The time period analyzed for forests is 2013-2018 and is applied to the 2020 GHG inventory.

BAU Projections

BAU projections account for driving factors such as growth in population, housing and commercial development, and transportation patterns, and estimate the impact they will have on future GHG emissions. BAU projections reflect policies and practices that are currently in place and implemented to reduce GHG emissions, but do not incorporate any additional GHG emission reductions from anticipated future action. The assumptions and methodology for the BAU projections for each sector are described below.

RESIDENTIAL & COMMERCIAL BUILDINGS

Residential and commercial BAU emissions are projected to decrease 41% and 51%, respectively. The reductions are primarily driven by reductions in the grid emission factor (particularly in Virginia) and some energy efficiency improvements.

Residential

Year-over-year growth rates from AEO 2023 Table 2 for the Middle Atlantic region were applied to residential electricity, natural gas, fuel oil, and propane consumption from the 2023 inventory for COG jurisdictions and 2020 inventory for remaining jurisdictions. The electricity consumption projections were multiplied by the applicable emission factor for the state containing each jurisdiction (see Electricity Emission Factor section below).

Commercial

Utility data provided for the commercial sector includes electricity consumption for data centers and electric rail. Electricity consumption from these two subsectors were subtracted from the total commercial utility data to isolate other commercial electricity consumption. The method for calculating the data center and rail electricity consumption is described in the following sections.

Year-over-year growth rates from AEO 2023 Table 2 for the Middle Atlantic region were applied to remaining commercial electricity, natural gas, fuel oil, and propane consumption from the 2023 inventory for COG jurisdictions and 2020 inventory for remaining jurisdictions. The electricity consumption projections were multiplied by the applicable emission factor for the state containing each jurisdiction (see Electricity Emission Factor section below).

Data Centers

A 352% increase in electricity consumption by data centers is projected from 2020-2050. However, a 16% reduction in emissions from data center electricity consumption is projected from 2020-2050 primarily because of the reduction in electricity emission factor from the Virginia Clean Economy Act.

Data center electricity consumption estimates and projections carry a high degree of uncertainty. Data on actual data center electricity consumption and energy use intensity is not publicly available. Thus, historical, current, and future electricity consumption estimates are based on existing, permitted, and future expected data center square footage data provided by each locality and available in CoStar and a review of historical energy consumption. There are two exceptions: 1) Frederick County, MD, which provided projections based on the capacity of a planned data center campus, and 2) Loudoun County, VA, for which 2023 data center electricity consumption in NOVEC service territory was obtained from NOVEC and incorporated into the estimate for 2023 kWh total. The data center emissions also do not include emissions from backup generation, since this data is not publicly reported.

The Primary Methodology outlines the methodology used to estimate data center square footage in most cases, except for Loudoun County, Prince William County, and Frederick County. The methodologies for these counties are described later in this section.

Primary Methodology

Utility data was collected for total commercial sector electricity consumption for each locality. The commercial sector includes consumption for data centers, electric rail, and all other commercial uses. Electricity consumption from data centers and electric rail was subtracted from the total commercial electricity consumption. See the Rail BAU section of this appendix for more detail about this methodology. The section below describes the approach to apportion a share of the total commercial electricity use to data centers. Regardless of the amount allocated to this subcategory, total GHG emissions from the commercial sector are still based on the commercial sector electricity use data provided by utilities.

Data center electricity consumption for each year was estimated by multiplying the data center square footage by an estimated EUI, which is an estimate of the annual kWh of electricity consumed per square foot of data center. The EUI estimates are outlined in Table 15, and the method for estimating these EUIs is described below the table. Then, the electricity consumption was multiplied by the state's electricity emission factor to estimate projected emissions (see Electricity Emission Factor section below).

Table 15: Estimated Data Center EUIs Used in the Primary Methodology

Data Center Type	EUI
Existing Data Centers (already in operation by the end of 2023)	300 kWh/sqft – Equivalent to Loudoun County's estimated 2018 data center EUI
Projected New Data Centers (operational starting in 2024)	439 kWh/sqft – Equivalent to Loudoun County's estimated 2023 data center EUI

EUI Estimation

Existing and projected data center square footage was obtained via a survey sent to each locality in the MSA. Existing data center square footage was also obtained from CoStar. The CoStar data was used and held flat through 2050 for any locality that did not directly provide data.

Loudoun County's 2023 EUI was estimated based on the following:

- Dominion Energy's 15-year data center plan gauged Loudoun's share of its data center market at 74%.
- Dominion's 2023 Integrated Resource Plan (IRP) showed the utility's data center electricity consumption to be about 23 billion kWh in 2023.
- NOVEC provided Loudoun County with its 2023 electricity sales to data centers within the county in 2023.
- Loudoun reported to COG the total square feet of data centers in the county in 2023. Using the utility information above, Loudoun's 2023 EUI was calculated to be about 439 kWh/sqft.

This 439 kWh/sqft EUI was then applied to all projected new data center square footage for each locality, under the assumption that new data centers in the region will have a higher EUI than existing data centers.

Due to recent hyperscale data center development in Loudoun County, it's highly likely that the data centers in Loudoun County in 2023 have a higher EUI than in previous years within the county and in most other jurisdictions in the region. Thus, Loudoun's 2018 data center EUI was used to estimate data center electricity consumption from existing data centers in operation by the end of 2023. The 2018 value was chosen to represent the data center EUI prior to many hyperscale data centers coming online and incorporate data center electricity GHG estimates into the 2020 GHG inventory.

Loudoun County's 2018 data center EUI was estimated based on the following:

- The average 2018 non-data center commercial EUI, estimated using total utility electricity consumption and CoStar square footage data for all counties under COG jurisdiction except for Loudoun and Prince William Counties. It was assumed that Loudon's non-data center commercial electricity consumption can be represented by the regional average, as county-specific data was not available.
- Loudoun's 2018 non-data center commercial square footage from CoStar.
- Loudoun's 2018 non-data center commercial electricity consumption was then estimated from the above information and subtracted from the 2018 total commercial electricity consumption to find 2018 data center electricity consumption.
- The 2018 data center EUI was then estimated using the 2018 data center electricity consumption and 2018 data center square footage that Loudoun County reported to COG.

Loudoun County

Loudoun County's data center electricity consumption for 2020-2022 was estimated using the method described above for finding the county's the 2018 electricity consumption, but with 2020, 2021, and 2022 data. CoStar non-data center commercial square footage was only available for 2020 and 2023, so square footage was interpolated for 2021 and 2022. Loudoun's 2023 EUI of 439 kWh/sqft was applied to all projected new data center square footage in the county from 2024-2050.

Then, the electricity consumption was multiplied by Virginia's electricity emission factor to estimate projected emissions (see Electricity Emission Factor section below).

Prince William County

Prince William County's data center electricity consumption for 2020-2023 were estimated using the method described above for Loudoun County's 2018 electricity consumption. 2021 and 2022 data center electricity consumption were interpolated. Loudoun's 2023 EUI of 439 kWh/sqft was applied to all projected new data center square footage in the county from 2024-2050.

Then, the electricity consumption was multiplied by Virginia's electricity emission factor to estimate projected emissions (see Electricity Emission Factor section below).

Frederick County

Frederick County's data center electricity consumption projections based on square footage that Frederick County provided to COG were estimated by applying Loudoun's 2023 data center EUI of 439 kWh/sqft. However, in addition to the projected square footage, a planned data center campus is expected to be developed with a potential 2 GW capacity. This campus is expected to be fully operational by 2035. Since data centers within the campus are coming online over time, the available capacity was assumed to increase linearly to 2 GW through 2035 starting in 2026.

A capacity factor of 60% was applied to the available capacity each year to estimate the annual electricity consumption in kWh from that capacity. This means that on average, the data center campus was assumed to use power at 60% of its full capacity. The 60% capacity factor was derived based on a report from Lawrence Berkeley National Lab (LBNL), which showed server utilization for hyperscale and AI training data centers in the 50-80% utilization range. The actual capacity factor of the data center campus will depend heavily on what the servers are actually used for.

Then, the electricity consumption was multiplied by Maryland's electricity emission factor to estimate projected emissions (see Electricity Emission Factor section below).

LIMITATIONS AND UNCERTAINTIES

Key limitations of this analysis are a lack of available data regarding data center operations and renewable procurement activities and the fast moving nature of the industry. Notably, the following data would further reduce the uncertainty of the emission estimates for historical inventory years and should be continually evaluated over time as the industry evolves:

- Annual data center electricity use
- Planned and existing data center square footage
- Energy use intensity
- Fuel consumption for backup generation by fuel type
- Data center renewable energy purchases (e.g., through power purchase agreements for offsite renewable facilities located within the PJM region) and/or carbon offsets that are verified as being applied towards facilities located within the MSA

Because these data are mostly unavailable, the data center electricity consumption estimates and projections carry a high degree of uncertainty, as noted above.

Further, it is worth noting that this is one EUI applied for the whole region, and that published energy use intensities for data centers and are highly variable. These variations are driven by factors like data center types, ages of the data centers, and technology evolution. This presents a large level of uncertainty in the presented estimates.

While additional data availability would support inventory development, there is still a high degree of uncertainty for BAU projections. Information on potential growth in data centers was provided by localities, but whether they may actually be constructed is not certain, and their future operations and energy intensities are also unknown. Changes in technology for servers and IT equipment, efficiencies in AI, and how data centers source their energy (e.g., onsite resources as opposed to grid electricity) will all impact the projections of energy use and emissions going forward.

The current methodology also attributes emissions from data centers entirely to the local jurisdictions in which the data centers are located, in alignment with a consumption-based inventory framework. However, this does not represent where emissions are occurring on the electric grid to supply the power. Some of the disbenefits from emissive power plants are felt by communities outside the MSA.

FUTURE DATA TRACKING

Options for obtaining future data center information include:

- **Localities**: Localities may request data center electricity usage information from local utilities.
- **Local permitting:** Data center square footage (both permitted and applied for), and expected energy consumption if disclosure of expected energy use becomes required during permitting process.
- **EU reporting:** The European Union now requires data centers 500 kW and larger to report metrics including energy consumption, PUE, temperature set points, waste heat utilization, water usage, and usage of renewable energy. Tracking EU reporting will help COG compare U.S. and EU trends and developments.
- **MD and DC BEPS:** MD and DC both have BEPS programs that require large commercial facilities to report their energy and water usage. However, Maryland's BEPS currently exempts critical infrastructure and some data centers may apply for that exemption. Changes in state policies and regulations across the entire COG region in future years may lead to new avenues for data collection and transparency.
- Any future updates to LBNL United States Data Center Energy Usage Report.

ON-ROAD TRANSPORTATION

A 7% decrease in emissions from on-road transportation is projected from 2020-2050. A year-over-year growth rate from draft on-road transportation emission projections for TPB's Visualize 2050 plan was applied to the 2020 inventory emissions developed from NEI data.

OFF-ROAD TRANSPORTATION

Nonroad

Nonroad emissions were held flat at the most recent inventory value – 2023 for COG jurisdictions and 2020 for the rest of the MSA.

Aviation

Aviation emissions were projected using year-over-year growth rates derived from the FAA's airport enplanement forecasts for BWI, DCA, and IAD.

Rail

Commuter rail diesel emissions for the Maryland Transit Administration (MTA) and VRE systems were held flat at 2023 values.

Total WMATA electricity consumption was provided for DC, Montgomery County, Prince George's County, and the state of Virginia. Electricity consumption in Virginia was allocated to Arlington, Fairfax County, Alexandria, and Loudoun based on the number of stations in each county. Electricity consumption was held flat at 2024 levels through 2050, and the applicable electricity emission factor was applied for each state.

MTA electricity consumption for the Penn Line was allocated to DC and Prince Geroge's County based on the miles of Penn Line rail and train schedule in those jurisdictions. Electricity consumption was held flat at 2023 levels through 2050, and the applicable electricity emission factor was applied for each state.

Key Assumptions

- Nonroad activity does not change over time.
- Aviation does not get more efficient over time.
- Rail service does not change over time.

TRANSMISSION & DISTRIBUTION LOSSES

BAU emissions from T&D losses are projected to decrease 68% from 2020-2050 because of a reduction in the grid emission factor in the MSA.
A grid gross loss of 5.3% was assumed for the region and held constant over time. The kWh of electricity generated were calculated. Then the kWh of electricity lost was found by subtracting the kWh consumed from the kWh generated. The electricity lost was multiplied by the grid emission factor each year for each state to find the associated emissions.

NATURAL GAS FUGITIVE

BAU natural gas fugitive emissions are projected to decrease 4% from 2020-2050 because of a reduction in natural gas consumption.

Year-over-year growth rates from the total natural gas consumption across all sectors in the MSA were applied to the natural gas fugitive emissions in the 2023 inventory for COG jurisdictions and 2020 inventory for remaining jurisdictions. The leakage rate from the GHG inventory was held constant over time.

HFCS

BAU HFC emissions are projected to decrease 75% from 2020-2050 because of the low GWP refrigerant requirements in the American Innovation and Manufacturing (AIM) Act.

HFC emissions were projected from the 2023 inventory for COG jurisdictions and the 2020 inventory for remaining jurisdictions based on population growth forecasts from the Round 10.0 Cooperative Forecast. GHG reductions from the AIM Act, which will reduce the GWP of refrigerants in new refrigerated equipment, were also included in the BAU. 5% of the equipment population was assumed to be replaced each year (assuming a 20-year equipment lifespan), and new equipment was modeled to have a GWP reduction of 40% starting in 2025, 70% starting in 2029, 80% starting in 2034, and 85% starting in 2036, per AIM Act requirements.

AGRICULTURE

BAU emissions from the Agriculture sector are projected to increase over time, attributable to an increase in livestock. All dominant livestock populations increase over the time series (except sheep, goats, and horses). Total agriculture emissions are projected to increase 9.2% from 2020 to 2050. Emissions from Agricultural Soil Management – Fertilizer Application had the highest percent change, increasing by 23% over the timeseries. Enteric Fermentation retains the greatest share of agriculture sector emissions; its growth is driven by the increase in population of dominant species. Increasing emissions from Fertilizer Application over the timeseries are driven by increased production over time and increased fertilizer use.

Livestock

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

Population rates of change were based on USDA 2025 Baseline Projections. Livestock populations from 2021-2050 were estimated based on 2020 values, using the USDA's projected rates of change.

Agricultural Soils, Liming and Urea

Agricultural soils emissions include direct and indirect N_2O from nitrogen inputs to agricultural soils, including from synthetic and organic fertilizers, crop residues, and manure deposited by grazing animals. Activity data for N_2O from synthetic and organic fertilizers is based on 2020 data from the State Inventory Tool (SIT) (EPA, 2024), detailing the total synthetic fertilizer applied. For N_2O from manure deposited by grazing animals, 2020 SIT data provides the kilograms of nitrogen excretion (Nex) deposited annually onto pasture, range, and paddock (PRP) per animal head.

Agricultural soils emission factors and constants are sourced from the US GHG Inventory (EPA, 2024). For synthetic and organic fertilizers, 2020 emissions are calculated by multiplying the total amount of fertilizer applied by a direct N_2O emission factor. Indirect emissions are calculated by determining the fraction volatilized, leached, or lost via runoff using GHG inventory constants, then multiplying by an indirect emission factor. For manure deposited by grazing animals, Nex is multiplied by a direct N_2O emission factor. Indirect emissions are similarly calculated using the fraction volatilized, leached, or runoff, combined with the appropriate indirect emission factor.

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

Liming and urea methodology utilize data from SIT for 2020, and use the same surrogate data method as described above for agricultural soils. Activity data is multiplied by the emissions factor per unit of limestone, dolomite, or urea applied to derive emissions estimates.

For agricultural soils, liming, and urea, BAU input amounts were estimated by using USDA NASS regional fertilizer expense data (including lime and soil conditioners) as surrogate data for the annual rate of change of fertilizer use. Fertilizer and amendment amount for 2021-2050 were estimated using this rate of change from 2020 values developed using the methods described above. Emissions were estimated based on 2020 values as estimated per the methods described above.

Field Burning of Agricultural Residues (FBAR)

FBAR emissions were estimated based on 2020 wheat yield data (USDA NASS), and burning constants and parameters from SIT. Emissions estimates for crop residue burning are calculated using specific formulas for methane (CH_4) and nitrous oxide (N_2O). CH_4 emissions are determined by multiplying the crop yield by the residue-to-crop ratio, the fraction of residue burned, the fraction of dry matter, the burning efficiency, the carbon content, and the conversion factor from carbon to methane. Similarly, N_2O emissions are estimated by multiplying the crop yield by the residue-to-crop ratio, the fraction of residue burned, the fraction of dry matter, the burning efficiency, the nitrogen content, and the conversion factor from nitrogen to nitrous oxide.

For BAU projections, FBAR was estimated by determining a historical rate of change of wheat yield from USDA-NASS QuickStats data. Annual production was estimated from 2021-2050 using this rate of change applied to 2020 values.

Key Assumptions

- Livestock projection methods assumes the emissions factors, which are based on the most recent US GHGI (EPA, 2024), remain constant. Projecting changing emissions factors would require more sophisticated modelling that considers the key drivers of productivity gains; this approach is more appropriate for mitigation modelling.

Data Sources

- Population rates of change were based on USDA Baseline Projections (2025)
- All activity data is sourced from USDA NASS
- Weighted species emissions factors developed from US GHG inventory modelling which is state specific (U.S. EPA, 2024)

NWL

The ICLEI LEARN tool was used to estimate GHG impacts from forests and trees. LEARN applies methods from the ICLEI Greenhouse Gas Protocol's Appendix J and integrates national datasets to estimate annual emissions and removals over time. LEARN tracks land cover transitions using the National Land Cover Database (NLCD), assigning each 30-meter pixel a transition type (e.g., forest to nonforest, nonforest to forest). It also incorporates tree canopy cover and loss data outside of forests from the U.S. Forest Service, and disturbance data (e.g., fire, insect, harvest) from national sources. For trees outside of forests, LEARN uses Chesapeake Bay Program Land Cover Data (1 meter resolution) to estimate gains and losses in tree cover that is outside of forested lands.

Historical data was initially stored per jurisdiction and time frame. A script was developed to automate the extraction, reformatting, and consolidation of these datasets into a single output file for analysis. The full MSA projection is based on historical inventory trends by subsector. Localities with outlier trends were held flat to avoid skewing regional results. Source trends are primarily driven by forest conversion and disturbances, while sink trends are influenced by forest retention, tree canopy gains, and afforestation.

Key Assumptions

- Historical land cover and disturbance trends continue under BAU conditions.
- Localities with outlier or irregular trends are held constant, so they don't distort the regional trends.
- Tree canopy and forest cover data are accurate and consistently classified across time periods.
- LEARN's national datasets and default parameters are representative of local conditions.
- No additional policy or conservation interventions are assumed beyond current practices.

ELECTRICITY EMISSION FACTOR

Table 16 outlines the methodology for developing the BAU electricity emission factor for each state in the MSA.

Table 16. Grid Emission Factor Projection Approach

State	BAU Approach
MD	Derived from AEO 2023 Table 54 Total Electricity Generation and Carbon Dioxide Emissions, and eGRID CH4 and N_2O emissions for PJME region
VA	Emission factors used from Virginia State CCAP modeling, inclusive of VCEA net zero emission mandates for utilities
DC.	Average of VA and MD emission factor projections
WV	Derived from AEO 2023 Table 54 Total Electricity Generation and Carbon Dioxide Emissions, and eGRID CH4 and N_2O emissions for PJMW region

GHG REDUCTION MEASURE QUANTIFICATION

The following is a summary of methods used for calculating GHG emission reductions and costs in the COG CCAP. The methods outline a "what would it take" approach to reach net zero GHG emissions by 2050 and include aggressive but feasible strategies and assumptions. In some instances, existing modeling efforts were used. The sections below detail the modeling approaches and assumptions used for each sector and measure to assess the potential GHG reductions and costs for the net zero CCAP Implementation Scenario.

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

- **Capital Expenses** associated with the upfront investment costs to implement a measure, including investments in infrastructure, equipment, or technology.

- **Operational Expenses** linked to the execution of each measure, including recurring costs required to operate and maintain the measure, as well as any changes in ongoing expenditures or savings resulting from its implementation, such as variations in fuel and electricity use, or incentives deployed to support the measure.

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

Buildings and Clean Energy

Table 17. Summary of Building and Clean Energy Sector CCAP Measure GHG Reductions MMTCO₂e

Sector	Measure	Cumulative 2025-2030 GHG reductions	Cumulative 2025-2050 GHG reductions
Buildings and Clean Energy	Accelerate the deployment of energy efficiency solutions and decarbonization of residential, institutional, municipal, and commercial buildings.	18.59	187.20
Buildings and Clean Energy	Accelerate the deployment of local renewable energy.	4.79	25.02
Buildings and Clean Energy	Study, plan for, and deploy district energy and microgrid opportunities.	0.01 - 0.38	0.25 - 0.84
Buildings and Clean Energy	Data center solutions.	3.17	45.81

ACCELERATE THE DEPLOYMENT OF ENERGY EFFICIENCY SOLUTIONS AND DECARBONIZATION OF RESIDENTIAL, INSTITUTIONAL, MUNICIPAL, AND COMMERCIAL BUILDINGS

This measure covers energy efficiency and electrification improvements for both existing and new buildings. The GHG reduction modeling is split into two separate categories: existing buildings and new buildings. Modeling results for each category are discussed separately below. Table 18 shows the reductions from the two categories.

Table 18. Annual and Cumulative GHG Reductions ($MMTCO_2e$), 2025-2050

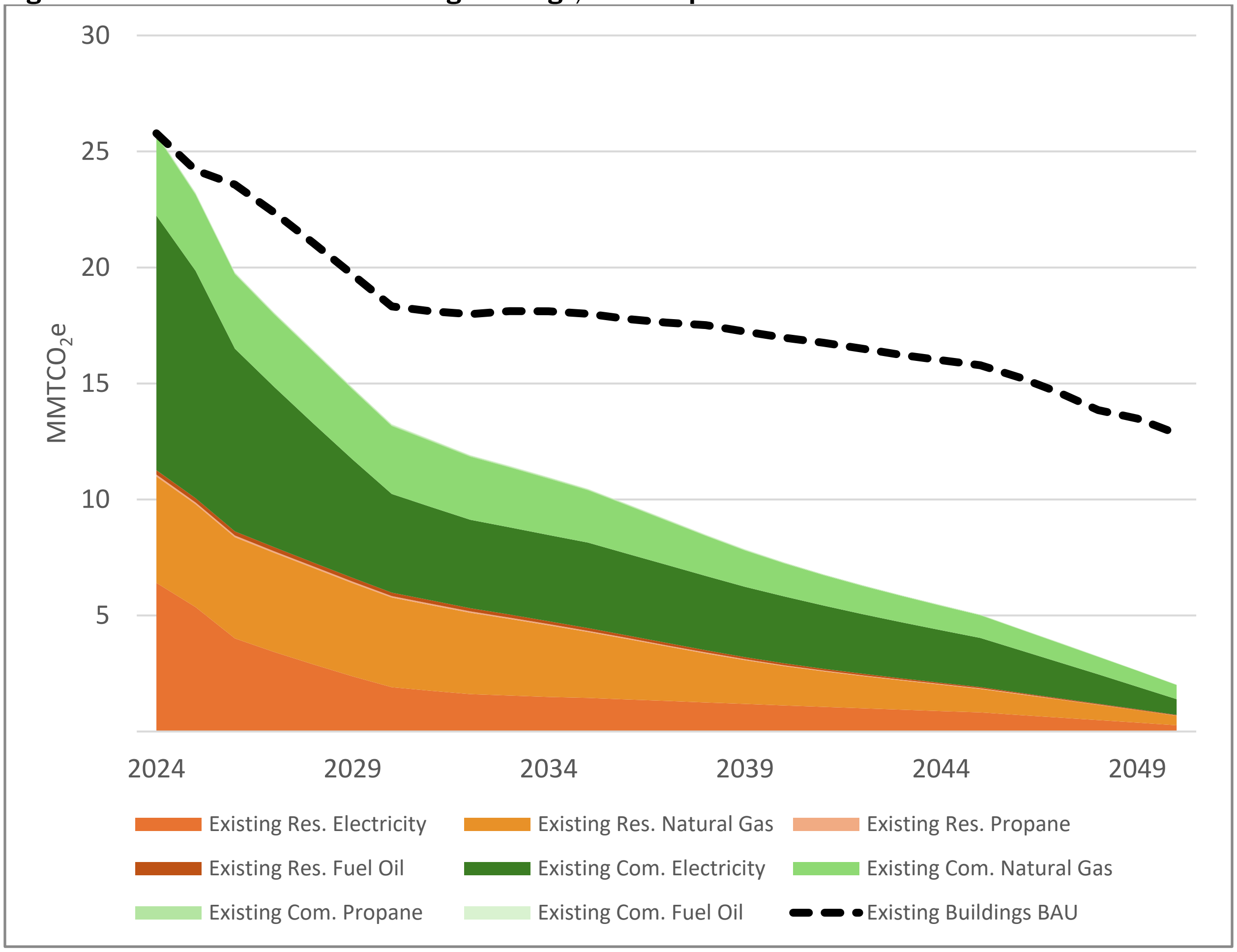
$MMTCO_2e$	2025	2030	2035	2040	2045	2050	2025-2050
Existing Buildings	0.09	4.19	6.53	8.59	9.63	9.97	181.16
New Buildings	N/A	0.05	0.17	0.30	0.43	0.44	6.04

Note: Scope 2 impacts from a cleaner electric grid are included in emission reductions.

EXISTING BUILDINGS

Figure 13 shows the projected decrease in emissions over time from building electrification, incorporating the additional emission reductions obtained from grid decarbonization and RNG.

Figure 13. GHG Emissions from Existing Buildings, CCAP Implementation Scenario



METHODOLOGY

Emissions reductions from increasing electrification and energy efficiency in existing residential and commercial buildings were estimated using ICF's proprietary Distributed Energy Resources Planner (DER Planner) tool. DER Planner models changes in energy consumption and associated emissions by simulating a suite of retrofit measures, including space heating and water heating electrification, building envelope improvements, building controls, efficient appliances and lighting. Assumptions on equipment performance, lifetimes, and achievable energy savings were drawn from a variety of sources, including NREL, EIA, the Northeast States for Coordinated Air Use Management (NESCAUM), state technical reference manuals, energy potential studies, and ICF's program experience.

Technology adoption curves in DER Planner were based on NREL's Electrification Futures Study (EFS) and expert judgment. These curves account for factors including capital costs, infrastructure readiness, ownership type, policy incentives, and market adoption potential. For this category, high-electrification adoption curves were selected to represent an accelerated transition to electric technologies through 2050, in alignment with NREL's High Electrification scenario. Assumptions were further refined to reflect regional market and policy drivers, including BEPS adopted in Maryland and DC, the VCEA, and net-zero emission targets.

Energy savings were estimated using county-level building stock data from NREL's ResStock and ComStock datasets, which integrate public and proprietary datasets, statistical sampling methods and high-performance computing to simulate detailed building characteristics. Electrification and energy efficiency retrofits were applied across a mix of building types found in COG's building stock, including single-family homes, multi-family homes, office buildings, schools, retail stores, restaurants, hospitals, and warehouses. For each building type, retrofit savings were evaluated using ICF's CO_2Sight measures database and upgrade packages from ResStock and ComStock. To ensure consistency with COG's GHG inventory, baseline energy consumption outputs from ResStock and ComStock were reweighted to align with county-level fuel consumption. Key assumptions include:

- Systems are assumed to be either replaced in kind, upgraded to more efficient models, or converted to electric alternatives as they reach the end of their useful life.
- Electrification measures include end-of-life electrification for space heating, water heating, cooking, and drying end-uses.
- Energy efficiency measures include the conversion of space and water heating equipment to high-efficiency alternatives, building envelope improvements, HVAC controls, efficient appliances and lighting.
- Technology adoption curves were primarily based on the EFS High Adoption scenario and supplemented with expert judgment and regional studies, including NESCAUM's report on Residential Building Electrification in the Northeast and Mid-Atlantic. Assumptions were further refined to align with state-level policies and targets, including Maryland and DC's BEPS, statewide net-zero emission targets, Maryland's Clean Heat Standard, and the VCEA.

Limitations include:

- Modeling assumes consistent adoption rates within each residential building type, without explicitly accounting for differences by income level, tenure, or housing vintage. In reality, adoption rates are likely to vary across single-family and multifamily residences, due to differences in decision-making structures, retrofit feasibility, and financing options.
- Baseline commercial energy use reported in ComStock is lower than COG's GHG inventory. Samples were reweighted to match county fuel consumption, which assumes ComStock underrepresents some commercial buildings. If instead the gap reflects uses outside ComStock's scope, emissions reductions may be overstated.
- Technology adoption curves are based on NREL's 2017 EFS. These curves may not accurately reflect more recent market dynamics or policy shifts.

Data sources include:

- NREL ResStock v2024.2
- NREL ComStock v2024.1
- EIA's Updated Building Sector Appliance and Equipment Costs and Efficiencies Report
- NREL's National Residential Efficiency Measures Database
- NREL's EFS
- NESCAUM's report on Residential Building Electrification in the Northeast and Mid-Atlantic
- EIA Annual Energy Outlook 2023

COST APPROACH

The range of costs that building owners and occupants may incur when implementing energy efficiency measures in buildings were evaluated. These include both the upfront capital investments required to install new equipment and the long-term impacts on customer utility bills resulting from changes in electricity and fuel consumption after installation. The analysis does not account for other potential cost elements such as annual maintenance costs, program administration expenses, the effects of rebates and incentives, or avoided fuel infrastructure costs.

Capital expenses were estimated by multiplying the number of technology units installed each year by the incremental cost of replacing baseline systems with efficient or electric alternatives. In the residential sector, costs were calculated on a per-home basis. In the commercial sector, costs were modeled based on building attributes such as HVAC system tonnage, floor area, and building type, as represented in ComStock. All capital costs were assumed to occur at the time of equipment replacement, consistent with adoption curves and equipment lifetime assumptions. Once equipment had been upgraded to an electric system, future replacements were assumed to be like-for-like exchanges (e.g., a heat pump replaced with another heat pump). In these cases, no additional incremental cost was applied.

To develop equipment cost estimates, ICF consulted multiple sources for each equipment category, including national studies, state-specific assessments, and utility potential studies. Sources were evaluated based on technology coverage and efficiency assumptions, publication date and relevance, and regional applicability. The U.S. EIA's Updated Building Sector Appliance and Equipment Costs and Efficiencies Report (2023) was used most frequently, due to its breadth of equipment types and inclusion of efficiency tiers. Cost trajectories for heat pumps were drawn from NREL's EFS Moderate Technology Advancement case, while costs for all other systems were assumed to remain constant over time.

State-specific cost estimates for residential HVAC heat pumps were drawn from *NESCAUM's Heat Pumps in the Northeast and Mid-Atlantic: Costs and Market Trends (2024).* Labor and equipment costs were adjusted using RS Means City Cost Indexes to generate regional cost estimates. Incremental heat pump costs were calculated relative to the avoided cost of both space heating and cooling equipment in homes with existing air conditioning systems. For homes without existing AC, incremental costs were calculated relative to heating equipment only.

Energy costs and savings associated with electrification and energy efficiency were estimated using projected energy use and retail fuel prices from EIA. To represent regional electricity and natural gas prices, ICF developed a blended rate based on a weighted average of state-level retail prices across the four states in the region. All fuel prices were escalated over time using growth rates from EIA's Annual Energy Outlook 2025, Table 3.

Table 19. Total Net Costs for Existing Buildings, Cumulative 2025-2050 (2025$ Million)

Cost Segment	Upfront Costs	Operating Costs	Total Net Costs
Residential Electrification	$6,116	$2,568	$8,683
Residential Efficiency	$4,946	$(8,291)	$(3,346)
Commercial Electrification	$8,120	$(725)	$7,395
Commercial Efficiency	$1,828	$(3,426)	$(1,598)
Total Net Costs	**$21,009**	**$(9,875)**	**$11,135**

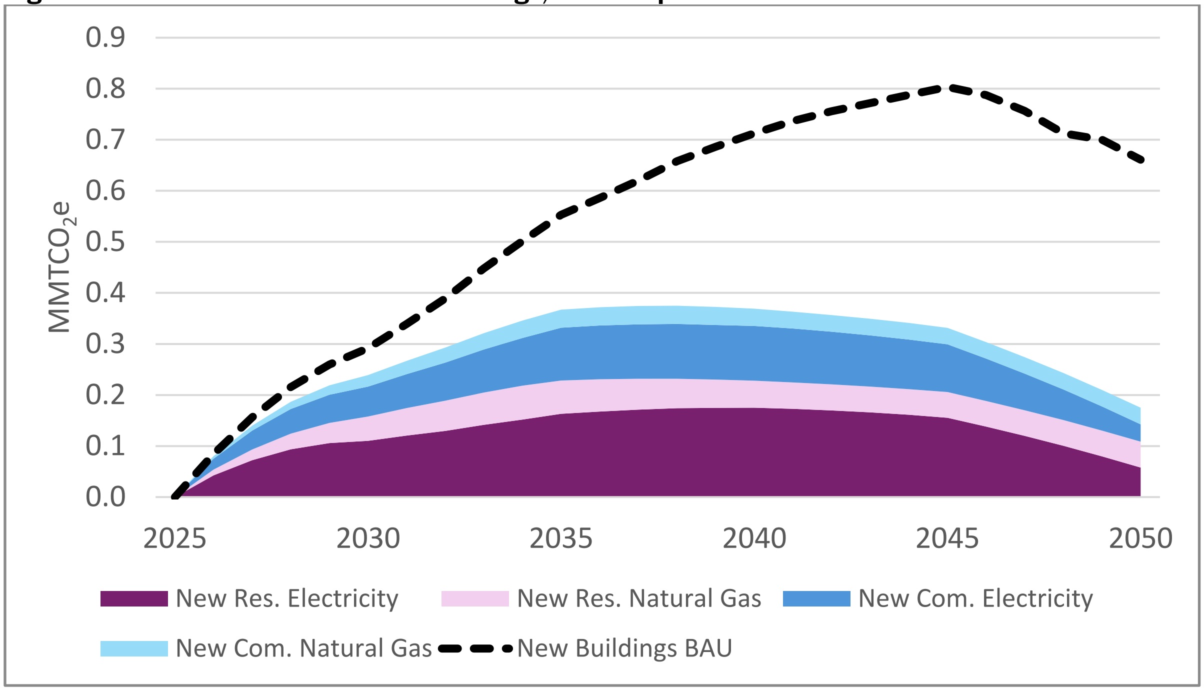
Cost data sources include:

- Average 2024 retail electricity price: EIA-861
- Average 2024 natural gas price: EIA Natural Gas Prices
- Average 2024 fuel oil and propane price in South Atlantic region: EIA's Annual Energy Outlook 2025, Table 3.5
- Projected growth rates for electricity and fuel prices in the South Atlantic region: EIA's Annual Energy Outlook 2025, Table 3.5
- Residential space heating/cooling: NESCAUM Heat Pumps in the Northeast and Mid-Atlantic – Costs and Market Trends; EIA's 2023 Technology Forecast Updates; RMI Green Upgrade Calculator; NREL Residential Measures Database
- Residential water heating: RMI Green Upgrade Calculator; NREL Residential Measures Database
- Residential cooking equipment: RMI Green Upgrade Calculator
- Residential lighting: Dominion Virginia Energy Efficiency Potential Study (2024); EIA's 2023 Technology Forecast Updates
- Residential appliances: NREL Residential Measures Database; Dominion Virginia Energy Efficiency Potential Study (2024)
- Residential building envelopes: RSMeans 2025 Residential Costs Data
- Commercial space heating/cooling: EIA's 2023 Technology Forecast Updates
- Commercial water heating: EIA's 2023 Technology Forecast Updates
- Commercial cooking equipment: RSMeans 2025 Commercial Renovation Costs Data
- Commercial interior lighting: NEEA 2022 LLLC Incremental Cost Study
- Commercial wall and roof insulation: RSMeans 2025 Commercial Renovation Costs Data
- Commercial window replacements: CalNEXT Commercial Windows Market Study

NEW BUILDINGS

Figure 14 illustrates the trends in BAU and mitigation scenario emissions for new buildings across the projection period.

Figure 14. GHG Emissions from New Buildings, CCAP Implementation Scenario



METHODOLOGY

Emissions reductions from increasing energy efficiency in new construction beginning in 2026 were estimated based on projected improvements in building energy codes, along with state/district-specific energy and emissions standards. Also incorporated into the new buildings modeling is a range of broader new building electrification. It is assumed that the states/district comprising the COG region adopt updates to the International Energy Conservation Code (IECC) and the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) 90.1 standards at regular intervals from 2026 through 2050, with code compliance assumed for all new buildings based on a 30-year measure life. For COG regions in Virginia and Maryland, fossil fuel combustion phase-outs are assumed in later projection years. A certain percentage of buildings are also assumed to be built to a green buildings code. Detailed state/district-specific modeling inputs can be found in the Assumptions section below. Key assumptions include:

- Energy code compliance was assumed for all new buildings based on a 30-year measure life.
- New residential home growth was based on household growth rates provided by COG; commercial construction growth projections were based on labor projections and commercial square footage per labor growth estimates provided by COG.
- The percentage of residential properties categorized as multi-family properties as provided by COG was kept flat through the projection period for each city/county.
- Multi-family residential building energy usage was modeled to be 50% of single-family usage, based on EPA data.

Additional state/district-level assumptions below:

- Virginia / West Virginia
  - Updated IECC and ASHRAE 90.1 standards are adopted every six years.
  - Fossil fuel combustion phase-outs for new buildings begin in 2035 for the residential sector and 2040 for the commercial sector.
  - The residential green buildings standard corresponds to Passive House standards, reflecting all-electrified homes meeting a 13.6 kBtu/ft2 site EUI and decreasing in line with energy code progression. 1% of new homes are assumed to comply with the standard in 2026, growing linearly to 15% by 2050.
  - The commercial green buildings standard corresponds to a Portfolio Manager ENERGY STAR score of 90, reflecting all-electrified buildings meeting a 28.4 kBtu/ft2 site EUI and decreasing in line with energy code progression. 1% of new commercial square footage is assumed to comply with the standard in 2026, growing linearly to 25% by 2050.
- Maryland
  - Updated IECC and ASHRAE 90.1 standards are adopted every three years.
  - In alignment with BEPS, buildings over 35,000 square feet must achieve zero net direct GHG emissions by 2040. ICF assumed that 90% of new commercial and multi-family buildings will exceed this threshold, and modeled these buildings as fully electrified beginning in 2026.
  - Reflecting Maryland's net-zero emissions by 2045 target and proposed Clean Heat Standard and Zero-Emission Heating Equipment Standard, fossil fuel combustion phase-outs are modeled as being 95% complete by 2035 for all remaining new residential buildings and by 2040 for all remaining new commercial buildings. The remaining 5% reflects hard-to-electrify buildings/locations, which are fully electrified by 2040 and 2045 for new residential and commercial buildings, respectively.
  - The residential green buildings standard corresponds to Passive House standards, reflecting all-electrified homes meeting a 13.6 kBtu/ft2 site EUI and decreasing in line with energy code progression. 1% of new homes are assumed to comply with the standard in 2026, growing linearly to 15% by 2050.
  - The commercial green buildings standard corresponds to a Portfolio Manager ENERGY STAR score of 90, reflecting all-electrified buildings meeting a 28.8 kBtu/ft2 site EUI and decreasing in line with energy code progression. 1% of new commercial square footage is assumed to comply with the standard in 2026, growing linearly to 25% by 2050.
- Washington DC
  - Updated IECC and ASHRAE 90.1 standards are adopted every three years.
  - All new buildings are assumed to be fully electrified beginning in 2026 to meet the District's net-zero new construction standard.

Limitations include:

- New buildings projections are heavily dependent upon household and commercial square footage growth rates. Changes to these rates will correspond to similar changes in emissions reductions. Commercial square footage growth rates were estimated based on employment growth across the region. More detailed studies into the types of projected employment and their correspondence to commercial building growth may give a more accurate estimation of square footage growth.

- The new buildings modeling is simplified by only accounting for the fuel usage and EUI per residential home or commercial square foot. In actuality, there are numerous types of housing (detached vs. attached single family homes, multifamily buildings with a variety of units, etc.) as well as many different types of commercial buildings (offices, hospitals, schools, industry, etc.) that ICF's modeling cannot reasonably account for. As such, deviations in energy usage based on the growth rates of different types of buildings are to be expected. EUI is also a simplified annual metric that does not take into account specific building equipment types. ICF's modeling assumes that increases in equipment efficiencies are expected to continue, but future energy consumption may be higher if this assumption changes (such as due to state/district or federal policies, economic/technological limitations, or other barriers).
- The projected split between single-family and multi-family housing in the region will also affect the energy consumption of new buildings. ICF used recent county/city-level data provided by COG and kept these values flat through the projection period; however, further state/district policies as well as demographic/land usage shifts have the potential to alter these projected trends.

Data sources include:

- COG Round 10.0 Cooperative Forecast
- ICF Energy Codes Tool
- PNNL code cost effectiveness studies (VA, MD, DC)
- State/district requirements
- Passive House and ENERGY STAR standards

COST APPROACH

For new buildings, costs were split out between upfront costs and operational costs (reflecting energy usage change). Upfront costs were split between code improvements and additional stretch/green buildings code costs.

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

To reflect the additional costs of a stretch/green buildings code (including Washington DC's net-zero new construction standard[60]), ICF modeled new residential buildings meeting this additional standard as achieving Passive House EUI requirements. Costs for Passive House implementation were sourced from Passive House Institute U.S. ("Phius") cost data research, with state/district new construction cost estimates sourced from Home-Cost. New commercial buildings were modeled to meet EUI standards corresponding to a Portfolio Manager ENERGY STAR score of 90, with cost estimates derived from studies by Built Environment Plus and BR+A, along with construction cost estimates from RSMeans.

[60] Note: ICF's Energy Code Tool projects that new commercial buildings will already meet Maryland's BEPS program requirements under standard code progression, so costs for these buildings are projected under the standard code improvement pathway.

Upfront code improvement costs for new buildings are commonly financed as an increase in the mortgage/loan amount; at least in the near-term, annual energy cost changes will typically exceed the increase in amortized upgrade costs, resulting in positive monthly cash flows for owners when applying more stringent energy codes.

Energy cost savings from new building measures were calculated based on changes in fuel and electricity consumption relative to baseline code-compliant construction. Fuel prices were sourced from the U.S. EIA and escalated using growth rates from EIA's Annual Energy Outlook 2025 (Table 3), consistent with the approach for existing buildings.

Table 20. Total Net Costs for New Buildings, Cumulative 2025-2050 (2025$ Million)

Costs	2025 - 2050
Upfront Costs	$4,102
Operating Costs	$(1,772)
Net Costs	$2,330

Cost data sources include:

- Residential code improvement cost estimates: Virginia, Maryland, Washington D.C.
- Residential green buildings/stretch code cost estimates: PHIUS Cost Data Research Report, Home-Cost new housing construction data
- Commercial code improvement cost estimates: Virginia, Maryland, Washington D.C.
- Commercial green buildings/stretch code cost estimates: Built Environment Plus MA Net Zero Report, BR+A case studies, RSMeans new construction costs and state-level scaling factors
- Operating costs: Modeling results combined with EIA fuel price projection data from Table 5.

ACCELERATE THE DEPLOYMENT OF LOCAL RENEWABLE ENERGY.

This measure quantifies the GHG emission reductions associated with increased local grid-connected and rooftop solar deployment in the MSA. This measure builds from existing progress in the region and incorporates COG's goal for 250,000 solar projects by 2030. Beyond GHG emission reductions, solar–particularly onsite systems paired with battery storage–can help lower household energy bills and increase resiliency to grid outages. By 2050, the MSA has nearly 4.8 GW of installed solar capacity, up from 1.1 GW in 2024.

The modeling for this measure is based on COG goals and NREL datasets and reports identifying rooftop solar technical potential by state, market and economic adoption potential, and estimates of rooftop square footage area for residential and commercial buildings by county from EIA's ResStock and ComStock datasets.

The modeling process to assess solar adoption uses data on 1) rooftop area available for solar, 2) solar output potential and 3) the adoption rate.

1. The available rooftop area is from NREL's 2016 Rooftop Potential Study, which includes state-level roof area suitable for solar for residential (small) and commercial (medium-large) systems. This is downscaled to the county level using EIA RECS and CBECS rooftop area for residential and commercial buildings.
2. The NREL dataset also provides the kW/m2 solar output potential for the roof area.

3. Using the county rooftop area and solar output potential, NREL defines a technical potential for rooftop solar. NREL DG Solar and Storage Outlook, EFS 2021 provides adoption scenarios. ICF selected the aggressive "Advanced PV" adoption scenario, which achieves a 20% adoption rate (of technical potential) as an average across the MSA. Based on the COG goals described below, some localities end up with solar deployment that is greater than the 20% adoption rate.
4. The avoided emissions from solar were estimated based on the net zero grid emissions factor used in the CCAP Implementation Scenario.

In addition to meeting those trajectories for the MSA, COG counties were also assumed to meet the goal of 250,000 solar installations by 2030. To estimate the additional capacity needed to meet the goals, data on the number and capacity of existing solar installations in the region was used to determine the gap to 2030. Initial data for 2024 showed nearly 93 thousand installations in the region providing about 1 GW of capacity, resulting in an average system size of 11.1 kW. This system size was used to add the additional systems needed to reach 250,000 by 2030.

Limitations include:

- Using the NREL data and adoption rate for rooftop solar is an imperfect proxy to estimate the potential for solar growth in the region alongside COG's goals. In reality, systems will have varying sizes, and large (>20 MW) front-of-the-meter installations can increase the pace of solar deployment compared to residential rooftop installations (which average 7-8 kW per home).
- Actual adoption rates will be influenced by a range of factors, including the cost-effectiveness of solar installations, the efficiency of permitting and regulatory approval processes, and the ease of grid interconnection. Ongoing market uncertainties—such as fluctuations in clean energy tax incentives, tariffs, and broader economic conditions—will play a significant role in determining the real-world impact of this measure.

Data sources include:

- NREL's 2016 Rooftop Potential Study
- NREL DG Solar and Storage Outlook, EFS 2021
- EIA RECS and CBECS

COST APPROACH

To estimate the cost of deploying solar, NREL's 2024 Annual Technology Baseline was used for forecasts of capital and operating costs for residential and commercial distributed solar systems. These costs were applied to the incremental capacity added in each year of the forecast. In addition, potential bill savings were also estimated based on projected retail rates from EIA's 2025 Annual Energy Outlook, which were projected through 2050 based on EIA's Annual Energy Outlook trends. On net, total potential electricity bill savings outweigh the capital costs and operating expenses.

Table 21. Total Net Costs for Solar Cumulative 2025-2050 (2025$ Million)

Costs	2025 - 2050
Total Costs	$763
Total Savings	$979
Net Costs	$(216)

Cost Data Sources include:

- 2024 NREL Annual Technology Baseline Moderate scenario CAPEX and Fixed O&M costs for residential and commercial distributed solar resources
- Average 2024 retail electricity price: EIA-861
- Projected growth rates for electricity and fuel prices in the South Atlantic region: EIA's Annual Energy Outlook 2025

DATA CENTER SOLUTIONS

No specific modeling was conducted to change data center energy use; the reductions only reflect the impact from an increasingly clean grid.

STUDY, PLAN FOR, AND DEPLOY DISTRICT ENERGY AND MICROGRID OPPORTUNITIES.

In 2011, COG worked with FVB Energy Inc to study potential benefits and costs of generalized example district energy systems in the region. This report, "Development of Cost Benefit Information and Business Case for Integrated Community Energy Solutions, Final Report" analyzed the benefits of the application of various generalized example district energy system types to a comparison building. Table 22 below presents information from this study in terms of energy consumption differences between applied district systems and the comparison building, emission factors used for the year 2025, and conversion factors used to arrive at annual GHG emissions and GHG reductions for different system types.

Table 22: DE System Types

Annual DE System Energy Consumption	Boilers and chillers	Engine CHP	Turbine CHP	Combined cycle CHP	Biomass Boiler	GSHP	Waste Heat	Solar
Gas (MMBtu)	339,845	1,335,623	1,118,251	1,442,068	49,319	94,763	150,313	261,856
Grid power (MMBtu)	256,223	(1,266,944)	(737,520)	(1,493,840)	215,443	489,447	256,223	256,223
Annual Comparison Building Energy Consumption								
Gas (MMBtu)	335,616	335,616	335,616	335,616	335,616	335,616	335,616	335,616
Grid power (MMBtu)	254,853	254,853	254,853	254,853	254,853	254,853	254,853	254,853
% Change in Annual Energy Consumption with DE System	1%	-88%	-36%	-109%	-55%	-1%	-31%	-12%
Conversion and Emission Factors								
kwh/ MMBtu	293.071070							
MTC02e/ MMBtu (gas)	0.053115							
$MTCO_2e$/kwh (grid power, 2025)	0.00027							
$MTCO_2e$/kwh (grid power, BAU, 2025)	0.00029							
Annual DE System GHG Emissions								
Gas ($MTCO_2e$)	18,051	70,941	59,395	76,595	2,620	5,033	7,984	13,908
Grid power ($MTCO_2e$)	20,130	(99,535)	(57,942)	(117,361)	16,926	38,453	20,130	20,130
Annual Comparison BAU Building GHG Emissions								
Gas ($MTCO_2e$)	17,826	17,826	17,826	17,826	17,826	17,826	17,826	17,826
Grid power ($MTCO_2e$)	21,711	21,711	21,711	21,711	21,711	21,711	21,711	21,711
% Reduction in Annual GHG Emissions with DE System	-3%	-172%	-96%	-203%	-51%	10%	-29%	-14%

Transportation

Table 23. Summary of Transportation Sector CCAP Measure GHG Reductions MMTCO$_2$e

Sector	Measure	Cumulative 2025-2030 GHG reductions	Cumulative 2025-2050 GHG reductions
Transportation	Provide and promote new and expanded opportunities to reduce VMT through public transportation, non-motorized travel, micromobility, shared travel options, and development.	0.94	2.65
Transportation	Accelerate the deployment of low- and zero-emissions transportation, fuels, and vehicles.	10.70	203.37
Transportation	Accelerate the deployment of off-road/non-road electric equipment.	0.21	1.65

PROVIDE AND PROMOTE NEW AND EXPANDED OPPORTUNITIES TO REDUCE VMT THROUGH PUBLIC TRANSPORTATION, NON-MOTORIZED TRAVEL, MICROMOBILITY, SHARED TRAVEL OPTIONS, AND DEVELOPMENT.

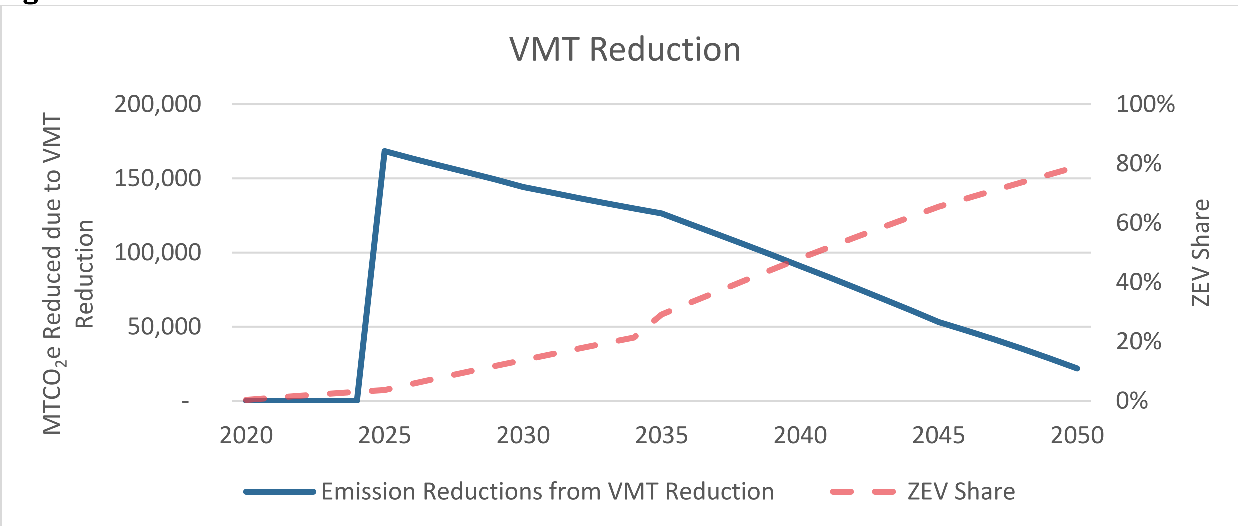
The measure models the resulting GHG emissions reduced if the MSA achieves the VMT reductions modeled for scenario MS.4 of the TPB Climate Change Mitigation Study of 2021: Additional Transportation Scenarios Analysis. This scenario models a variety of strategies to reduce VMT, including land use changes, reduction in transit travel times, telework, and increased walk and bike access, and uptake of micromobility. The MS.4 scenario from this study results in a possible 1.8% VMT reduction and 3.0% VMT reduction from BAU VMT levels by 2030 and 2050, respectively, across all COG jurisdictions. This scenario was chosen because TPB has adopted this scenario.

Table 24. Annual and Cumulative GHG Reductions (MMTCO$_2$e), 2025-2050

MMTCO$_2$e	2025	2030	2035	2040	2045	2050	2025-2050
VMT Reduction	0.17	0.14	0.13	0.09	0.05	0.02	2.65

Figure 15. shows the level of annual emission reductions through 2050 as a result of this measure.

Figure 15. GHG Reductions Due to VMT Reduction



A notable result is that after 2030, despite a modeled increase in VMT reduction, emission reductions from VMT reduction decrease. This is because of the fast pace of electrification modeled. As more and more vehicles are electrified and powered by cleaner electricity, this reduces the potential for additional GHG reductions from VMT reduction. In theory, if all vehicles were electrified and powered by clean electricity, any amount of VMT reduction would not result in further emission reductions.

METHODOLOGY

A VMT reduction schedule was developed that assumes a 1.8% VMT reduction by 2030 and 3.0% VMT reduction by 2050. Reductions were assumed to begin in 2025 and were linearly interpolated in interim years. VMT, energy consumption, and emissions after ZEV adoption and clean fuels phase in were reduced by the VMT reduction percentage each year for light duty vehicles and motorcycles only. Reductions were applied evenly for COG jurisdictions. No VMT reduction was modeled for the other rural counties in the MSA. Key assumptions include:

- VMT reductions are applied evenly across COG jurisdictions.
- VMT is not changed in rural counties in the MSA outside of the COG region.

Limitations include:

- It is unlikely that VMT reductions will actually occur evenly across all COG jurisdictions. However, the MS.4 scenario from the TPB Climate Change Mitigation Study was modeled as a total reduction across the localities, rather than for each locality individually.
- Data on possible VMT reductions for each locality was not available.

COST APPROACH

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

Based on the analysis of representative projects, ICF estimated the capital cost of transit and active transportation investments at $4.35 per VMT reduced. This includes infrastructure development such as bike lanes, pedestrian pathways, and e-bike programs.

The operations and maintenance costs were estimated at $3.03 per VMT reduced. This includes ongoing expenses such as transit incentives (free fare), improved transit service operation, and equipment maintenance necessary to sustain the VMT reductions over time.

Table 25. Total Net Costs for VMT Reduction, Cumulative 2025-2050 (2025$ Million)

Costs	2025 - 2050
Capital Costs	$89,372
Operating Costs	$57,351
Total Net Costs	$146,723

Cost data sources include:

- Projected fuel costs and electricity prices: EIA's Annual Energy Outlook 2025, Table 3
- Vehicle maintenance costs: AFLEET (Alternative Fuel Life-Cycle Environmental and Economic Transportation)

ACCELERATE THE DEPLOYMENT OF LOW- AND ZERO-EMISSIONS TRANSPORTATION, FUELS, AND VEHICLES.

This measure covers on-road vehicle electrification and fuel switching for on- and off-road transportation. The GHG reduction modeling is split into four separate categories: ZEV adoption, on-road alternative diesel fuels, sustainable aviation fuel (SAF), and off-road alternative diesel fuels. Modeling results for each category are discussed separately below. Table 26 shows the reductions from each of the four categories.

Table 26. Annual and Cumulative GHG Reductions ($MMTCO_2e$), 2025-2050

$MMTCO_2e$	2025	2030	2035	2040	2045	2050	2025-2050
ZEV Adoption	1.73	1.57	3.46	6.14	9.93	13.88	151.83
On-Road Alternative Diesel Fuel	0.13	0.17	0.83	1.20	1.28	1.03	20.88
Sustainable Aviation Fuel	N/A	0.06	0.32	0.92	1.15	1.30	16.19
Off-Road Alternative Diesel Fuel	-	-	0.34	0.69	1.03	1.38	14.48

Note: Scope 2 impacts from a cleaner electric grid are included in emission reductions.

ZEV ADOPTION

This category quantifies the emission reductions that result from increasing the use of zero-emission vehicles (ZEVs) including battery electric vehicles (BEVs), plug-in hybrids (PHEVs), and hydrogen fuel cell electric vehicles (FCEVs). ZEV adoption is modeled to occur at the following rates, with a linear ramp up period:

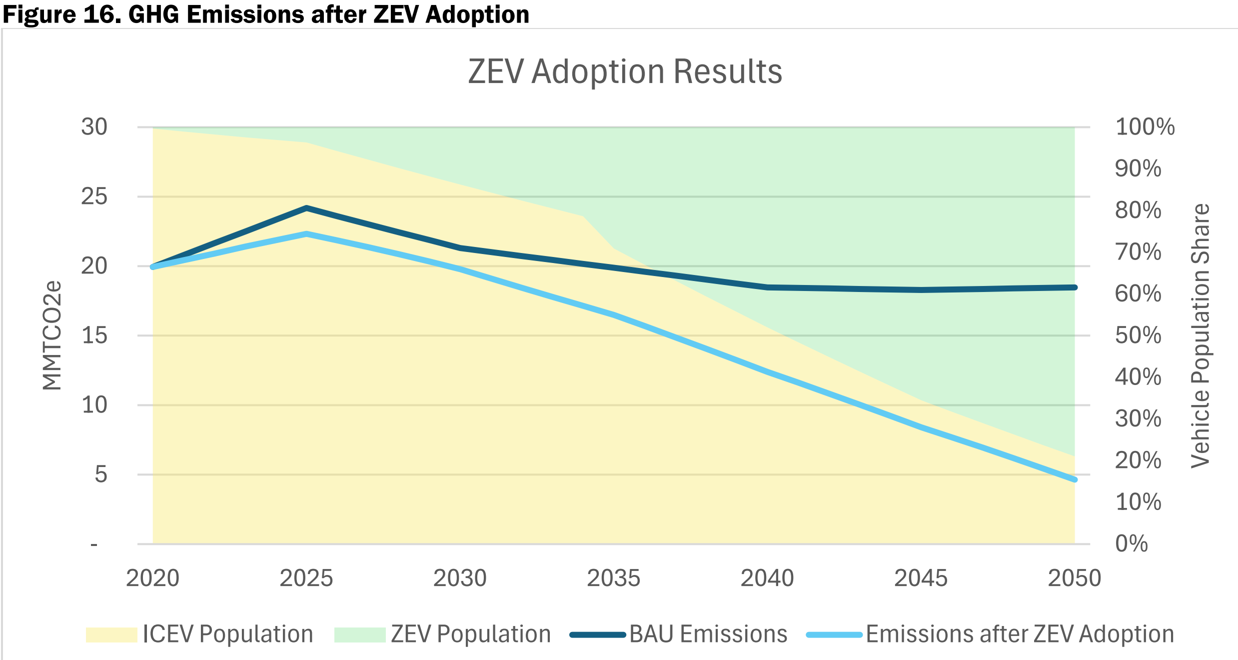
Table 27. ZEV Sales Assumptions

Vehicle Category	ZEV Sales Assumption
Light-duty vehicles (LDVs)	100% ZEV sales starting 2040
Medium- and heavy-duty vehicles (MHDVs)	100% of new MHDV sales are BEV (short-haul) or hydrogen fuel cell (long-haul) by 2050
Buses	100% of new bus sales are electric

These are the same assumptions that were modeled for ZEV adoption in the PCAP. These assumption were chosen because a) DC, MD, and VA had all adopted California's Advanced Clean Cars II rule, which required 100% of LDV sales to be ZEVs by 2035, and b) DC, MD, and VA have all signed on to the Multi-state Medium -and Heavy Duty Zero Emission Vehicle Memorandum of Understanding, which aims for 100% of new MHDV sales to be ZEVs by 2050.

Under the mitigation scenario, the ZEV population is expected to reach 14% and 79% of the on-road vehicle population in 2030 and 2050, respectively, as illustrated in Figure 16.

Figure 16. GHG Emissions after ZEV Adoption



METHODOLOGY

The ZEV adoption category uses ICF's CO_2Sight Turnover Projections for On-Road Transportation (TPORT) tool to model the change in energy consumption and GHG emissions due to the above ZEV sales assumptions. TPORT uses outputs from the EPA Motor Vehicle Emissions Simulator (MOVES4) as a baseline for VMT, vehicle population, energy consumption, and Scope 1 emissions for on-road transportation in the MSA by fuel type (gasoline, diesel, ethanol (E-85), compressed natural gas, and electricity), vehicle source type, and model year. Default input values were used.

To model GHG emission reductions in the mitigation scenario, for each model year, a fraction of VMT was designated as fuel type “electricity” or “hydrogen” based on the ZEV sales curve. The resulting energy consumption was by multiplying VMT with energy efficiency, where energy efficiency was in units of kJ/mi for BEVs and FCEVs. Implied BEV energy efficiencies from the MOVES4 baseline results were used. FCEV energy efficiencies were sourced from the California Advanced Clean Fleets (ACF) rule. Scope 1 emissions were found by reducing baseline internal combustion engine vehicle (ICEV) emissions by the ZEV sales fraction. Scope 2 emissions were calculated by applying the net zero electricity emission factor to the electricity consumption for each year. Scope 2 emissions from hydrogen were not modeled. Key assumptions include:

- ZEVs exist in the vehicle fleet for the same length of time as ICEVs.
- ZEV activity/use is identical to an ICEV.
- The annual ZEV sales fraction applies to every fuel type.
- Long-haul MHDVs ZEVs are modeled as FCEV and all other MHDVs ZEVs are modeled as BEV.
- All LDVs ZEVs are modeled as BEVs.
- All BEV populations 2021 and earlier are EPA MOVES4 default.

Limitations include:

- Successful ZEV adoption requires EV charger installation and accessibility and hydrogen availability. A lack of charging and hydrogen infrastructure may inhibit the amount of ZEV adoption possible.

COST APPROACH

The costs that may be incurred when transitioning and adopting ZEVs were evaluated. These include both the upfront capital investments required to purchase new vehicles and install new EV supply equipment (EVSE), as well as the energy cost and vehicle maintenance impacts on customers. The analysis does not account for other potential cost elements such as program administration expenses, the effects of rebates and incentives, or avoided fuel infrastructure costs. Reported cost estimates represent the net change in total costs between the zero-emission adoption scenario and the BAU scenario.

- Vehicle capital costs associated with electrification were estimated by multiplying the projected number of new vehicle purchases in each model year by the average purchase price per vehicle. These costs were differentiated by vehicle class (e.g., passenger car, single-unit short-haul truck, transit bus) and engine type (e.g., internal combustion engine, battery electric vehicle). The average cost per vehicle reflects the additional upfront cost of EVs compared to conventional vehicles, accounting for technology improvements and cost declines over time.
- EVSE capital costs were estimated assuming one level 2 charger per LDV, one 50 kW fast charger per short-haul MHDV and bus, and one 150 kW fast charger per long-haul MHDV.
- All capital costs were assumed to occur at the time of vehicle replacement, consistent with adoption curves and equipment lifetime assumptions.
- Energy costs and savings associated with electrification and energy efficiency were estimated using projected annual energy use for each fuel type (e.g., gasoline, diesel) by the corresponding projected cost per unit of fuel, derived from EIA’s Annual Energy Outlook 2025. Electricity prices

were calculated using electricity prices from residential sector for LDV and electricity prices from commercial sector for MHDVs and buses.

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

Table 28. Total Net Costs for ZEV Adoption, Cumulative 2025-2050 (2025$ Million)

Costs	2025 - 2050
Capital Costs	$100,113
Operating Costs	$(43,316)
Total Net Costs	$56,804

Cost data sources include:

- ICF's projection of vehicle capital cost by type and fuel using AFLEET
- Projected fuel costs and electricity prices: EIA's Annual Energy Outlook 2025, Table 3
- Vehicle maintenance costs: AFLEET

ON-ROAD ALTERNATIVE DIESEL FUELS

Even with aggressive electrification, there will still be ICEVs on the roads in 2050. Alternative diesel fuels are one option to reduce emissions from remaining ICEVs. Two alternative fuels are modeled to reduce emissions from diesel consumption – renewable diesel and biodiesel. Renewable diesel is a "drop-in" fuel, meaning it can be blended with or used in place of conventional diesel without modifications to the vehicle. Biodiesel can be blended with conventional diesel in small quantities and be used in typical diesel vehicles, but use of 100% biodiesel requires some modifications to the vehicle.

This emission reduction category assumes that all diesel consumption for on-road transportation will be transitioned to biodiesel or renewable diesel by 2050, and all off-road diesel consumption will be transitioned to renewable diesel, per the schedule and emission intensity described below.

METHODOLOGY

For on-road transportation, the category assumes that 100% of the diesel supply is composed of alternative fuels by 2050 – 90% renewable diesel and 10% biodiesel. Renewable diesel adoption begins in 2031 and grows linearly through 2050. There is some biodiesel consumption in the MSA today, so increased biodiesel consumption and emission reductions are assumed to begin in 2023 and grow linearly through 2050. 65% and 75% carbon intensity reduction factors were applied to the share of diesel converted to renewable diesel and biodiesel, respectively, thus reducing emissions from those fuels' portions of overall diesel consumption by 65% and 75% respectively. Key assumptions include:

- Assumes that the carbon intensity of renewable diesel is 65% lower than conventional diesel, per the Alternative Fuels Data Center assumption for Renewable Diesel.
- Assumes that the carbon intensity of renewable diesel is 65% lower than conventional diesel, per the Alternative Fuels Data Center assumption for Renewable Diesel.

- Renewable diesel phase in starts in 2031 and linearly increases to 90% of the diesel supply in 2050.
- Biodiesel increase starts in 2023 and linearly increases to 10% of the diesel supply in 2050.
- There is enough renewable diesel and biodiesel available in the region to supply the demand.

Limitations include:

- The assumptions of 65% and 75% reduction in carbon intensity are based on California's Low Carbon Fuel Standard (LCFS) average and studies completed by Argonne National Laboratory. The actual carbon intensity reduction could be different for the MSA depending on the feedstocks used to produce renewable diesel and biodiesel.

COST APPROACH

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

To reflect the higher cost of renewable diesel prior to the implementation of regulatory incentives or market-based programs, ICF used a production cost of $4.8 per gallon for renewable diesel and $4.7 per gallon for biodiesel. This figure represents the estimated cost of producing alternative fuels in the absence of subsidies and credits. By using the production cost, ICF aimed to capture the full economic burden of alternative fuel adoption in a pre-regulatory context.

Table 29. Total Net Costs for On-Road Alternative Diesel, Cumulative 2025-2050 (2025$ Million)

Costs	2025 - 2050
Total Net Costs	$3,108

Cost data sources include:

- Conventional diesel prices: EIA's Annual Energy Outlook 2025, Table 3

SUSTAINABLE AVIATION FUEL

The best option to decarbonize aviation available today is to replace petroleum-based jet fuel with biomass- or waste-based fuel – commonly referred to as sustainable aviation fuel (SAF). SAF is a chemical equivalent to conventional jet fuel but releases a fraction of the emissions because the carbon released was recently sequestered by its feedstock – typically a crop, waste oil or other biomass. The barrier to wide adoption of SAF is its production costs, which run at least two times the cost of conventional jet fuel. A number of incentives like the Federal Renewable Fuel Standard and California's LCFS offset the cost of SAF but are widely viewed as insufficient to induce demand at scale. To further offset the costs, some states like Illinois and Washington have implemented a SAF tax credit, which is the focus of this analysis.

The purpose of a SAF tax credit is to provide direct cash to the producer or off-taker (the airline) to reduce or eliminate the price premium for SAF. The tax credit analyzed here is modeled as a simple addition in revenue to SAF producers. Other states have implemented feedstock restrictions and other parameters for additional sustainability goals related to ecosystem preservation. This analysis is focused on answering the question how much additional value SAF producers require to scale to

100% blends of SAF. The focus is not determining the exact details of a potential tax credit, but rather understanding the additional value needed in the supply chain to expand production.

The end goal is that those developing the CCAP will utilize this analysis to drive their thinking around aviation decarbonization. Beyond this strictly economic estimation, there are political and social implications for a SAF incentive that would be considered before implementation. The purpose here is simply to quantify the value required for higher levels of SAF blending and therefore lower carbon emissions.

METHODOLOGY

The emissions impact of an additional SAF incentive was estimated by comparing the emissions related to BAU jet consumption and the carbon savings of various SAF pathways. This calculation was done on a life cycle basis – meaning that the carbon intensity of a gallon of jet fuel included drilling crude, transporting the crude, refining it into Jet fuel, transporting the refined product to an airport and its combustion in a turbine. SAF carbon intensity includes feedstock production and harvesting, transportation, refining and combustion. Using a life cycle approach is important because at combustion, SAF and jet fuel have similar emissions profiles. It is the carbon savings earlier in the production process that provide the savings. The total carbon savings over the forecast period are calculated by comparing an economic environment with and without the incentive, which leads to differing blends of SAF and therefore differing emission levels. The reported savings are the difference in emissions between the two scenarios.

To estimate how much SAF would enter the market given a specific incentive level, ICF uses the renewable diesel (RD) market as a corollary, noting its rapid growth in the late 2010s and early 2020s. By aligning incentive values, conventional diesel prices, and RD production costs, ICF applies time series analysis to predict production volumes based on historical profit trends, finding the strongest correlation at a 13-quarter lag, indicating it typically takes about three years for profitability to translate into new production capacity. RD is a suitable proxy for SAF because both rely on hydroprocessed esters and fatty acid (HEFA) pathways, share feedstocks, and operate under similar incentive structures. Their recent emergence, high blend potential (e.g., RD reaching 70% in California), and status as drop-in fuels requiring no infrastructure or engine modifications make RD's trajectory a valuable indicator for SAF market development.

ICF is able to forecast profitability because it has access to forecasts of the main building blocks of production costs and revenue sources. ICF contracts with a third party for feedstock prices, which are a key input to production costs. These are combined with internal analysis on the cost of capital and other operating costs. Additionally, ICF produces its own forecast of crude oil, and the Renewable Fuel Standard which constitute a large portion of a producer's revenue. Key assumptions include:

- Blend restrictions are resolved. Currently the American Society for Testing and Materials (ASTM) has approved pathways for SAF production that only allow a 50% blend of SAF with conventional jet fuel. ICF modeling contemplates a future where SAF is close to 100% of the jet fuel pool in Delaware. While technically feasible, it would require a SAF producer to undergo the necessary steps to acquire qualification for higher blends.
- Feedstocks are available. The current SAF industry is dominated by HEFA production pathways that use soybean oil, used cooking oil or other crops or waste oils as a feedstock. These feedstocks are in high demand currently because of the expansion in the RD and SAF industries. As demand for HEFA feedstocks approaches supply constraints, it is anticipated that other

pathways like alcohol to jet (ATJ), which uses ethanol to produce jet fuel, would be utilized. Feedstocks of ethanol and corn (to produce the ethanol) have spare but finite capacity. Electrification of the on-road transportation sector may free up feedstocks as demand for RD and ethanol falls. Rather than model these various dynamics in the feedstock markets, this study assumes that feedstocks will not be a constraint to industry expansion nor that they will significantly rise in price in real dollar terms.

- SAF Industry Development will Mirror RD Development given the same profitability profile. Because the SAF industry has low production to date, it is difficult to use past data for SAF to develop a view of the future. Therefore, it became necessary to find a corollary to SAF that had a stronger data history to analyze. RD has many characteristics that make it a helpful corollary which are articulated above. For these reasons, ICF relies on RD production history to develop a theory around what will be required for SAF industry expansion, with the assumption that the SAF industry will develop similar to that of the RD industry given the same profitability profile.

Limitations include:

- One key limitation of this analysis is that it does not show a decarbonized aviation industry. That is because the primary beneficiary of the policy – SAF production – is not carbon neutral. It is generally acknowledged that for the aviation industry to claim carbon neutrality, it will be necessary to implement other measures like carbon capture and sequestration or carbon offset credits from other economic sectors.

Another potential shortfall in this analysis lies in a key difference between RD and SAF. In the relevant incentives like the California LCFS, diesel is an obligated fuel. Meaning that if a refiner blends RD, they both avoid generating a deficit by producing less diesel and generate a credit. Jet fuel is not obligated, so blending SAF only provides a credit, and does not avoid any deficits. This feature essentially doubles the value of RD in comparison to SAF in these incentives and made rapid expansion of RD very valuable to regulated parties. ICF accounts for this difference by awarding LCFS value to RD for both the avoided deficits and the credits, which expands the calculated profitability when the relationship between profitability and production is analyzed. When this is applied to SAF production outlooks, the model essentially demands that incentive value rises to the same levels as if SAF was being credited for both avoided deficits and credits.

Another other key difference between RD and SAF is in their current blend limits. Over the course of RD's rapid expansion, the fuel was certified to be blended to 100% levels, meaning there was no regulatory limit to diesel purchased at the pump from being entirely renewable. The safety considerations inherent in the aviation sector make the process for such certification much more complex. Today almost all SAF pathways are certified for 50% blends. Given the low percentage of SAF in the market today, this is not a barrier to expansion in the industry, but at the levels contemplated in this study, certification will have to be granted for 100% blends by around the mid-2030s.

Implicit in our analysis is an assumption that initial volumes of SAF production will be produced using HEFA pathways. That technology pathway is one of a number of possible ways to produce SAF including ATJ and Fischer Tropsch (FT). Currently HEFA is the only pathway that actually produces SAF at commercial scale, although there have been significant developments for other pathways. ICF analysis assumes that FT pathways do not reach commercial viability during the forecast period and that ATJ pathways develop in a similar pattern to HEFA. Technological development of FT pathways faster than anticipated could result in outcomes different from the current analysis.

Data sources include:

- California Air Resources Board
- U.S. Energy Information Administration
- Oil Price Information Service (OPIS)
- Fastmarkets

COST APPROACH

The incremental cost of SAF implementation was estimated by multiplying the projected SAF consumption by the cost difference between SAF and conventional jet fuel.

To reflect the high cost of SAF prior to the influence of federal incentives and market scaling, ICF used a production cost of $7.00 per gallon. This figure represents the estimated cost of producing SAF using current technologies and feedstocks, such as HEFA or alcohol-to-jet pathways. SAF production costs are significantly higher than conventional jet fuel due to limited commercial-scale production, feedstock availability, and complex refining processes. For conventional jet fuel, ICF relied on price forecasts from the EIA's Annual Energy Outlook 2025, Table 3.

To account for policy-driven cost reductions, COG accounted for the $2/gallon SAF tax credit established in mitigation scenario to facilitate SAF adoption. This credit is designed to incentivize SAF production and adoption by offsetting part of the cost differential with conventional fuels.

Table 30. Total Net Costs for SAF, Cumulative 2025-2050 (2025$ Million)

Costs	2025 - 2050
Total Net Costs	$23,107

Cost data sources include:

- Conventional jet fuel prices: EIA's Annual Energy Outlook 2025, Table 3

OFF-ROAD ALTERNATIVE DIESEL FUELS

This category models blending RD with conventional diesel for off-road transportation use. RD is a "drop-in" fuel, meaning it can be blended with or used in place of conventional diesel without modifications to the existing diesel equipment. This category assumes that all diesel consumption for off-road transportation will be transitioned to RD by 2050 per the schedule and emission intensity described below.

METHODOLOGY

For off-road transportation, the category assumes that 100% of the diesel supply is converted to RD by 2050. Similar to on-road, RD adoption begins in 2031 and grows linearly through 2050. A 65% carbon intensity reduction factor was applied to the share of diesel converted to RD, thus reducing emissions from RD's share of overall diesel consumption by 65%. Key assumptions include:

- Assumes that the carbon intensity of RD is 65% lower than conventional diesel, per the Alternative Fuels Data Center assumption for RD.
- RD phase in starts in 2031 and linearly increases to 100% of the diesel supply in 2050.

Limitations include:

- The assumption of 65% reduction in carbon intensity is based on California's LCFS average. The actual carbon intensity reduction could be different for the MSA depending on the feedstocks used to produce RD.

COST APPROACH

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

Similar to the on-road, to reflect the higher cost of RD prior to the implementation of regulatory incentives or market-based programs, ICF used a production cost of $1.27 per liter. This figure represents the estimated cost of producing RD in the absence of subsidies and credits. By using the production cost, ICF aimed to capture the full economic burden of RD adoption in a pre-regulatory context.

Table 31. Total Net Costs for Off-Road Alternative Diesel, Cumulative 2025-2050 (2025$ Million)

Costs	2025 - 2050
Total Net Costs	$2,206

Cost data sources include:

- Conventional diesel prices: EIA's Annual Energy Outlook 2025, Table 3

ACCELERATE THE DEPLOYMENT OF OFF-ROAD/NON-ROAD ELECTRIC EQUIPMENT

The measure models the resulting GHG emissions reduced if the MTA Penn Line fully electrifies by 2035, as is already planned. About 10% of the trains operated on the Penn Line have already been electrified. Under the mitigation scenario, emissions from the Penn Line are modeled to reduce 94% from 2020 by 2050.

METHODOLOGY

This measure models a gradual phase-in of electric trains to replace existing diesel trains on the Penn Line from 2026-2035. BAU diesel consumption was linearly converted to electricity over this time period using a conversion factor derived from the MARC diesel and electric fuel efficiencies below, which are presented in a report from the National Cooperative Rail Research Program (NCRRP).

Table 32. MARC Diesel and Electric Fuel Efficiencies

Fuel	BTU/seat mile
Diesel	478
Electricity	565

This results in a conversion factor of 48 kWh/diesel gallon.

Notably, the BTU/seat mile for the electric trains are higher than the diesel trains because the electric trains are able to go faster than the diesel trains. However, it is still worthwhile to transition to electric trains because as the electricity emission factor improves over time, the emissions associated with rail electricity consumption will decrease over time. Emissions from diesel trains will not decrease over time with continued use.

Key assumptions include:

- Electrification occurs linearly through 2035.
- Diesel and electric trains operate the same number of trips per day.

Limitations include:

- The diesel and electric energy efficiency numbers in the NCRRP study were based on simulation, rather than measured data. They were also based on electric trains already in existence. Future electric Penn Line trains may be designed differently than trains that are in operation today.

COST APPROACH
The operating cost of rail electrification were estimated by calculating the difference in electricity cost and conventional diesel cost, then multiplying that difference by the projected volume of RD consumed, using unit prices derived from EIA's Annual Energy Outlook 2025. Capital cost is calculated assuming an annual investment of $139 million dollars from 2026 – 2035 to replace the existing diesel trains, assuming a total route of 77 miles and $18 million electrification cost per mile from similar rail electrification projects.

Table 33. Total Net Costs for Penn Line Electrification, Cumulative 2025-2050 (2025$ Million)

Costs	2025 - 2050
Total Net Costs	$49

Cost data sources include:

- Energy costs: EIA's Annual Energy Outlook 2025, Table 3

Waste

Table 34. Summary of Waste Sector CCAP Measure GHG Reductions MMTCO$_2$e

Sector	Measure	Cumulative 2025-2030 GHG reductions	Cumulative 2025-2050 GHG reductions
Waste	Reduce GHG emissions from waste and wastewater treatment.	0.07	17.42

REDUCE GHG EMISSIONS FROM WASTE AND WASTEWATER TREATMENT.

This measure focuses on diverting waste from landfills and combustion to recycling and composting, therefore reducing solid waste emissions. Table 35 shows the reductions from each component of this measure.

Table 35. Annual and Cumulative GHG Reductions (MMTCO$_2$e), 2025-2050

MMTCO$_2$e	2025	2030	2035	2040	2045	2050	2025-2050
Recycling	-	0.05	0.33	0.64	0.99	1.36	14.03
Composting	-	0.01	0.08	0.16	0.24	0.32	3.40

METHODOLOGY
To determine a potential diversion rate of compostable and recyclable material, ICF used waste composition data from multiple counties within the MSA. ICF used a landfilled waste diversion target of 80%, with diversion beginning in 2030, and applied that diversion rate to the share of landfilled waste that is assumed to be organic or recyclable based on the composition data. ICF adjusted the projected tonnage data to reflect the waste diversion. This updated waste tonnage data was used in ICLEI protocol equations SW.4.1 and SW.2.2.a and SW.2.2.b to calculate the resulting landfill and combustion emissions after diversion.

By 2050, this measure assumes that 80% of recyclable and compostable waste that would be landfilled under the BAU scenario, based on waste characterization reports, will be diverted to the alternate management type.

Data sources include:

- Constants and default values from the ICLEI Community Protocol
- Waste characterization data from Maryland Department of the Environment, Fairfax County, and Washington, DC.

This methodology does not calculate the added emissions due to increased composting and recycling.

COST APPROACH
For the recycling costs, a unit cost of $244 per ton of recycling was used as a reference, based on the NYC Independent Budget Office (2017). This value was adjusted to 2025 dollars using historical GDP implicit price deflator data from the Federal Reserve Bank of St. Louis (FRED), based on a $191 baseline input.

For organic waste diversion, the ReFED Solutions Database was used to acquire data specific to Virginia and Maryland to determine annual diversion potential in tons and annual GHG reduction potential in $MTCO_2e$. Three action types from the database were used in the cost analysis: 1) Recycle Anything Remaining, 2) Reshape Consumer Environments, and 3) Strengthen Food Rescue. Each action type contributes a different share to the overall diversion potential. Recycle Anything Remaining contributes 74%, Reshape Consumer Environments contributes 22%, and Strengthen Food Rescue contributes 4%. Each action has a different cost per ton of GHG reduced, ranging from $93.33 to $661.79, depending on the strategy and the state. Finally, the weighted average cost per ton of organic waste diverted was calculated, using the diversion share and cost per ton GHG for each action for each state. The result per ton for the average implementation cost for diverting one ton of organic waste was $205.19 for Virginia and $208.37 for Maryland. The implementation cost was applied to each jurisdiction's waste diverted quantity and the average of the two implementation costs was used for District of Columbia and West Virginia.

Table 36. Total Net Costs for Waste, Cumulative 2025-2050 (2025$ Million)

Costs	2025 - 2050
Recycling	$2,961
Organic Waste Diversion	$2,479
Net Costs	$5,441

Cost Data Sources include:

- NYC Independent Budget Office for cost per ton of recycling
- ReFED Solutions Database for cost per ton of organics diverted

Land Use

This sector covers emission reductions from land use, including agricultural activities, and enhanced sequestration. The GHG reduction modeling is split into three categories: tree canopy, land conservation and management, and agriculture activities. Modeling results for each category are discussed separately below.

Table 37. Summary of Land Use Sector CCAP Measure GHG Reductions $MMTCO_2e$

Sector	Measure	Cumulative 2025-2030 GHG reductions	Cumulative 2025-2050 GHG reductions
Land Use	Accelerate the expansion of the regional tree canopy and reduce tree canopy loss.	0.12	5.67
Land Use	Conserve and improve management of natural resources.	-	27.66
Land Use	Additional agriculture subsector modeling.	0.06	2.67

ACCELERATE THE EXPANSION OF THE REGIONAL TREE CANOPY AND REDUCE TREE CANOPY LOSS

This measure quantifies the additional carbon sequestration by expanding regional tree canopy and reducing tree canopy loss. Table 38 shows the additional sequestration from each component of this measure.

Table 38. Annual and Cumulative GHG Sequestration ($MMTCO_2e$), 2025-2050

$MMTCO_2e$	2025	2030	2035	2040	2045	2050	2025-2050
Enhance Tree Canopy	-	0.06	0.16	0.27	0.37	0.47	5.67

METHODOLOGY

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

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

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

Tools used to quantify additional sequestration for this measure include:

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

The following goals set forth by Washington, DC, and Maryland were modeled:

- In Washington, DC, the goal is to increase tree canopy coverage from 35% to 40%. The goal is within Sustainable DC—a planning effort to make the District of Columbia the greenest, healthiest, and most livable city in the nation (District of Columbia Urban Tree Canopy Plan).
- The COG regional 50% tree canopy cover goal was adopted by the COG board in 2024.

Limitations include:

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

Data sources include:

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

COST APPROACH

The costs were estimated by using the CAST cost profiles dataset for Maryland, Virginia, DC, And West Virginia. The dataset provides default unit cost estimates for each state within the Chesapeake Bay Watershed. All costs are expressed in 2018 dollars and reflect expenses incurred across both public and private entities. The dataset does not include the cost of technical assistance. The urban tree expansion measure costs include tree planting on developed lands.

Table 39. Total Net Costs for Tree Canopy, Cumulative 2025-2050 (2025$ Million)

Costs	2025 - 2050
Net Costs	$102

Cost data sources include:

- CAST - Cost Profiles

CONSERVE AND IMPROVE MANAGEMENT OF NATURAL RESOURCES

This category quantifies increased carbon sequestration from increasing the use of improved land management practices on forested lands and wetlands. Given the region's preexisting landscape with large areas of forests and wetlands, the area has a large potential for increasing carbon sequestration by preserving and enhancing the land cover it already has. This category has a very high impact with potentially large sequestration gains throughout the MSA. The category was estimated by comparing the baseline total carbon stock with a measure scenario that increased total carbon stock from improved land management. Table 40 shows the additional sequestration from each component of this measure.

Table 40. Annual and Cumulative GHG Sequestration ($MMTCO_2e$), 2025-2050

$MMTCO_2e$	2025	2030	2035	2040	2045	2050	2025-2050
Improved Land Management	-	-	0.66	1.32	1.98	2.63	27.66

METHODOLOGY

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

After finding the baseline total carbon stock in each land cover class, ICF modeled the improved land management carbon stock. ICF assumed 50% of each land cover type would be converted to an improved management category. ICF also assumed a linear trend from the start year of 2030 to the assumed maximum in 2050, and the sequestration value in 2050 acts as a new baseline sequestration for the MSA. The improved land management factors are assumed to be 1.3 which is pulled from the IPCC 2006 guidance for grasslands. The 1.3 represents an improvement factor which is a very general estimation of the impact of improving land management on these lands' carbon stocks, and it is also assumed to be the same amount for each land cover type, which may not capture the full picture of the effect of improved land management in the specific land cover classes. Literature review can be conducted in the future for more specific improvement factors.

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

Key assumptions include:

- Biomass to carbon ratio was taken from IPCC 2006 guidance for grasslands of 0.47. The ratio of 0.50 was taken for both forests and wetlands from the USFS and USDA, respectively.
- Above to below-ground biomass ratios (root to shoot ratios) were taken from the IPCC guidance for all land cover types. The mixed forest land cover type was assumed to be the average ratio of deciduous and evergreen.
- The turnover assumed was 50% of all land cover types modeled would be converted to the improved management category. A linear trend was assumed from the start year to the beginning of the theoretical maximum in 2050.

Limitations include:

- It is assumed that all area of forests and wetlands will remain constant due to maximally effective conservation measures.
- It is assumed that all areas are available for receipt of improved land management practices.
- The improvement factor is rough and limits differentiation by improvement practice.
- Land conversion to or from the 4 modeled categories would affect the outcomes of this analysis.

Data sources include:

- Land cover data: National Land Cover Dataset (NLCD)
- Forest biomass: USDA Forest Biomass across the Lower 48 states and Alaska
- Soil carbon stock: Gridded Soil Survey Geographic (gSSURGO) Database

COST APPROACH

The costs were by using the CAST cost profiles dataset for Maryland, Virginia, DC, And West Virginia. The dataset provides default unit cost estimates for each state within the Chesapeake Bay Watershed. All costs are expressed in 2025 dollars and reflect expenses incurred across both public and private entities. The dataset does not include the cost of technical assistance. The land management category was divided into two cost estimates: forest management and wetlands management. For forests, the costs calculated include forest harvesting practices and agriculture and developed forest buffers. For wetlands, costs include both wetland preservation and enhancement.

Table 41. Total Net Costs for Improved Land Management, Cumulative 2025-2050 (2025$ Million)

Costs	2025 - 2050
Forests	$965
Wetlands	$409
Net Costs	$1,347

Cost Data Sources include:

- CAST - Cost Profiles

ADDITIONAL AGRICULTURE ACTIVITIES MODELING

Three land use categories were modeled to demonstrate potential emission reductions in the agriculture sector:

- Nitrification Inhibitor Adoption
- Feed Management
- Cover Crop Adoption

Table 42 shows the reductions from each of the three categories.

Table 42. Annual and Cumulative GHG Reductions ($MMTCO_2e$), 2025-2050

$MMTCO_2e$	2025	2030	2035	2040	2045	2050	2025-2050
Nitrification Inhibitor Adoption	-	-	0.01	0.01	0.01	0.01	0.19
Feed Management	-	-	0.00	0.08	0.17	0.18	1.80
Cover Crop Adoption	-	0.01	0.02	0.03	0.04	0.04	0.68

NITRIFICATION INHIBITOR ADOPTION

Nitrification Inhibitors (NI) are chemical compounds that inhibit the nitrification process, which can prolong the retention time of nitrogen (N) in the soil. This mechanism increases nitrogen use efficiency (NUE), reducing N losses and GHG emissions.

This category supports agricultural GHG emissions reduction by enhancing NUE, reducing nitrogen fertilizer inputs, and subsequent N_2O emissions. Based on region-specific adoption rates and USDA analysis, NI adoption provides a viable pathway for mitigating N_2O emissions and improving overall nitrogen management.

Quantifying the impact of NI adoption allows for a targeted strategy to reduce agricultural emissions. The projected impact aligns with USDA report findings, demonstrating a measurable reduction in synthetic fertilizer-driven N_2O emissions, which informs broader agricultural emissions reduction efforts within the CCAP.

METHODOLOGY

Annual GHG emissions reduction impacts from increased NI adoption were estimated by comparing baseline emissions with the mitigation scenario (2026–2050). For the measure, national crop specific adoption rates based on USDA data are assumed for 2025 and adoption rates increase annually for soybeans, corn, and wheat, assuming a 4% increase in adoption area annually until a maximum adoption rate of 80% is reached.

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

Activity data: Crop planted areas for corn, soybeans, and wheat were projected (2026-2050) using historical production data from USDA National Agriculture Statistics Services (NASS). Average annual rates of change in production were derived from USDA Baseline Projections which account for market trends, trade and other demand shifts, and production trends. National averages for the percentage of acres receiving N fertilizer were used to isolate applicable acres. Current adoption rates of NIs were established using data from the Agricultural Resource Management Survey (ARMS) (USDA). Key assumptions include:

- National average crop-specific fertilizer application (lbs/acre) rate utilized in place of state-specific values as state level rates were not available.
- Assumed percent reduction in N_2O from NI application for each applicable crop based on USDA Marginal Abatement Cost Curve (MACC) Report.
- Reduction in total N inputs of 10% due to enhanced NUE based on USDA MACC Report.
- Current adoption of NI estimated based on USDA Economic Research Service (ERS) report: Cover Crop Trends, Programs, and Practices in the United States (2021).
- Increased adoption of NI over time: Maximum adoption reaches 80% for corn in 2042 and for wheat and soybeans in 2025, based on expert opinion.

Limitations include:

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

Data sources include:

- USDA NASS Quick Stats
- Fertilizer Use and Price Economic Research Service
- USDA National Baseline Projections, 2024-2034
- Fertilizer Use and Price Economic Research Service
- USDA National Baseline Projections, 2024-2034
- ARMS Farm Financial and Crop Production Practices - Tailored Reports: Crop Production Practices
- USDA Marginal Abatement Cost Curve Estimate Methodology Report
- IPCC 2019 Refinement, Chapter 11: N_2O Emissions from Managed Soils, and CO_2 Emissions from Lime and Urea Application

FEED MANAGEMENT

This category involves the use of feed additives to reduce enteric methane emissions from beef and dairy cattle. These additives inhibit microbial processes in the rumen that produce methane, thereby lowering GHG emissions from livestock.

The inclusion of this category targets enteric fermentation, a significant source of agricultural GHG emissions, by leveraging scientifically supported, feed-based emissions reduction strategies.

This quantification provides a data-driven projection of emissions reductions achievable through phased adoption of Monensin (2026–2035) and 3-Nitrooxypropanol (3-NOP) (2036–2050), based on livestock population trends and additive efficacy.

METHODOLOGY

To estimate the GHG emissions reduction potential of feed additives in livestock production, baseline population data for beef forage cattle, beef feedlot cattle, and dairy cows was provided by COG. Future livestock population estimates from 2022 to 2050 were projected using national average annual growth rates from the USDA Baseline Projections which account for market trends, trade and other demand shifts, and production trends.

To calculate enteric fermentation emissions for the Feed Additives Mitigation Scenario, the applicable population was multiplied by the proportion receiving either Monensin or 3-NOP depending on the year, and the respective feed additive emission reduction factor. This was added to the remaining proportion of the applicable population that did not receive any mitigation feed additive, which was multiplied by the standard per head emission factor.

The measure assumes phased adoption of Monensin from 2026–2035, ramping up from 3% to 30%. Due to current cost and consumer perception barriers, the measure assumes adoption of 3-NOP from 2035-2050, ramping up from 5% to 100% (100% adoption is reached in 2046). Adoption of the two strategies is phasic as there is insufficient scientific evidence to suggest that impacts on enteric fermentation emissions would be additive if implemented at the same time (despite that science may later show they are additive). Emissions reductions per head were applied based on literature values of 3.0% to 8.0% for Monensin, with the conservative value of 3.0% being used, and 38.5% for 3-NOP. The total emissions reductions were calculated as the difference in enteric methane emissions between the BAU and the mitigation scenario, expressed in $MTCO_2e$. Key assumptions include:

- Assumed adoption rates would be applicable to 100% of all animals. This broad applicability reflects the potential for sector-wide implementation once adoption barriers are addressed.
- Assume that effects of Monensin and 3-NOP are not additive due to lack of consensus of research on combined feed additives and associated effects, therefore when 3-NOP adoption ramps up, assume zero effect from Monensin.
- Monensin is assumed to be market-ready with low implementation costs. Adoption ramps from 3% in 2026 to 30% by 2035.
- 3-NOP is FDA-approved but faces consumer and cost-related barriers. Adoption begins in 2036, increasing from 5% to 100% by 2050.
- These adoption curves reflect realistic market penetration based on regulatory status, economic feasibility, and producer behavior.

Limitations include:

- **Applicability assumptions:** The analysis assumes that 100% of beef forage cattle, beef feedlot cattle (excluding calves), and dairy cattle are eligible for feed additive treatment. In practice, variability in farm management practices, regional feed availability, and animal health considerations may limit full adoption. This simplification was used to estimate the maximum technical potential of the measure and can be refined with more granular, region-specific adoption data.

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

Data sources include:

- USDA NASS Quick Stats
- Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2022 | US EPA, Table A-148
- 2025.1 SIT Ag Module for Maryland, Virginia, and West Virginia
- USDA Marginal Abatement Cost Curve Estimate Methodology Report
    - Arndt, et al, 2022. “Full adoption of the most effective strategies to mitigate methane emissions by ruminants can help meet the 1.5 °C target by 2030 but not 2050”
- Hegarty, et al, 2021. “An evaluation of emerging feed additives to reduce methane emissions from livestock”

COVER CROP ADOPTION

Cover crops are plants grown primarily to enhance soil health, reduce erosion, lower GHG emissions, and increase carbon sequestration. They also affect soil nitrous oxide (N_2O) emissions by enabling more plant uptake of nitrogen in the soil, reducing soil nitrogen available for nitrification and denitrification processes that result in nitrous oxide. As a key sustainable agriculture practice, they improve soil fertility and structure, contributing to better crop yields and reduced environmental impact.

By incorporating the GHG emissions impacts of projected cover crop adoption, this measure provides a scalable and viable agricultural strategy for reducing emissions. The region’s long-standing engagement in cover cropping, particularly in Maryland, demonstrates its feasibility, offering an effective pathway to lower agricultural-sector emissions through carbon sequestration and reduced N_2O emissions.

METHODOLOGY

Annual GHG emissions reduction impacts from increased cover crop adoption were estimated by comparing baseline emissions with the mitigation scenario (2026–2050), in which adoption rates increase annually, ramping up from 25% to a maximum of 100%, reached in 2044.

Current cover cropping applicable acres were estimated based on the annual harvested area (acres) of field crops and vegetables in 2022 based on USDA NASS datasets. Future harvested areas were projected using observed rates of change. The BAU scenario assumes cover crop adoption remains constant at 25%, meaning 25% of eligible acres continue using cover crops, sourced from 2017 USDA ERS data for Maryland and Virgina's percent of harvested cropland. This measure models a 4% annual increase in cover crop adoption on eligible acres until reaching the maximum threshold.

Emissions calculations incorporate soil carbon sequestration ($MTCO_2e$) and reductions in N_2O emissions from decreased nitrogen fertilizer application. Fossil fuel emissions from agricultural equipment used for planting and maintaining cover crops were also factored into the analysis. The total emissions impact was determined by comparing GHG levels in each modeled year under the BAU scenario (no change in cover crop adoption) and the mitigation scenario (2026-2050). Key assumptions include:

- Current adoption of cover crops on 25% of applicable crop acres in region based on USDA ERS Cover Crops Report data for Maryland and Virgina.
- Applicable crop acres assumed to exclude pasture as they are not generally planted annually.
- Maximum adoption assumed to be 100% reached in 2044.
- Utilize Soil Carbon Sequestration and N_2O Reduction Factor ($MTCO_2e$) from USDA MACC Report.
- Additional fuel use is 0.92 gallons per acre for planting and cultivating activities, which results in 9.7 kgs CO_2e per cover crop acre emitted from fuel use based on EPA GHG Emission Factor Hub emission data. ICF implemented a scheduled phase in of 100% RD by 2050 which partially offset fuel use emissions.

Limitations include:

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

Data sources include:

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

Other Emissions Changes

T&D LOSSES

An increase in electricity consumption will increase T&D losses, but with a cleaner electricity mix, the GHG emissions associated with those losses will decrease.

Table 43. Annual and Cumulative GHG Reductions ($MMTCO_2e$), 2025-2050

$MMTCO_2e$	2025	2030	2035	2040	2045	2050	2025-2050
T&D Losses	-0.09	-0.01	-0.01	0.01	0.08	0.18	0.84

A negative reduction indicates an increase in emissions compared to BAU. Annual emissions from T&D losses can be modeled to be larger than BAU emissions because of increased electricity consumption from building and vehicle electrification. However, the cleaner electricity emission factor after 2040 results in lower emissions from losses than the BAU.

METHODOLOGY

The T&D loss methodology used the same method to quantify emissions from T&D losses as described in the BAU section, but based the losses off of mitigation scenario electricity consumption. This modeling did not consider methods for reducing the rate of T&D losses, which could help reduce T&D losses to below BAU levels despite increasing electricity consumption. Example ways to reduce the T&D loss rate include but are not limited to reducing the distance electricity must travel such as through more distributed generation, upgrading or resizing lines to reduce resistance, reducing the current in lines by increasing voltage, and/or improving the power factor throughout the system.

NATURAL GAS FUGITIVE

As natural gas consumption decreases as a result of measure implementation, natural gas fugitive emissions are also expected to decrease.

Table 44. Annual and Cumulative GHG Reductions ($MMTCO_2e$), 2025-2050

$MMTCO_2e$	2025	2030	2035	2040	2045	2050	2025-2050
Natural Gas Fugitive	0.00	0.03	0.07	0.11	0.15	0.20	2.38

METHODOLOGY

The quantification approach uses the same method as described in the BAU sections but with updated consumption values.

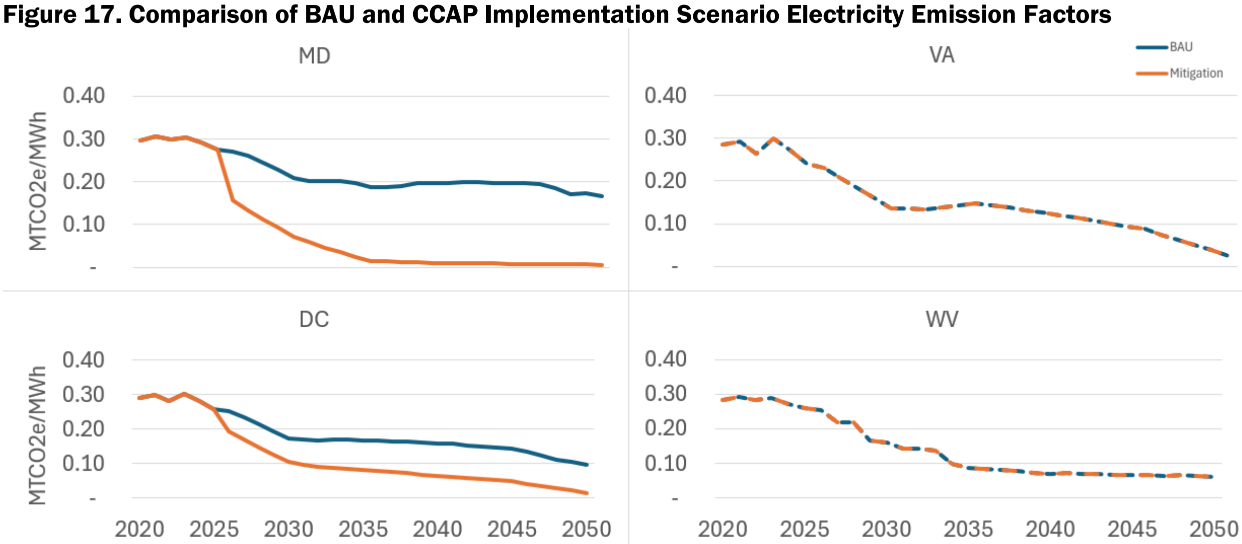
This modeling did not consider methods for reducing the rate of natural gas fugitive emissions, which would help further reduce natural gas fugitive emissions. Example ways to reduce the rate of natural gas leakage include but are not limited to monitoring and repairing leaks, replacing old valves, and/or tightening flanges.

ELECTRICITY EMISSION FACTOR

An increase in the share of clean electricity sources in the MSA's generation mix will reduce the emissions from electricity consumption and electric T&D losses.

Figure 17 compares the BAU and mitigation scenario electricity emission factors for each state.

Figure 17. Comparison of BAU and CCAP Implementation Scenario Electricity Emission Factors



METHODOLOGY

Table 45 compares the methodology for developing the BAU and mitigation scenario electricity emission factors for each state in the MSA. Only Maryland and DC's emissions factors differ compared to the BAU.

Table 45. Grid Emission Factor BAU and CCAP Implementation Scenario Approaches

State	BAU Approach	CCAP Implementation Approach
MD	Derived from AEO 2023 Table 54 Total Electricity Generation and Carbon Dioxide Emissions, and eGRID CH4 and N2O emissions for PJME region	Derived from the MD Climate Pollution Reduction Plan's proposed Clean Power Standard
VA	Emission factors used from Virginia State CCAP modeling, inclusive of VCEA net zero emission mandates for utilities	Same as BAU
DC.	Average of VA and MD emission factor projections	Average of VA and MD
WV	Derived from AEO 2023 Table 54 Total Electricity Generation and Carbon Dioxide Emissions, and eGRID CH4 and N2O emissions for PJMW region	Same as BAU

APPENDIX B. METROPOLITAN WASHINGTON CLIMATE AND ENERGY PLANS AND TARGETS

REGIONAL

- Metropolitan Washington 2030 Climate and Energy Action Plan, 2020
  - 50% below 2005 levels by 2030
  - 80% below 2005 levels by 2050
- Visualize 2045 National Capital Region Transportation Plan, 2022 update, goals are specific to the on-road transportation sector:
  - 50% below 2005 levels by 2030
  - 80% below 2005 levels by 2050

DISTRICT OF COLUMBIA

- Carbon Free DC, 2023
  - 60% below 2006 levels by 2030
  - Net-zero by 2045

MARYLAND

- Climate Solutions Now Act (CSNA), 2022
  - 60% below 2006 levels by 2030
  - Net-zero by 2045
- Maryland Climate Pollution Reduction Plan, 2023

CITY OF BOWIE

- Climate Action Plan 2020-2025, 2020
  - 50% below 2015 levels by 2030
- 2022 – 2025 Implementation Plan, 2022
  - 50% below 2015 levels by 2030
  - Net-zero by 2050

CHARLES COUNTY

- Community Climate Plan began development in 2023, scheduled to be completed in 2026.

FREDERICK COUNTY

- Sustainable Frederick County, 2017
  - 25% below 2007 levels by 2025
- Climate Emergency Resolution, 2020
  - 50% below 2010 levels by 2030
  - 100% reduction by 2050
- Frederick Community-Wide Climate and Energy Action Plan, 2025

CITY OF FREDERICK

- Sustainability Plan, 2016
- Climate Emergency Resolution, 2020
  - 50% below 2010 levels by 2030
  - 100% reduction by 2050
- Frederick Community-Wide Climate and Energy Action Plan, 2025

CITY OF GREENBELT

- Sustainability Plan Framework, 2013
  - 25% below 2006 levels by 2020 (align with MD state goals)
  - 20% below 2005 levels by 2020 (align with COG goals)
  - 50% below 2005 levels by 2030 (align with COG goals)
  - 80% below 2005 levels by 2050 (align with COG goals)

CITY OF HYATTSVILLE

- Climate Action Plan began development in 2025, scheduled to be completed in 2026.

CITY OF LAUREL

- City of Laurel Sustainability Plan, 2025

MONTGOMERY COUNTY

- Montgomery County Climate Action Plan, 2021
  - 80% below 2005 levels by 2027
  - 100% below 2005 levels by 2035

PRINCE GEORGE'S COUNTY

- Climate Action Plan, 2022
  - 50% below 2005 levels by 2030
  - Net-zero by 2050

CITY OF ROCKVILLE

- Climate Action Plan, 2022
  - 50% below 2005 levels by 2030
  - Net-zero by 2050

CITY OF TAKOMA PARK

- Sustainable Energy Action Plan, 2014
- Sustainability and Climate Action Plan, 2019
- Climate Emergency Response Resolution, 2020
  - Net-zero by 2035

VIRGINIA

- Virginia Energy Plan, 2018
- Virginia Clean Economy Act, 2020
- SB 94 Virginia Energy Plan; Climate Change Pressing Challenge, 2020
  - Net-zero by 2045
- Virginia Energy Plan, 2022

CITY OF ALEXANDRIA

- Environmental Action Plan 2040, 2019
  - 50% below 2005 levels by 2030
  - 80 – 100% below 2005 levels by 2050
- Energy and Climate Change Action Plan, 2023

ARLINGTON COUNTY

- Community Energy Plan (CEP), 2019
  - Net-zero by 2050
- Community Energy Plan (CEP) Roadmap, 2022
- Carbon Neutral Transportation Master Plan, 2024
- Carbon Roadmap, 2024

FAIRFAX COUNTY

- Community-Wide Energy and Climate Action Plan (CECAP), 2021
  - 50% below 2005 levels by 2030
  - 75% below 2005 levels by 2040
  - Net-zero by 2050
- CECAP Implementation Plan, 2022

CITY OF FAIRFAX

- 80% below 2005 levels by 2050

CITY OF FALLS CHURCH

- Community Energy Action Plan (CEAP), 2023
  - 50% below 2005 levels by 2030
  - Net-zero by 2050

LOUDOUN COUNTY

- Loudoun County Energy Strategy, 2009
- Loudoun County Energy Strategy, 2023
- Loudoun County Energy Strategy Progress Report and Implementation Plan, 2025

CITY OF MANASSAS

- Draft Climate Action Plan, 2023

- 50% below 2005 levels by 2030 (align with COG goals)
- 80% below 2005 levels by 2050 (align with COG goals)

PRINCE WILLIAM COUNTY

- Community Energy and Sustainability Master Plan, 2023
  - 50% below 2005 levels by 2030
  - Net-zero by 2050

APPENDIX C. IDENTIFICATION OF LIDACS IN THE WASHINGTON-ARLINGTON-ALEXANDRIA, DC-VA-MD-WV MSA

City/County	State	Census Block ID	City/County	State	Census Block ID
District of Columbia	DC	11001000501	Prince George's County	MD	24033804001
District of Columbia	DC	11001001002	Prince George's County	MD	24033804002
District of Columbia	DC	11001001803	Prince George's County	MD	24033804002
District of Columbia	DC	11001001803	Prince George's County	MD	24033804102
District of Columbia	DC	11001001803	Prince George's County	MD	24033804102
District of Columbia	DC	11001001804	Prince George's County	MD	24033804300
District of Columbia	DC	11001001804	Prince George's County	MD	24033804300
District of Columbia	DC	11001001804	Prince George's County	MD	24033804400
District of Columbia	DC	11001001901	Prince George's County	MD	24033804400
District of Columbia	DC	11001001901	Prince George's County	MD	24033804600
District of Columbia	DC	11001001901	Prince George's County	MD	24033804801
District of Columbia	DC	11001001902	Prince George's County	MD	24033804801
District of Columbia	DC	11001002001	Prince George's County	MD	24033804801
District of Columbia	DC	11001002001	Prince George's County	MD	24033804802
District of Columbia	DC	11001002002	Prince George's County	MD	24033804802
District of Columbia	DC	11001002101	Prince George's County	MD	24033804900
District of Columbia	DC	11001002101	Prince George's County	MD	24033804900
District of Columbia	DC	11001002102	Prince George's County	MD	24033805000
District of Columbia	DC	11001002102	Prince George's County	MD	24033805000
District of Columbia	DC	11001002201	Prince George's County	MD	24033805000
District of Columbia	DC	11001002201	Prince George's County	MD	24033805101
District of Columbia	DC	11001002202	Prince George's County	MD	24033805101
District of Columbia	DC	11001002400	Prince George's County	MD	24033805201
District of Columbia	DC	11001002501	Prince George's County	MD	24033805201
District of Columbia	DC	11001002501	Prince George's County	MD	24033805202
District of Columbia	DC	11001002503	Prince George's County	MD	24033805202
District of Columbia	DC	11001002504	Prince George's County	MD	24033805202
District of Columbia	DC	11001002702	Prince George's County	MD	24033805500
District of Columbia	DC	11001002702	Prince George's County	MD	24033805500
District of Columbia	DC	11001002704	Prince George's County	MD	24033805601
District of Columbia	DC	11001002801	Prince George's County	MD	24033805601
District of Columbia	DC	11001002801	Prince George's County	MD	24033805601
District of Columbia	DC	11001002802	Prince George's County	MD	24033805602
District of Columbia	DC	11001002802	Prince George's County	MD	24033805602
District of Columbia	DC	11001002802	Prince George's County	MD	24033805602
District of Columbia	DC	11001002900	Prince George's County	MD	24033805700

City/County	State	Census Block ID	City/County	State	Census Block ID
District of Columbia	DC	11001002900	Prince George's County	MD	24033805700
District of Columbia	DC	11001003000	Prince George's County	MD	24033805700
District of Columbia	DC	11001003000	Prince George's County	MD	24033805801
District of Columbia	DC	11001003200	Prince George's County	MD	24033805801
District of Columbia	DC	11001003200	Prince George's County	MD	24033805802
District of Columbia	DC	11001003200	Prince George's County	MD	24033805802
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District of Columbia	DC	11001003600	Prince George's County	MD	24033805907
District of Columbia	DC	11001003702	Prince George's County	MD	24033805908
District of Columbia	DC	11001003802	Prince George's County	MD	24033805909
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District of Columbia	DC	11001004300	Prince George's County	MD	24033806000
District of Columbia	DC	11001004702	Prince George's County	MD	24033806000
District of Columbia	DC	11001004703	Prince George's County	MD	24033806100
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District of Columbia	DC	11001004703	Prince George's County	MD	24033806501
District of Columbia	DC	11001004703	Prince George's County	MD	24033806501
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District of Columbia	DC	11001004704	Prince George's County	MD	24033806601
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District of Columbia	DC	11001005004	Prince George's County	MD	24033806713
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District of Columbia	DC	11001005203	Prince George's County	MD	24033806713
District of Columbia	DC	11001005501	Prince George's County	MD	24033806714
District of Columbia	DC	11001005503	Prince George's County	MD	24033806714
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District of Columbia	DC	11001005601	Prince George's County	MD	24033806900
District of Columbia	DC	11001005801	Prince George's County	MD	24033806900
District of Columbia	DC	11001005900	Prince George's County	MD	24033807000
District of Columbia	DC	11001006400	Prince George's County	MD	24033807000
District of Columbia	DC	11001006400	Prince George's County	MD	24033807000
District of Columbia	DC	11001006804	Prince George's County	MD	24033807000

City/County	State	Census Block ID	City/County	State	Census Block ID
District of Columbia	DC	11001007100	Prince George's County	MD	24033807000
District of Columbia	DC	11001007100	Prince George's County	MD	24033807301
District of Columbia	DC	11001007100	Prince George's County	MD	24033807305
District of Columbia	DC	11001007203	Prince George's County	MD	24033807305
District of Columbia	DC	11001007301	Prince George's County	MD	24033807404
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District of Columbia	DC	11001007304	Prince George's County	MD	24033807409
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District of Columbia	DC	11001007408	Arlington County	VA	51013101704
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District of Columbia	DC	11001007502	Arlington County	VA	51013102001
District of Columbia	DC	11001007502	Arlington County	VA	51013102001
District of Columbia	DC	11001007502	Arlington County	VA	51013102002
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District of Columbia	DC	11001007604	Arlington County	VA	51013102701

City/County	State	Census Block ID	City/County	State	Census Block ID
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District of Columbia	DC	11001007806	Culpeper County	VA	51047930300
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District of Columbia	DC	11001007807	Culpeper County	VA	51047930501
District of Columbia	DC	11001007807	Fairfax County	VA	51059415300
District of Columbia	DC	11001007808	Fairfax County	VA	51059415401
District of Columbia	DC	11001007808	Fairfax County	VA	51059415401
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District of Columbia	DC	11001007901	Fairfax County	VA	51059420600
District of Columbia	DC	11001008802	Fairfax County	VA	51059420800
District of Columbia	DC	11001008802	Fairfax County	VA	51059421002
District of Columbia	DC	11001008802	Fairfax County	VA	51059421102

City/County	State	Census Block ID	City/County	State	Census Block ID
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District of Columbia	DC	11001008803	Fairfax County	VA	51059421400
District of Columbia	DC	11001008803	Fairfax County	VA	51059421500
District of Columbia	DC	11001008804	Fairfax County	VA	51059421500
District of Columbia	DC	11001008804	Fairfax County	VA	51059421500
District of Columbia	DC	11001008903	Fairfax County	VA	51059421500
District of Columbia	DC	11001008903	Fairfax County	VA	51059421600
District of Columbia	DC	11001008903	Fairfax County	VA	51059421600
District of Columbia	DC	11001008904	Fairfax County	VA	51059421600
District of Columbia	DC	11001008904	Fairfax County	VA	51059421701
District of Columbia	DC	11001008904	Fairfax County	VA	51059421701
District of Columbia	DC	11001009000	Fairfax County	VA	51059421800
District of Columbia	DC	11001009000	Fairfax County	VA	51059421900
District of Columbia	DC	11001009000	Fairfax County	VA	51059422101
District of Columbia	DC	11001009102	Fairfax County	VA	51059422102
District of Columbia	DC	11001009102	Fairfax County	VA	51059422302
District of Columbia	DC	11001009102	Fairfax County	VA	51059422302
District of Columbia	DC	11001009102	Fairfax County	VA	51059430202
District of Columbia	DC	11001009203	Fairfax County	VA	51059430600
District of Columbia	DC	11001009203	Fairfax County	VA	51059430600
District of Columbia	DC	11001009204	Fairfax County	VA	51059430600
District of Columbia	DC	11001009204	Fairfax County	VA	51059430600
District of Columbia	DC	11001009302	Fairfax County	VA	51059430700
District of Columbia	DC	11001009400	Fairfax County	VA	51059431001
District of Columbia	DC	11001009503	Fairfax County	VA	51059431001
District of Columbia	DC	11001009507	Fairfax County	VA	51059431602
District of Columbia	DC	11001009508	Fairfax County	VA	51059440100
District of Columbia	DC	11001009508	Fairfax County	VA	51059440202
District of Columbia	DC	11001009510	Fairfax County	VA	51059440202
District of Columbia	DC	11001009510	Fairfax County	VA	51059440503
District of Columbia	DC	11001009510	Fairfax County	VA	51059440504
District of Columbia	DC	11001009511	Fairfax County	VA	51059440505
District of Columbia	DC	11001009601	Fairfax County	VA	51059450100
District of Columbia	DC	11001009602	Fairfax County	VA	51059450200
District of Columbia	DC	11001009602	Fairfax County	VA	51059450300
District of Columbia	DC	11001009602	Fairfax County	VA	51059450300
District of Columbia	DC	11001009603	Fairfax County	VA	51059450300
District of Columbia	DC	11001009603	Fairfax County	VA	51059450300
District of Columbia	DC	11001009603	Fairfax County	VA	51059450400
District of Columbia	DC	11001009604	Fairfax County	VA	51059450500
District of Columbia	DC	11001009604	Fairfax County	VA	51059450500

City/County	State	Census Block ID	City/County	State	Census Block ID
District of Columbia	DC	11001009700	Fairfax County	VA	51059450602
District of Columbia	DC	11001009700	Fairfax County	VA	51059450602
District of Columbia	DC	11001009700	Fairfax County	VA	51059450602
District of Columbia	DC	11001009801	Fairfax County	VA	51059450702
District of Columbia	DC	11001009802	Fairfax County	VA	51059450702
District of Columbia	DC	11001009802	Fairfax County	VA	51059450800
District of Columbia	DC	11001009803	Fairfax County	VA	51059451000
District of Columbia	DC	11001009803	Fairfax County	VA	51059451400
District of Columbia	DC	11001009803	Fairfax County	VA	51059451400
District of Columbia	DC	11001009804	Fairfax County	VA	51059451501
District of Columbia	DC	11001009804	Fairfax County	VA	51059451501
District of Columbia	DC	11001009807	Fairfax County	VA	51059451501
District of Columbia	DC	11001009807	Fairfax County	VA	51059451501
District of Columbia	DC	11001009807	Fairfax County	VA	51059451502
District of Columbia	DC	11001009810	Fairfax County	VA	51059451502
District of Columbia	DC	11001009810	Fairfax County	VA	51059451601
District of Columbia	DC	11001009811	Fairfax County	VA	51059451601
District of Columbia	DC	11001009811	Fairfax County	VA	51059451601
District of Columbia	DC	11001009811	Fairfax County	VA	51059451602
District of Columbia	DC	11001009903	Fairfax County	VA	51059451900
District of Columbia	DC	11001009903	Fairfax County	VA	51059452000
District of Columbia	DC	11001009904	Fairfax County	VA	51059452101
District of Columbia	DC	11001009904	Fairfax County	VA	51059452102
District of Columbia	DC	11001009904	Fairfax County	VA	51059452200
District of Columbia	DC	11001009905	Fairfax County	VA	51059452200
District of Columbia	DC	11001009905	Fairfax County	VA	51059452200
District of Columbia	DC	11001009905	Fairfax County	VA	51059452200
District of Columbia	DC	11001009906	Fairfax County	VA	51059452301
District of Columbia	DC	11001009907	Fairfax County	VA	51059452301
District of Columbia	DC	11001009907	Fairfax County	VA	51059452302
District of Columbia	DC	11001010202	Fairfax County	VA	51059452302
District of Columbia	DC	11001010202	Fairfax County	VA	51059452400
District of Columbia	DC	11001010400	Fairfax County	VA	51059452400
District of Columbia	DC	11001010400	Fairfax County	VA	51059452400
District of Columbia	DC	11001010400	Fairfax County	VA	51059452400
District of Columbia	DC	11001010500	Fairfax County	VA	51059452400
District of Columbia	DC	11001010500	Fairfax County	VA	51059452501
District of Columbia	DC	11001010601	Fairfax County	VA	51059452501
District of Columbia	DC	11001010602	Fairfax County	VA	51059452502
District of Columbia	DC	11001010602	Fairfax County	VA	51059452502
District of Columbia	DC	11001010602	Fairfax County	VA	51059452600

City/County	State	Census Block ID	City/County	State	Census Block ID
District of Columbia	DC	11001010800	Fairfax County	VA	51059452600
District of Columbia	DC	11001010800	Fairfax County	VA	51059452700
District of Columbia	DC	11001010900	Fairfax County	VA	51059452700
District of Columbia	DC	11001010900	Fairfax County	VA	51059452700
District of Columbia	DC	11001011001	Fairfax County	VA	51059452801
District of Columbia	DC	11001011100	Fairfax County	VA	51059452801
District of Columbia	DC	11001011100	Fairfax County	VA	51059461604
Charles County	MD	24017850202	Fairfax County	VA	51059461700
Charles County	MD	24017850709	Fairfax County	VA	51059461901
Charles County	MD	24017850801	Fairfax County	VA	51059461902
Charles County	MD	24017850901	Fairfax County	VA	51059471204
Charles County	MD	24017850901	Fairfax County	VA	51059471301
Charles County	MD	24017850901	Fairfax County	VA	51059471301
Charles County	MD	24017851004	Fairfax County	VA	51059471401
Frederick County	MD	24021750300	Fairfax County	VA	51059471402
Frederick County	MD	24021750300	Fairfax County	VA	51059480203
Frederick County	MD	24021750505	Fairfax County	VA	51059480801
Frederick County	MD	24021750505	Fairfax County	VA	51059480901
Frederick County	MD	24021750505	Fairfax County	VA	51059480901
Frederick County	MD	24021750506	Fairfax County	VA	51059480901
Frederick County	MD	24021750507	Fairfax County	VA	51059480901
Frederick County	MD	24021750507	Fairfax County	VA	51059480902
Frederick County	MD	24021750507	Fairfax County	VA	51059480902
Frederick County	MD	24021750508	Fairfax County	VA	51059480903
Frederick County	MD	24021750508	Fairfax County	VA	51059480903
Frederick County	MD	24021750508	Fairfax County	VA	51059480903
Frederick County	MD	24021750701	Fairfax County	VA	51059481000
Frederick County	MD	24021750702	Fairfax County	VA	51059481000
Frederick County	MD	24021750702	Fairfax County	VA	51059481103
Frederick County	MD	24021750702	Fairfax County	VA	51059481202
Frederick County	MD	24021750801	Fairfax County	VA	51059481202
Frederick County	MD	24021750801	Fairfax County	VA	51059481202
Frederick County	MD	24021750801	Fairfax County	VA	51059481400
Frederick County	MD	24021751600	Fairfax County	VA	51059482206
Frederick County	MD	24021753001	Fairfax County	VA	51059482302
Frederick County	MD	24021765100	Fairfax County	VA	51059490101
Frederick County	MD	24021767600	Fairfax County	VA	51059490104
Frederick County	MD	24021772200	Fairfax County	VA	51059491103
Frederick County	MD	24021773500	Fairfax County	VA	51059491201
Frederick County	MD	24021775400	Fairfax County	VA	51059491303
Frederick County	MD	24021775400	Fairfax County	VA	51059491303

City/County	State	Census Block ID	City/County	State	Census Block ID
Montgomery County	MD	24031700310	Fairfax County	VA	51059491601
Montgomery County	MD	24031700313	Fairfax County	VA	51059491602
Montgomery County	MD	24031700613	Fairfax County	VA	51059491706
Montgomery County	MD	24031700706	Fairfax County	VA	51059491801
Montgomery County	MD	24031700710	Fauquier County	VA	51061930706
Montgomery County	MD	24031700713	Loudoun County	VA	51107610505
Montgomery County	MD	24031700713	Loudoun County	VA	51107610505
Montgomery County	MD	24031700713	Loudoun County	VA	51107610505
Montgomery County	MD	24031700713	Loudoun County	VA	51107610505
Montgomery County	MD	24031700720	Loudoun County	VA	51107611018
Montgomery County	MD	24031700721	Loudoun County	VA	51107611018
Montgomery County	MD	24031700721	Loudoun County	VA	51107611204
Montgomery County	MD	24031700723	Loudoun County	VA	51107611204
Montgomery County	MD	24031700723	Loudoun County	VA	51107611204
Montgomery County	MD	24031700724	Loudoun County	VA	51107611205
Montgomery County	MD	24031700724	Loudoun County	VA	51107611209
Montgomery County	MD	24031700724	Loudoun County	VA	51107611400
Montgomery County	MD	24031700725	Loudoun County	VA	51107611400
Montgomery County	MD	24031700725	Loudoun County	VA	51107611400
Montgomery County	MD	24031700726	Loudoun County	VA	51107611501
Montgomery County	MD	24031700726	Loudoun County	VA	51107611502
Montgomery County	MD	24031700727	Loudoun County	VA	51107611502
Montgomery County	MD	24031700728	Loudoun County	VA	51107611602
Montgomery County	MD	24031700728	Loudoun County	VA	51107611602
Montgomery County	MD	24031700729	Loudoun County	VA	51107611701
Montgomery County	MD	24031700731	Loudoun County	VA	51107611701
Montgomery County	MD	24031700732	Loudoun County	VA	51107611702
Montgomery County	MD	24031700732	Loudoun County	VA	51107611702
Montgomery County	MD	24031700812	Loudoun County	VA	51107611804
Montgomery County	MD	24031700813	Prince William County	VA	51153900201
Montgomery County	MD	24031700815	Prince William County	VA	51153900201
Montgomery County	MD	24031700815	Prince William County	VA	51153900202
Montgomery County	MD	24031700818	Prince William County	VA	51153900202
Montgomery County	MD	24031700818	Prince William County	VA	51153900202
Montgomery County	MD	24031700818	Prince William County	VA	51153900203
Montgomery County	MD	24031700819	Prince William County	VA	51153900203
Montgomery County	MD	24031700829	Prince William County	VA	51153900203
Montgomery County	MD	24031700832	Prince William County	VA	51153900301
Montgomery County	MD	24031700833	Prince William County	VA	51153900302
Montgomery County	MD	24031700833	Prince William County	VA	51153900403
Montgomery County	MD	24031700834	Prince William County	VA	51153900403

City/County	State	Census Block ID	City/County	State	Census Block ID
Montgomery County	MD	24031700834	Prince William County	VA	51153900403
Montgomery County	MD	24031700901	Prince William County	VA	51153900404
Montgomery County	MD	24031700904	Prince William County	VA	51153900404
Montgomery County	MD	24031700904	Prince William County	VA	51153900404
Montgomery County	MD	24031701102	Prince William County	VA	51153900407
Montgomery County	MD	24031701102	Prince William County	VA	51153900407
Montgomery County	MD	24031701102	Prince William County	VA	51153900407
Montgomery County	MD	24031701102	Prince William County	VA	51153900409
Montgomery County	MD	24031701102	Prince William County	VA	51153900409
Montgomery County	MD	24031701216	Prince William County	VA	51153900410
Montgomery County	MD	24031701219	Prince William County	VA	51153900503
Montgomery County	MD	24031701219	Prince William County	VA	51153900503
Montgomery County	MD	24031701422	Prince William County	VA	51153900504
Montgomery County	MD	24031701505	Prince William County	VA	51153900504
Montgomery County	MD	24031701505	Prince William County	VA	51153900504
Montgomery County	MD	24031701509	Prince William County	VA	51153900601
Montgomery County	MD	24031701509	Prince William County	VA	51153900601
Montgomery County	MD	24031701509	Prince William County	VA	51153900602
Montgomery County	MD	24031701509	Prince William County	VA	51153900602
Montgomery County	MD	24031701509	Prince William County	VA	51153900602
Montgomery County	MD	24031701601	Prince William County	VA	51153900702
Montgomery County	MD	24031701602	Prince William County	VA	51153900702
Montgomery County	MD	24031701602	Prince William County	VA	51153900803
Montgomery County	MD	24031701602	Prince William County	VA	51153900901
Montgomery County	MD	24031701602	Prince William County	VA	51153900901
Montgomery County	MD	24031701702	Prince William County	VA	51153900901
Montgomery County	MD	24031701703	Prince William County	VA	51153900901
Montgomery County	MD	24031701900	Prince William County	VA	51153901013
Montgomery County	MD	24031701900	Prince William County	VA	51153901014
Montgomery County	MD	24031701900	Prince William County	VA	51153901015
Montgomery County	MD	24031702000	Prince William County	VA	51153901102
Montgomery County	MD	24031702000	Prince William County	VA	51153901203
Montgomery County	MD	24031702000	Prince William County	VA	51153901203
Montgomery County	MD	24031702101	Prince William County	VA	51153901208
Montgomery County	MD	24031702101	Prince William County	VA	51153901209
Montgomery County	MD	24031702101	Prince William County	VA	51153901211
Montgomery County	MD	24031702101	Prince William County	VA	51153901211
Montgomery County	MD	24031702301	Prince William County	VA	51153901212
Montgomery County	MD	24031702301	Prince William County	VA	51153901212
Montgomery County	MD	24031702502	Prince William County	VA	51153901223
Montgomery County	MD	24031702503	Prince William County	VA	51153901227

City/County	State	Census Block ID	City/County	State	Census Block ID
Montgomery County	MD	24031702602	Prince William County	VA	51153901403
Montgomery County	MD	24031702604	Prince William County	VA	51153901403
Montgomery County	MD	24031702700	Prince William County	VA	51153901403
Montgomery County	MD	24031703207	Prince William County	VA	51153901403
Montgomery County	MD	24031703207	Prince William County	VA	51153901407
Montgomery County	MD	24031703207	Prince William County	VA	51153901407
Montgomery County	MD	24031703213	Prince William County	VA	51153901409
Montgomery County	MD	24031703213	Prince William County	VA	51153901416
Montgomery County	MD	24031703213	Prince William County	VA	51153901418
Montgomery County	MD	24031703214	Prince William County	VA	51153901418
Montgomery County	MD	24031703214	Prince William County	VA	51153901418
Montgomery County	MD	24031703214	Prince William County	VA	51153901419
Montgomery County	MD	24031703215	Prince William County	VA	51153901601
Montgomery County	MD	24031703215	Prince William County	VA	51153901702
Montgomery County	MD	24031703220	Prince William County	VA	51153901702
Montgomery County	MD	24031703301	Prince William County	VA	51153901702
Montgomery County	MD	24031703301	Prince William County	VA	51153901703
Montgomery County	MD	24031703301	Prince William County	VA	51153901703
Montgomery County	MD	24031703301	Prince William County	VA	51153901704
Montgomery County	MD	24031703302	Prince William County	VA	51153901704
Montgomery County	MD	24031703401	Prince William County	VA	51153901704
Montgomery County	MD	24031703403	Prince William County	VA	51153901704
Montgomery County	MD	24031703404	Prince William County	VA	51153901900
Montgomery County	MD	24031703404	Prince William County	VA	51153901900
Montgomery County	MD	24031703501	Spotsylvania County	VA	51177020108
Montgomery County	MD	24031703501	Spotsylvania County	VA	51177020201
Montgomery County	MD	24031703501	Spotsylvania County	VA	51177020202
Montgomery County	MD	24031703501	Spotsylvania County	VA	51177020202
Montgomery County	MD	24031703502	Spotsylvania County	VA	51177020204
Montgomery County	MD	24031703701	Spotsylvania County	VA	51177020305
Montgomery County	MD	24031703701	Spotsylvania County	VA	51177020307
Montgomery County	MD	24031703701	Spotsylvania County	VA	51177020311
Montgomery County	MD	24031704000	Spotsylvania County	VA	51177020313
Montgomery County	MD	24031706012	Stafford County	VA	51179010201
Prince George's County	MD	24033800102	Stafford County	VA	51179010211
Prince George's County	MD	24033800103	Stafford County	VA	51179010211
Prince George's County	MD	24033800109	Stafford County	VA	51179010215
Prince George's County	MD	24033800109	Stafford County	VA	51179010216
Prince George's County	MD	24033800206	Stafford County	VA	51179010216
Prince George's County	MD	24033800206	Warren County	VA	51187020300
Prince George's County	MD	24033800209	Warren County	VA	51187020400

City/County	State	Census Block ID	City/County	State	Census Block ID
Prince George's County	MD	24033800209	Warren County	VA	51187020400
Prince George's County	MD	24033800210	Warren County	VA	51187020400
Prince George's County	MD	24033800210	Warren County	VA	51187020400
Prince George's County	MD	24033800211	Warren County	VA	51187020400
Prince George's County	MD	24033800211	Warren County	VA	51187020500
Prince George's County	MD	24033800218	Warren County	VA	51187020500
Prince George's County	MD	24033800408	Warren County	VA	51187020500
Prince George's County	MD	24033800412	Warren County	VA	51187020500
Prince George's County	MD	24033801003	Warren County	VA	51187020601
Prince George's County	MD	24033801404	Warren County	VA	51187020602
Prince George's County	MD	24033801404	Alexandria City	VA	51510200102
Prince George's County	MD	24033801405	Alexandria City	VA	51510200102
Prince George's County	MD	24033801405	Alexandria City	VA	51510200102
Prince George's County	MD	24033801409	Alexandria City	VA	51510200104
Prince George's County	MD	24033801500	Alexandria City	VA	51510200104
Prince George's County	MD	24033801500	Alexandria City	VA	51510200104
Prince George's County	MD	24033801702	Alexandria City	VA	51510200105
Prince George's County	MD	24033801702	Alexandria City	VA	51510200105
Prince George's County	MD	24033801704	Alexandria City	VA	51510200106
Prince George's County	MD	24033801704	Alexandria City	VA	51510200109
Prince George's County	MD	24033801704	Alexandria City	VA	51510200109
Prince George's County	MD	24033801707	Alexandria City	VA	51510200301
Prince George's County	MD	24033801707	Alexandria City	VA	51510200302
Prince George's County	MD	24033801707	Alexandria City	VA	51510200302
Prince George's County	MD	24033801808	Alexandria City	VA	51510200304
Prince George's County	MD	24033801901	Alexandria City	VA	51510200304
Prince George's County	MD	24033801906	Alexandria City	VA	51510200304
Prince George's County	MD	24033801906	Alexandria City	VA	51510200305
Prince George's County	MD	24033802001	Alexandria City	VA	51510200305
Prince George's County	MD	24033802002	Alexandria City	VA	51510200406
Prince George's County	MD	24033802103	Alexandria City	VA	51510200408
Prince George's County	MD	24033802104	Alexandria City	VA	51510200408
Prince George's County	MD	24033802107	Alexandria City	VA	51510200408
Prince George's County	MD	24033802107	Alexandria City	VA	51510200409
Prince George's County	MD	24033802204	Alexandria City	VA	51510200409
Prince George's County	MD	24033802301	Alexandria City	VA	51510200409
Prince George's County	MD	24033802301	Alexandria City	VA	51510200409
Prince George's County	MD	24033802301	Alexandria City	VA	51510200500
Prince George's County	MD	24033802404	Alexandria City	VA	51510200500
Prince George's County	MD	24033802404	Alexandria City	VA	51510200500
Prince George's County	MD	24033802404	Alexandria City	VA	51510200600

City/County	State	Census Block ID	City/County	State	Census Block ID
Prince George's County	MD	24033802501	Alexandria City	VA	51510200703
Prince George's County	MD	24033802600	Alexandria City	VA	51510200802
Prince George's County	MD	24033802600	Alexandria City	VA	51510201100
Prince George's County	MD	24033802700	Alexandria City	VA	51510201204
Prince George's County	MD	24033802700	Alexandria City	VA	51510201205
Prince George's County	MD	24033802700	Alexandria City	VA	51510201205
Prince George's County	MD	24033802804	Alexandria City	VA	51510201206
Prince George's County	MD	24033802805	Alexandria City	VA	51510201206
Prince George's County	MD	24033802805	Alexandria City	VA	51510201206
Prince George's County	MD	24033802901	Alexandria City	VA	51510201602
Prince George's County	MD	24033802901	Alexandria City	VA	51510201802
Prince George's County	MD	24033802901	Alexandria City	VA	51510201805
Prince George's County	MD	24033803001	Fairfax City	VA	51600300100
Prince George's County	MD	24033803100	Fairfax City	VA	51600300100
Prince George's County	MD	24033803100	Fairfax City	VA	51600300200
Prince George's County	MD	24033803200	Fairfax City	VA	51600300500
Prince George's County	MD	24033803200	Fredericksburg City	VA	51630000201
Prince George's County	MD	24033803300	Fredericksburg City	VA	51630000301
Prince George's County	MD	24033803300	Fredericksburg City	VA	51630000400
Prince George's County	MD	24033803300	Fredericksburg City	VA	51630000400
Prince George's County	MD	24033803403	Fredericksburg City	VA	51630000500
Prince George's County	MD	24033803403	Fredericksburg City	VA	51630000500
Prince George's County	MD	24033803403	Manassas City	VA	51683910201
Prince George's County	MD	24033803403	Manassas City	VA	51683910202
Prince George's County	MD	24033803508	Manassas City	VA	51683910202
Prince George's County	MD	24033803508	Manassas City	VA	51683910202
Prince George's County	MD	24033803509	Manassas City	VA	51683910202
Prince George's County	MD	24033803509	Manassas City	VA	51683910301
Prince George's County	MD	24033803525	Manassas City	VA	51683910302
Prince George's County	MD	24033803602	Manassas City	VA	51683910401
Prince George's County	MD	24033803602	Manassas City	VA	51683910401
Prince George's County	MD	24033803605	Manassas City	VA	51683910401
Prince George's County	MD	24033803606	Manassas City	VA	51683910401
Prince George's County	MD	24033803606	Manassas Park City	VA	51685920100
Prince George's County	MD	24033803606	Manassas Park City	VA	51685920100
Prince George's County	MD	24033803608	Manassas Park City	VA	51685920100
Prince George's County	MD	24033803608	Manassas Park City	VA	51685920201
Prince George's County	MD	24033803610	Jefferson County	WV	54037972300
Prince George's County	MD	24033803612	Jefferson County	WV	54037972300
Prince George's County	MD	24033803612	Jefferson County	WV	54037972300
Prince George's County	MD	24033803613	Jefferson County	WV	54037972401

City/County	State	Census Block ID	City/County	State	Census Block ID
Prince George's County	MD	24033803613	Jefferson County	WV	54037972401
Prince George's County	MD	24033803613	Jefferson County	WV	54037972401
Prince George's County	MD	24033803700	Jefferson County	WV	54037972402
Prince George's County	MD	24033803700	Jefferson County	WV	54037972505
Prince George's County	MD	24033803801	Jefferson County	WV	54037972505
Prince George's County	MD	24033803803	Jefferson County	WV	54037972505
Prince George's County	MD	24033803803	Jefferson County	WV	54037972506
Prince George's County	MD	24033803900	Jefferson County	WV	54037972701
Prince George's County	MD	24033803900	Jefferson County	WV	54037972701
Prince George's County	MD	24033803900	Jefferson County	WV	54037972701
Prince George's County	MD	24033804001			

APPENDIX D. PROJECT IDEAS SUBMITTED TO COG

This list of project ideas is from fall of 2023 and may not be exhaustive of projects or programs that COG may be including in a CPRG implementation grant application. The ideas presented here were used as a starting point to develop PCAP and subsequent CCAP measures, and some may be carried into COG's implementation grant application.

Submitting Organization	Project Concept
Public	Consumer education campaigns for household food waste reduction ("prevention")
Alexandria	Direct installation and ownership of solar energy generation systems on city-owned and managed facilities
Alexandria	Deep energy retrofits for low-income multifamily housing
Alexandria	Healthy Homes improvements, capacity building, and monitoring
Alexandria	VFA facility capital planning software, climate mitigation overlay
Alexandria	Regional collaboration for passive-design and building performance education, training, and certification pathways
Arlington County	Energy performance for LIDAC multifamily & commercial buildings
Arlington County	Energy performance for non-LIDAC multifamily & commercial buildings
Arlington County	MUSH (Municipal, University, Schools & Hospitals) program for energy performance
Arlington County	Regional education and training program on advanced building design and retrofits
Arlington County	Energy efficiency, solar and storage for non-profits and places of worship
Arlington County	Finance mechanisms
Arlington County	Technical assistance and education
Charles County	Mulching facility relocation and composting facility
Charles County	Landfill gas (LFG) to energy
Charles County	Landfill convenience center and waste transfer station
Charles County	County fleet EV transition
Charles County	Urban tree canopy program expansion
City of Frederick	Tree canopy incentive program
DC DOEE	Regional composting program
Fairfax County	Technical and financial assistance to property owners implementing energy efficiency updates
Fairfax County	Resilience hubs pilot program
Fairfax County	Clean energy clearinghouse/ "concierge" service
Fairfax County	Boost low-income weatherization and energy efficiency programs
Frederick County	Solar power purchase agreement and community solar
Frederick County	Pilot projects for non-diesel alternatives and data center back up space
Frederick County	Solar and microgrids for county buildings
Frederick County	Reimbursements for energy efficiency upgrades, solar, and EVs
Frederick County	Weatherization and energy efficient retrofits to LIDAC multifamily buildings
Frederick County	Reducing VMT through transit systems

Frederick County	Urban reforestation and green infrastructure
Frederick County	Implementation of biodiesel for fleet that cannot be electrified
Frederick County	EVs for county fleet
Frederick County	BEPS internal
Frederick County	BEPS external
Loudoun County	Electrified and efficient equipment "road show"
Loudoun County	Studies and business plan for district energy for commercial and residential buildings
Montgomery College	Smart grid, ice thermal storage, natural refrigerants, Rockville Campus and Takoma Park Silver Spring Campus
Montgomery County	Urban shade tree planting project
Montgomery County	Installation of enhanced diversion technologies at the Montgomery County Shady Grove Transfer Station to manage approximately 450,000 tons of waste that was not recycled and that otherwise will go to the RRF or a landfill
Montgomery County	Community health worker climate-based community outreach and engagement, in Spanish
Montgomery County	Reforest open areas and enhance and expand existing forest and forested stream buffers on private properties. The project will work with private property owners to stop mowing and add forest plantings to expand and enhance forest coverage around the county
Montgomery County	133 affordable housing properties and 32 additional multifamily properties in overburdened and underserved neighborhoods to complete modernizing upgrades to save energy and improve quality of life
Montgomery County	Smart meter electrical panel upgrade program for EEAs, water heater loaner program, heat pumps for income-qualified residents with delivered fuel
Montgomery County	Support incentives and turn-key solutions to install EV charging infrastructure at multi-unit dwellings as well as other public and commercial sites needed to support the equitable and rapid adoption of electric vehicles
Montgomery County	Microgrid/resiliency hub and renewable energy "green" power production at four county owned locations
Montgomery County	Increase size of Capital Bikeshare e-bike fleet
Montgomery County	Provide funding to farmers or composting companies for the construction of an on-farm food scrap composting facility.
Montgomery County	Provide funding to farmers for the construction of an accessory solar array that will provide electricity to the agricultural operation.
Montgomery County	Increase the amount of funding in the Office of Agriculture (OAG)'s Soil Amendment Program, which provides county farmers with free deliveries of LeafGro, the compost produced at the County-operated yard trim composting facility in Dickerson
Montgomery County	Leaf blower rebate program
Montgomery County	Yard Trim Composting Program, installation of a dry fermentation anaerobic digester system will produce significant quantities of methane for use as Renewable Natural Gas for fuel or part of the process to produce hydrogen fuel for buses, trucks, and cars

Montgomery County Green Bank	MCGB BEPS Readiness Program - ASHRAE energy audit and guaranteed financing for projects identified in audit as economical
Montgomery County Green Bank	MCGB Energize Multifamily Program - Mezzanine finance loan to owners and developers who are restricted by senior lending.
Montgomery County Green Bank	MCGB Building Decarbonization Bond - Conduit capital markets issuance to support BEPS Readiness (above) and Energize Multifamily (above) by using grant capital for a guarantee.
Montgomery County Green Bank	MCGB Resiliency Hub Accelerator - Financing support from MCGB plus grant support to manage storage economics.
Montgomery County Green Bank	MCGB Resiliency Bond -Conduit capital markets issuance to support Resiliency Hub Accelerator (above) using grant capital for a guarantee.
Montgomery County Public Schools	Retrofit schools in equity areas with energy efficient upgrades and decarbonization measures to improve the indoor learning environment
Montgomery County Public Schools	Install agrivoltaics at Loiderman Reach Hub
Montgomery County Public Schools	Convert 35 additional fleet (nonbus) vehicles to clean energy & add messaging on fleet about Climate Actions
Montgomery County Public Schools	Install additional electric vehicle charging stations for fleet
Montgomery County Public Schools	Completely decarbonize some MCPS schools
Montgomery County Public Schools	Real-time energy/utility (electric, water, gas) monitoring enhancements at all schools so real-time consumption can be viewed and acted upon by students, staff, and other building users. Students have expressed a desire for their real-time data to be available for them to be able to act.
NVRC	Expand Solarize NoVA
Prince George's County	Solar PV grants for Energy Resiliency Communities (ERC)
Prince George's County	Implementation of Solar PV and Solar Thermal Hot Water Systems for public housing properties
Prince George's County	Zero emission bus and supporting infrastructure (microgrid, battery storage, charging stations)
Prince George's County	Circular tree canopy program
Prince George's County	Accelerate purchase of EVs for gov ops
Prince George's County	Assist affordable housing building owners to comply with BEPS
Prince George's County	BEPS for Government buildings
Prince George's County	Infrastructure and technical monitoring upgrades at Prince George's County's municipal landfills
Prince William County	Regional tree canopy grant program
Rockville	Renovation and conversion to efficient electrification of 100 affordable residential units
Rockville	LED streetlight conversion
Rockville	Heavy-Duty fleet electrification - replace three shuttle buses and seven heavy-duty vehicles with electric models (pending market availability)
Rockville	Heavy-Duty fleet EV charging - DC Fast Charging to serve 10 heavy-duty fleet vehicles
Rockville	Rockville Swim and Fitness Center Energy Efficiency and Renewable Energy Upgrades (Lighting, variable frequency pumps, solar hot water,

	solar panels, electrification, and energy efficiency strategy to meet Montgomery County and Maryland BEPS)
Rockville	Expansion of Montgomery County Residential Electrification Incentives
Rockville	Expansions of solar rooftops and parking lot canopies on City of Rockville facilities
Rockville	Upgraded efficient and electric appliances, solar, and energy efficiency of 100 apartments and town homes owned by Rockville Housing Enterprises (RHE) property at Scarborough Square
Rockville	Upgraded roofs, energy efficiency, insulation, and air sealing, windows, and doors at RHE Scarborough Square town homes and apartments.
Rockville	EV Charging stations at RHE properties (at three multifamily apartment/town home developments and 29 scattered single-family homes)
Rockville	City of Rockville Facility LED Light Retrofits
Rockville	Landscape equipment electrification (public and private)
Rockville	Mobile EV charger for fleet
Rockville	Energy Audits and Electrification Plan for City Facilities to meet County and State BEPS. Only one of about 10 facilities has received a Level 2 energy audit in the last 18 years.
Rockville	Implementing electrification for HVAC and other City appliances, energy efficiency upgrades at 10 facilities.
Rockville	Reforestation at RedGate Park Arboretum to plant 5,000 trees and 2,500 shrubs.
Rockville	Greenspace Master Plan to maximize sequestration of City-owned lands
Rockville	Curbside Food Waste Compost Program. A local transfer and regional commercial compost site would need to be identified.
Rockville	Bikeshare Program Expansion to Twinbrook metro and neighborhood
Rockville	Establish Carshare or E-carshare Program
Rockville	Multiple Bicycle and Pedestrian Safety and facility expansion Projects
Rockville	Transit projects: MD 355 BRT construction serving Rockville (County project currently under design); MD 586 BRT construction serving Rockville (County project currently under design)
Rockville	Outreach, Education, Engagement with diverse communities and messaging materials coordinated by County, State, or COG to advance IRA incentives, energy efficiency, electrification, EVs, bike/ped/transit, waste reduction/compost, and sequestration.
Takoma Park	Solar canopies in city-owned parking lots
Takoma Park	Technical assistance program to help municipalities divest from fossil fuels
Takoma Park	Multifamily Building Improvement Grant (MFBIG) to make electrification/efficiency upgrades
Takoma Park	Commercial Building Improvement Grant to make electrification/ efficiency upgrades
Takoma Park	Clean Building Workforce Development Program
Takoma Park	Capital Area Resiliency Hub creation - retrofit existing buildings like schools or community centers with solar, battery storage, generators, etc.

Takoma Park	Multifamily EV charging station program
Takoma Park	Municipalities Building Performance Support Program - support gov building efficiency upgrades
University of Maryland/Prince George's County	Retrofitted solar microgrid
WMATA	Enhanced bus service i.e., WMATA's Better Bus Network Redesign Visionary Network implementation and other regional transit service improvement projects that will align service with regional development and travel patterns and increase access to frequent service that is easier to use
WMATA	Bus priority infrastructure projects i.e., dedicated bus lanes/clear lanes, transit signal priority and access efforts across the region
WMATA	First/last mile improvements and use that support access to transit and other active transportation modes
WMATA	Zero-emission buses and supporting infrastructure (i.e., battery storage, charging stations)
WSSC Water	The implementation of aeration control improvements across all six Water Resource Recovery Facilities (WRRFs) including integration of blowers and upgrades/replacements of aeration systems.
WSSC Water	Capture and recovery of ammonia product from liquid portion of solids stream at Piscataway Maryland Bio-Energy WRRF to recycle as fertilizer and reducing treatment volume and methanol and electricity use.
WSSC Water	Water and Wastewater Pump Optimization: Develop a process/system to monitor operation of pumps and provide actionable information on performance and operational condition for operating efficiency and reduce minimal energy usage.
WSSC Water	Install sewer thermal exchange equipment and solar array at the Anacostia, Maryland Depot to provide low-carbon heating, cooling, and hot water at this facility.
WSSC Water	Continue fleet electrification plan through acquisition of 60 EVs and 13 electric forklifts as well as charging infrastructure available for both employees and the general public at our facilities throughout Prince George's and Montgomery County Maryland.
WSSC Water	Install a microgrid at the Potomac WFP consisting of 9 MW of natural gas engine generation plus 860 kW of solar. Include carbon capture of exhaust gas and removal and sequestration of carbon offsite.

APPENDIX E. COMMUNITY CLIMATE PRIORITIES SURVEY RESULTS

COG has undertaken a robust effort to formulate a PCAP and a CCAP for the Washington-Arlington-Alexandria, DC-VA-MD-WV MSA. COG is dedicated to addressing climate change by integrating priority measures and projects to reduce carbon and GHG pollutants across various industries. To capture a larger perspective of communities in the MSA, COG disseminated the CPRG Community Climate Priorities survey to assess community-wide climate priorities. The survey was shared through multiple online channels, extending beyond formal committees to include distribution through social media, the COG CPRG and main COG websites, local representatives, and community-based/non-governmental organizations. The survey gained responses from 86 participants from 13 different jurisdictions within the MSA, encompassing a diverse range of individuals, organizations, coalitions, and agencies.

Community Priorities

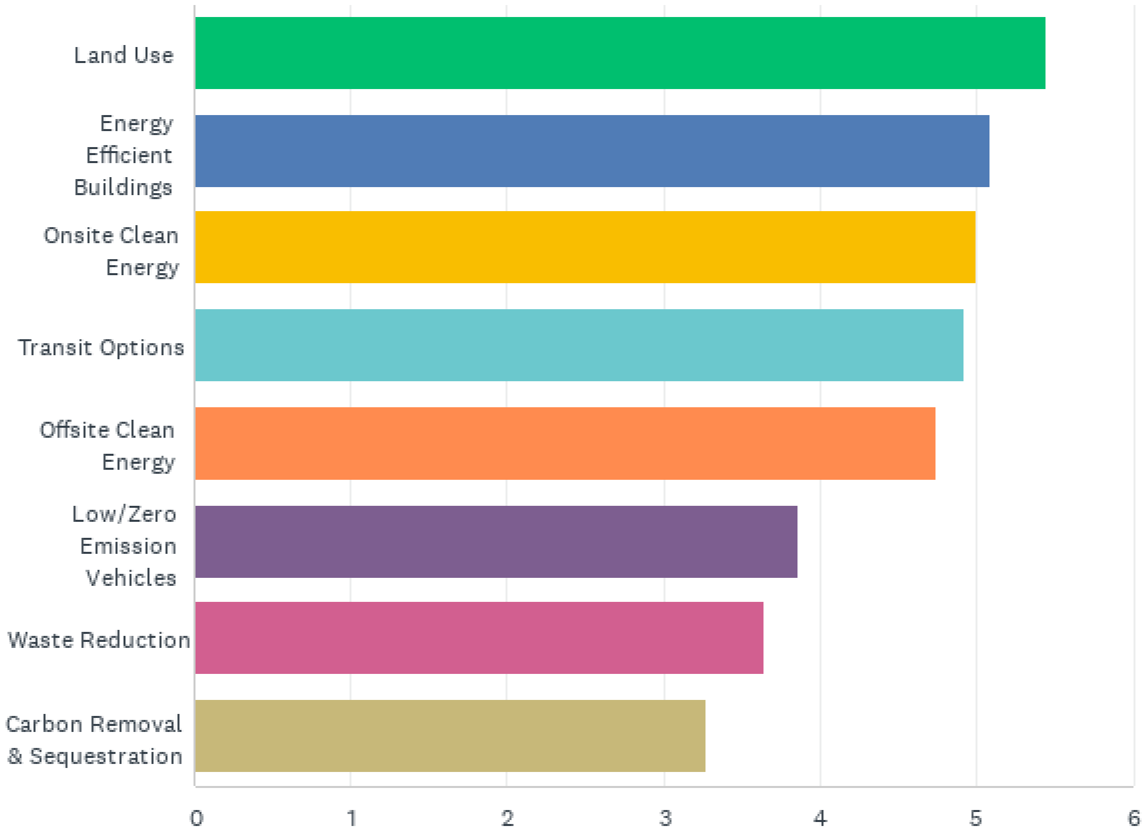
During the PCAP development process, participants were assigned the task of prioritizing GHG reduction strategies based on their perceived importance in mitigating climate change. The rankings of these strategies were averaged to generate an overall score. The following outlines the ranked strategies based on community input, listed from highest to least priority:

1. **Land Use** (including development planning, land conservation, and environment protection): 23.26%
2. **Energy Efficient and Clean Energy Buildings**: 17.44%
3. **Increasing Supply of On-site Clean Energy** (e.g., rooftop solar): 10.47%
4. **Transit Options** (such as increased use of public transportation, bike and pedestrian travel options, and reduction of travel): 17.44%
5. **Increasing Off-site Clean Energy** (e.g., community solar, utility-supplied energy): 9.30%
6. **Transportation Technology** (such as clean fuels and low/zero emission vehicles): 5.81%
7. **Waste Reduction, Composting, and Recycling**: 11.63%
8. **Carbon Removal and Sequestration** (including green infrastructure such as trees and wetlands): 4.65%

These results are also displayed in Figure 18.

These rankings, derived from the PCAP development process, reflect the community's prioritization of strategies to mitigate climate change. Land use, energy efficient buildings, and on-site clean energy supply ranked as top priorities, with an emphasis on sustainable development and clean energy initiatives.

Figure 18. Results from COG's Community Climate Priorities Survey



Equity and LIDAC Priorities

The community responses outlined two overarching themes in response to questions that polled equity impact priorities. There was a notable emphasis on environmental justice, particularly concerning the needs of LIDACs. Concerns included air and water quality, greenspace availability, and overall quality of life that underscored the importance of ensuring that climate initiatives benefit people who have historically faced disproportionate environmental burdens.

Community engagement and empowerment emerged as significant aspects of equity impacts. The responses highlighted the community's call for public support, ensuring investment returns to communities, and involving communities in project planning and decision-making. This theme also encompassed a focus on creating employment opportunities, supporting local initiatives such as community composting and neighborhood farming, and fostering a sense of ownership and agency within historically underserved populations. Together, these themes conveyed the community's perspective on the most important equity impacts to achieve in the context of climate action. When assessed on what emissions reduction projects would have the most positive impact on communities that are low-income, disadvantaged, and overburdened, or have been historically underrepresented in planning processes, respondents outlined initiatives tailored to the unique needs of these communities. Key strategies identified included the promotion of non-car travel, featuring expanded bike lanes, improved bus availability, and pedestrianized streets aimed at enhancing safety and accessibility. Additionally, there was a strong emphasis on reuse and repair initiatives, such as community-engaged compost programs and durable materials reuse infrastructure, with the goal of reducing waste and promoting local employment.

Affordable housing near transit emerged as a significant strategy, with respondents emphasizing the importance of funding allocation for such initiatives. Respondents also emphasized the importance of implementing energy efficiency projects in multifamily and commercial buildings as a crucial step toward reducing energy consumption and emissions. In summary, respondents delineated a comprehensive set of emissions reduction projects addressing transportation, waste management, energy efficiency, and community development, reflecting a commitment to sustainability and economic well-being within these communities.

Barriers

Stakeholder that COG engaged identified several barriers hindering their organizations from advancing climate change initiatives and energy efficiency planning. Some survey respondents highlighted leadership challenges such as time constraints and limited knowledge, emphasizing the need for more accessible and user-friendly (i.e., simplified, short, and specific) information and resources. Others mentioned specific barriers related to their expertise or organizational focus, such as the lack of transparency on data center energy use, obstacles in rezoning industrial space, and challenges related to living in an apartment where residents may feel limited control over larger-scale initiatives.

The most prevalent challenges for CBOs included limited access to program funding, cited by 37% of respondents, followed closely by the high cost of alternatives at 36%. Time constraints were identified by 35% of respondents, while 29% specified other barriers not covered in the options provided. Limited knowledge was noted as a challenge by 21% of respondents, and 20% indicated limited access or inconvenience of programs as a barrier. These findings underscore a range of impediments that individuals and organizations encounter, providing valuable insights into consideration of the multifaceted challenges associated with advancing climate mitigation initiatives and energy efficiency planning.

Additionally, respondents underscored financial considerations, including the high capital cost, the need for concierge services to guide individuals through the process, and limited access to utility services and infrastructure. These nuanced insights highlight the diverse array of obstacles faced by organizations, emphasizing the importance of tailored solutions to address their unique circumstances.

Project Emphasis

When responding to the question about advancing projects within COG's identified areas for climate action strategies, participants provided a diverse range of project ideas aligned with the key focus areas: Planning, Equity, Clean Electricity, Zero Energy Buildings, Zero Emission Vehicles, Mode Shift and Travel Behavior, Zero Waste, and Sequestration.

Their input reflected emphasizing the need for projects that span urban planning, social equity, renewable energy, sustainable infrastructure, transportation, waste management, and carbon sequestration. The following insights offer valuable perspectives on the types of initiatives respondents believe should be prioritized to address the multifaceted challenges posed by climate change within the COG region.

The community responses reflected several key themes that resonated across the spectrum of climate action strategies within COG's identified areas.

- **Equity and Inclusive Clean Energy Transition:** A recurring priority was the promotion of equitable clean energy transitions, particularly in LIDACs. The responses advocated for green job opportunities, diverse representation, and inclusive decision-making processes to ensure the benefits of clean energy initiatives reached everyone.
- **Renewable Energy:** Another prevalent theme was the commitment to advancing renewable energy. This involved a push for increased use of renewable energy sources, such as solar.
- **Sustainable Transportation:** This recurring theme of sustainable transportation focused on ZEVs, robust charging infrastructure, and enhanced public transit options.
- **Waste Reduction and Recycling Initiatives:** Respondents expressed a collective commitment to a circular economy, emphasizing waste reduction, recycling initiatives, and legislative support for reuse infrastructure. Additionally, there was a shared focus on climate resilience through community planning, increased green spaces, and stormwater management solutions.

These common themes underscored the community's strong emphasis on inclusivity, environmental sustainability, and climate resilience in shaping climate action strategies.

Education and Public Outreach Summary

TRIBAL ENGAGEMENT: PATAWOMECK INDIAN TRIBE AND THE ACCOKEEK FOUNDATION

COG met with the Patawomeck Indian Tribe and the regional Accokeek Foundation to discuss climate priorities and explore collaboration under the CPRG program. The sessions deepened COG’s understanding of tribal concerns around water quality, land loss, and development pressures. Engagement feedback shaped many of the CCAP measures, as well as the benefits and workforce analyses.

REGIONAL ENGAGEMENT MAP

COG reviewed climate education and outreach programs across the region and shared key findings with the Climate, Energy, and Environment Policy Committee (CEEPC). The analysis (called the engagement map) helped COG identify strengths, gaps, and opportunities for regional climate programming to support more inclusive and coordinated public education and outreach across the MSA. The programs varied in scope and accessibility based on the jurisdiction or municipality, with many lacking a clear equity focus or LIDAC engagement. COG used this assessment to shape the CCAP’s public education and outreach engagement approach and to inform the Education and Public Outreach Measure.

COG CLIMATE, ENERGY, AND ENVIRONMENT POLICY COMMITTEE (CEEPC)

On January 22, 2025, COG hosted a meeting with the CEEPC to discuss best practices for developing a regional engagement approach with local municipalities. COG identified and shared research on effective climate programs in the MSA and conducted a Q&A for attendees after the presentation. Staff from local governments posed questions on environmental organization structure and staff support, requested data on the utilization of programs by audiences of different demographics, and shared further knowledge on existing effective climate campaigns and programs. The meeting served as a baseline for the COG to assess the needs and interests of local municipalities in developing the CCAP and the Education and Public Outreach Measure.

In addition to this formal meeting, COG engaged with CEEPC regularly to share updates on the CCAP development process and to receive feedback from CEEPC members. These touchpoints helped inform and bolster multiple CCAP measures and analyses.

ENVIRONMENTAL JUSTICE INTERVIEWS AND OUTREACH

COG conducted interviews and outreach with environmental justice organizations to update its Environmental Justice (EJ) Toolkit and gather input from LIDAC communities to inform future public education and outreach strategies. Through these conversations, COG gained valuable insight into relevant priorities and concerns. CBOs emphasized that pollution, outdoor air quality, and the resulting impacts on public and personal health are top concerns for the populations they serve. They also highlighted additional challenges, including housing affordability, increasing energy costs and unreliability, food insecurity, increased flooding, and waste management. These insights directly informed the development of the Education and Public Outreach Measure.

WORKFORCE DEVELOPMENT OUTREACH AND PLANNING

COG launched workforce outreach to organizations in spring 2025 to identify labor gaps and training needs. COG briefed local committees, facilitated stakeholder meetings, and reviewed survey input. Participants confirmed shortages in climate-critical roles such as EV technicians, energy auditors, and tree maintenance. COG compiled an inventory of workforce organizations to support career development. Participants discussed the need for comprehensive solutions beyond training to ensure equitable access to programs and to enhance worker retention (e.g., through internship programs, alternative career pathways, competitive pay, etc.). The RTCS meeting (discussed below) also provided input on the workforce assessment, and the topic was similarly discussed at other committee meetings, including CEEPC and BEEAC to hear from localities about local workforce challenges and successful programs. This work guided CCAP strategies that align labor needs with equitable economic opportunity.

COG BUILT ENVIRONMENT & ENERGY ADVISORY COMMITTEE (BEEAC)

On February 20, 2025, COG presented information on the ENERGY STAR certification for data centers, as well as data center GHG inventory results.

COG conducted a meeting on April 17, 2025, to discuss the CCAP’s workforce development requirements and approach with BEEAC. COG shared information about the goals of the workforce development analysis, including identifying and mitigating workforce shortfalls in the environmental and climate sectors. Meeting attendees shared their program’s investments in workforce development initiatives, recommended resources to consider as a part of the analysis and suggested possible collaborators for a workforce development contact database. The findings from the meeting were used to develop an effective and accurate workforce development analysis, reflecting the evolving challenges and needs of the metropolitan Washington region.

On June 12, 2025, COG shared information on the data center measure with the committee. Attendees highlighted the challenges of acquiring energy-use data from data centers and understanding how higher energy costs resulting from increased energy demands will impact customers across different demographics. Feedback gathered from the discussion was considered in the development of the Data Center Measure, supporting a comprehensive regional climate plan.

On September 18, 2025, COG shared an update on the draft CCAP analysis, including the GHG modeling, co-benefits analysis, and workforce assessment.

DATA CENTER OUTREACH AND REGIONAL PLANNING

COG examined the climate impact of data centers, now with more than 300 facilities nearby and responsible for nearly 25% of building electricity use and 8% of regional gross GHG emissions in 2023. COG engaged localities through surveys, GHG inventory data gathering, technical meetings, and workshops. Local leaders shared concerns about sourcing accurate energy-use data from data centers, the challenges of addressing increasing regional energy demands, and the importance of considering equity with rising residential energy costs. Their feedback informed the development of a new CCAP measure focused on clean energy sourcing and energy efficient data centers.

COG AIR AND CLIMATE PUBLIC ADVISORY COMMITTEE (ACPAC)

On May 19, 2025, COG presented information about the CPRG Data Center Measure to ACPAC. The presentation provided an overview of the CPRG, data on projected energy demands from data centers in the MSA, and a draft data center CCAP measure. Meeting attendees discussed concerns about data center impacts on water and air pollution, and the inclusion of the impacts of developing technologies in the measure's projections. Insights gathered from ACPAC committee members shaped the development of the Data Center Solutions Measure.

On September 15, 2025, COG shared an update on the draft CCAP analysis, including the GHG modeling, co-benefits analysis, and workforce assessment.

RTCS MEETING

COG hosted a discussion session on workforce development related to urban forestry at the August 19, 2025, meeting of the RTCS. The discussion began with an overview of the CPRG and CCAP requirements to provide context for the group, which consisted of government staff and relevant private sector stakeholders. Attendees described a lack of expertise in environmental specialties, insufficient training from educational institutions, and gaps in hands-on knowledge of the natural environment as barriers to those seeking roles in urban forestry. The high cost of living in the Washington DC area and lower pay rates for the strenuous outdoor work of forestry are also driving young professionals away from the sector, according to meeting attendees. The information gathered at the meeting informed the Workforce Development Analysis section of the CCAP.

TPB TECHNICAL AND STEERING COMMITTEES

The TPB Steering Committee and Technical Committee each meet monthly to discuss transportation issues in the region. With multiple transportation measures in the CCAP, it was critical for COG to collaborate and coordinate with these committees to inform the CCAP development and to inform the TPB Committees' programs and plans.

CPRG PROGRAM STEERING COMMITTEE

The CPRG Program Technical Committee was created to provide technical guidance and expertise on strategies and deliverables for the CPRG program. The committee is comprised of local and state government staff and other key stakeholders in the region. COG met with the committee on April 30, 2025 to discuss updates to the CCAP, including the updated measures, the initial results of the benefits analysis and workforce analysis, engagement efforts to date, and other general updates. The conversation informed local stakeholders of COG's progress and provided a forum for them to share recommendations with COG to improve the CCAP.

CLIMATE LEADERS WEBINAR

COG hosted a Climate Leaders Webinar on September 4, 2025, to gather feedback on the CCAP Education and Public Outreach Measure. The session brought together government staff, environmental partners, and community stakeholders to inform the public education and outreach strategies. Attendees discussed the challenges of garnering community participation in climate and energy programs, incentives that inspire action, and the mechanisms used to center LIDAC communities in decision-making processes. Challenges for local organizations included community distrust of all levels of government, a lack of concern for climate change as a priority issue, and engaging citizens who are indifferent to ongoing climate efforts. Logistical issues, such as budget challenges and a misalignment of community needs and available programs, are also limiting factors to community and LIDAC-specific engagement. Attendees shared that coordinating with community partners, creating accessible and relevant content in multiple languages, and providing incentives such as food or financial support for community members participating in events were efforts that fostered engagement in local climate and energy programs. Feedback from the webinar refined the Education and Public Outreach Measure and supported the development of a more coordinated and actionable plan for the region.

METROPOLITAN WASHINGTON AIR QUALITY COMMITTEE TECHNICAL ADVISORY COMMITTEE (MWAQC-TAC)

On September 12, 2025, MWAQC-TAC convened and viewed a presentation on the CPRG and CCAP measures. COG shared information on the CCAP GHG modeling and mitigation measure requirements, transportation measures, and the co-pollutant benefit analysis. COG used the feedback from meeting attendees to inform the technical aspects of the CPRG and CCAP measures.

The table below presents CCAP outreach activities with corresponding timeframes, participant groups, key themes, and resulting outcomes.

Table 46. CCAP Outreach Activities, Timeframe, Attendees, Key Themes, and Outcomes

Outreach Entities and Topics	Outreach Activities	Date	# of Attendees	Key Themes	Outcomes
Tribal Engagement	Two conversations with the Patawomeck Indian Tribal Leader (VA) and the Executive Director of the	December 2024	2 tribal leaders	The Patawomeck leader was most concerned with water quality, data centers, and energy access, and youth engagement.	Informed CCAP strategies and future tribal engagement

Outreach Entities and Topics	Outreach Activities	Date	# of Attendees	Key Themes	Outcomes
	Accokeek Foundation of Piscataway Park (MD), and remained in touch over email regarding data centers and youth engagement.			The leader of the Accokeek Foundation of Piscataway expressed interest in youth engagement, cultural preservation, concerns associated with land change and land restoration, invasive species, and water quality.	
Regional Engagement Map	Review of 100+ regional education and outreach programs	January 2025	N/A	Equity gaps, accessibility, outreach coordination, and public education	Informed the outreach and education measure
CEEPC Meeting	Meeting and discussion with government staff and local stakeholders	November 2024; January, July, and September 2025	191 total	Identifying effective climate programs, best practices for regional planning, successful organizational structures, data on climate program utilization, and accessible materials	Informed the Education and Public Outreach Measure and provided input on all components of the draft CCAP analysis
Environmental Justice Workshops and Interviews	Interviews, surveys, committee meetings, and	February 2025 – June 2025	67 total	Build community trust, partner with trusted messengers, increase in-	Informed the Education and Public

Outreach Entities and Topics	Outreach Activities	Date	# of Attendees	Key Themes	Outcomes
	six community events			person outreach, strengthen staff capacity, ensure transparent decision-making, support two-way communication, offer compensation and support, provide accessible materials, and use credible, neutral data	Outreach Measure
Workforce Development Outreach	Outreach to 100+ organizations, three stakeholder meetings, a regional survey, and an inventory of 25+ workforce organizations	April 2025 and June 2025	20 total	Labor gaps, training access, equity, certifications, and partner collaboration	Guided workforce strategies aligned with CCAP goals
BEEAC Meetings	Three meetings and discussions with government staff and local stakeholders	February, April, June, and September 2025	83 total	ENERGY STAR and data centers inventory projections Workforce planning and development, investment in training, identifying partners for	Guided workforce assessment and conclusions, informed the Data Center Solutions Measure, and provided input on all

Outreach Entities and Topics	Outreach Activities	Date	# of Attendees	Key Themes	Outcomes
				workforce development opportunities, apprenticeship, and certification programs Access to data center energy-use data, impacts to residents on rising energy costs from data centers, and incorporating data center emissions into planning	components of the draft CCAP analysis
Data Center Outreach	Survey, small group engagements with localities, presentations at committee meetings (CEEPC, BEEAC, ACPAC)	Various, September 2024 – September 2025	Various	GHG emissions, data transparency, permitting, and regional coordination	Developed a new GHG inventory category and the Data Center Solutions Measure
ACPAC Meeting	Meeting and discussion with government staff and local stakeholders	May and September 2025	22	The Data Center Measure, technological impacts on pollution, and changing energy demands	Informed the Data Center Measure
TPB Steering Committee and Technical Committee meetings	Participated in meetings, providing updates and seeking input	May 2025 and September 2025	44	CCAP measures, CCAP modeling to achieve net zero emissions	Informed the transportat-ion sector measures

Outreach Entities and Topics	Outreach Activities	Date	# of Attendees	Key Themes	Outcomes
	on modeling and measures				and modeling
CPRG Program Steering Committee	Participated in a meeting to share updates and discuss potential CCAP updates	April 2025	11	CCAP development process, measures, engagement, workforce assessment, benefits analysis	Committee reviewed draft CCAP and provided recommen-dations
RTCS Meeting and Workforce Development Discussion	Meeting and discussion with government staff and private sector stakeholders	August 2025	21	Identify training opportunities and education gaps, place importance on career specialization, increase investment in technical environmental education, and connect staff to their natural environments	Guided workforce strategies
Climate Leaders Webinar	Outreach to 50+ local governments and organizations, one virtual meeting	September 2025	34	Barriers to community engagement, centering equity and LIDAC communities, fostering collaboration, and evaluating effective incentives for program participation	Informed the Education and Public Outreach Measure

Outreach Entities and Topics	Outreach Activities	Date	# of Attendees	Key Themes	Outcomes
Metropolitan Washington Air Quality Committee Technical Advisory Committee (MWAQC-TAC) Meeting	Meeting and discussion with government staff and local stakeholders	April 2025 and September 2025	24 total	GHG inventory, GHG projections, CCAP transportation measures, GHG reduction, co-pollutant benefit analysis	Informed the co-pollutants benefit analysis and technical CCAP measures

LIDAC Engagement Outreach Summary

COG launched a focused outreach initiative to engage LIDACs in shaping the region's CCAP. Recognizing that inclusive planning was essential for effective climate action, COG developed a concise, plain-language survey aimed at capturing the key priorities of LIDAC's and their members. The survey addressed crucial issues, including health, affordability, energy savings, transportation options, and climate resilience. Through this engagement, the survey aimed to amplify the voices and experiences of historically underrepresented groups in the decision-making process.

In preparation for this outreach effort, COG conducted extensive research on CBOs throughout the region. This research identified potential partners who could help reach LIDAC populations. COG staff contacted organizations by phone to establish relationships and share information about the purpose and importance of the survey. To further enhance engagement, staff sent out follow-up emails to additional organizations, encouraging their participation and support for the initiative. As a result, several organizations expressed their willingness to help promote the survey within their respective networks, demonstrating a strong commitment to community involvement.

To facilitate the outreach process, COG created a variety of supportive materials. These materials included informative flyers outlining the survey's purpose and significance, as well as an FAQ document addressing common questions and concerns. Recognizing the importance of financial compensation, COG also offered stipends to help organizations conduct outreach at local events. The table below shows the number of CBOs contacted and responses received, the survey's key design features, and the outreach materials used.

Table 47. LIDAC Outreach Summary

Metric	Details
Number of CBOs contacted	111 organizations
Responses received from CBOs	32 responses received
Survey design features	QR code, short, accessible, focused on health, affordability, energy, and resilience

Metric	Details
Outreach materials	Flyers, the CPRG fact sheet, and an FAQ document

Although the number of survey responses was modest, the outreach effort represented a significant step toward a more inclusive planning process. By prioritizing engagement with LIDAC, COG laid the groundwork for deeper, ongoing relationships and a stronger foundation for equity-centered climate action. This effort reaffirmed COG's commitment to ensuring all communities have a voice in shaping a more sustainable future for the region.

Conclusion

COG values community input and has broadly engaged with the public within the MSA on the development of the CCAP, with a focus on addressing environmental justice concerns and supporting historically underrepresented and overburdened communities. While all input from the Community Climate Priorities survey was carefully considered in developing CCAP measures, not all suggestions could be feasibly included as designated measures. Survey responses were used in conjunction with ongoing and planned project activities from participating jurisdictions, serving as a resource to confirm regional climate priorities. COG used the responses of this survey and its wider CEP to inform the CCAP and continued to seek engagement from a wider, more diverse audience within its climate mitigation planning processes.

Thank you to all community members who participated in shaping the climate priorities for the metropolitan Washington region.

APPENDIX F. STAKEHOLDER AND COMMUNITY REPRESENTATIVES

Some of the organizations that attended meetings or engaged with COG, or which COG initiated outreach are listed below.

Table 48. COG CPRG Steering and Technical Committees

Committee	Organization	Jurisdiction
Steering Committee Members	Arlington County, Office of Sustainability and Environmental Management and the Climate Policy Office	Virginia
	Charles County, Climate Resilience and Sustainability	Maryland
	City of Falls Church, Environmental Sustainability Programs	Virginia
	City of Frederick, Office of Sustainability	Maryland
	City of Greenbelt, Public Works	Maryland
	City of Manassas, Planning and Development	Virginia
	Clarke County, Environmental and Water Resources	Virginia
	Culpeper County	Virginia
	District Department of Energy & Environment (DOEE)	District of Columbia
	Loudoun County, Department of Building & Development	Virginia
	Maryland Department of Environment (MDE)	Maryland
	Maryland Department of Transportation (MDOT)	Maryland
	Montgomery County, Climate Change	Maryland
	Prince George's County, Department of Environment	Maryland
	Prince William County, Environmental and Energy Sustainability	Virginia
	Rappahannock County, Community Development	Virginia
	Town of Bladensburg	Maryland
	Virginia Department of Environmental Quality (DEQ)	Virginia
	Virginia Department of Transportation (VDOT)	Virginia
	Washington Suburban Sanitary Commission (WSSC Water)	Maryland
	Arlington County, Energy Program	Virginia
	City of Fairfax, Public Works and Environment	Virginia
	City of Falls Church, Environmental Sustainability Programs	Virginia
Technical Committee Members	City of Laurel, Environmental Programs	Maryland
	City of Rockville, Environment Commission	Maryland
	City of Takoma Park, Public Works	Maryland
	Connected DMV, Climate and Energy	District of Columbia
	DC Water	District of Columbia
	District Department of Energy & Environment (DOEE)	District of Columbia
	Fairfax County, Environmental and Energy Coordination	Virginia

Committee	Organization	Jurisdiction
	Loudoun County, Energy Program	Virginia
	Maryland Department of Environment (MDE)	Maryland
	Maryland Department of Transportation (MDOT)	Maryland
	Montgomery County Department of Environmental Protection	Maryland
	Prince George's County, Department of Environment	Maryland
	Virginia Department of Environmental Quality (DEQ)	Virginia
	Virginia Department of Transportation (VDOT)	Virginia
	Northern Virginia Regional Commission (NVRC)	Virginia
	Washington Suburban Sanitary Commission (WSSC Water)	Maryland

COG and TPB Committees

- BEEAC
- Chief Equity Officers Committee (CEOC)
- CEEPC
- Food and Agriculture Regional Member (FARM) Policy Committee
- Metropolitan Washington Air Quality Committee (MWAQC)
- Metropolitan Washington Air Quality Committee Technical Advisory Committee (MWAQC-TAC)
- National Capital Region Transportation Planning Board (TPB)
- Regional Electric Vehicle Deployment (REVD) Working Group
- Transportation Planning Board Community Advisory Committee (TPB-CAC)
- Transportation Planning Board Technical Committee (TPB-Tech)

Industry, Utilities, Other Government Partners, and Stakeholders

- DC Sustainable Energy Utility (DCSEU)
- District of Columbia City Council
- Dominion Energy
- Potomac Electric Power Company (Pepco)
- Frederick County Division of Solid Waste and Recycling
- Fredericksburg Planning Commission
- Georgetown, George Mason, George Washington, and Catholic Universities
- Greater Washington Region Clean Cities Coalition (GWRCCC)
- George Washington Regional Commission
- Institute for Local Self-Reliance
- Maryland Clean Energy Center (MCEC)
- Maryland Department of Agriculture
- Maryland Energy Administration (MEA)
- Maryland Energy Innovation Institute

- Maryland Forestry Foundation (MFF)
- Montgomery County Solid Waste Advisory Committee
- Neighborhood Sun
- Northern Shenandoah Valley Regional Commission
- Northern Virginia Regional Commission (NVRC)
- Members of the public
- Prince George's County Solid Waste Advisory Commission
- Prince William County Public Schools (PWCPS)
- Rappahannock Electric Cooperative
- Southern Environmental Law Center (SELC)
- Virginia Clean Cities Coalition
- Virginia Department of Environmental Quality (DEQ)
- Virginia Energy
- Virginia PACE Authority
- Washington Gas (WGL)
- Washington Metropolitan Area Transit Authority (WMATA)
- Washington Suburban Sanitary Commission (WSSC)
- Agricultural, Working Lands, Food, and Solid Waste regional stakeholder group

CBOs

- Campaign to Reduce Lead Exposure & Asthma
- CASA Maryland
- Centro de Apoyo Familiar
- Charles County NAACP
- Charles County Resilience Authority
- Chesapeake Climate Action Network
- Cheverly Area Environmental Justice Action Team
- Climate Ready DC/Sustainable DC
- DC Commission on Climate Change and Resiliency / Ward 8
- DC Environmental Network
- EcoAction Arlington
- EcoLatinos
- Emerald Cities Collaborative (ECC)
- Empower DC
- Environmental and Energy Study Institute (EESI)
- Faith Alliance for Climate Solutions
- Fossil Free Fredericksburg
- Greater Washington Clean Cities Coalition
- Green Scheme

- Groundswell
- Interfaith Power and Light (DC, MD, NoVA)
- Loudoun Climate Project
  Metropolitan Group
- Mobilize Frederick
- Moms Clean Air Force, DC Chapter
- Montgomery County GreenBank
- Montgomery County NAACP
- Montgomery Energy Connection
  Nature Forward
- NOVEC
- Piedmont Environmental Council
- Prince George's County Community College Sustainable Energy and Workforce Development Program
- Resilient VA
- Sierra Club DC Chapter
- Sierra Club Maryland
- Sierra Club Virginia
- Solarize VA
- SRH Consulting
- Thrive Montgomery 2050
- University of Mary Washington Climate Action Plan
- Virginia Environmental Justice Collaborative
- Virginia NAACP
- Virginia Clean Cities
- Ward 7 Resilience Hub Community Coalition
- Young Gifted Green
- 350.org (county chapters)

Tribes

- Accokeek Foundation at Piscataway Park
- Patawomeck Indian Tribe in Virginia

APPENDIX G. CO-POLLUTANT QUANTIFICATION METHODOLOGY

Co-Pollutant Quantification Approach by Sector

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 was 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 EVs are used and VMT decreases, emissions of HAPs 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.[61]

BUILDINGS

For energy efficiency or fuel-switching measures in the buildings sector, less fuel is used in both new and existing buildings. This not only reduces GHG emissions but also decreases emissions of other harmful pollutants that are released during fuel combustion. COG used the following methodology to quantify co-pollutant emission reductions in the building sector:

1. Quantify Fuel Saved: Determine the amount of each fuel type saved by comparing the baseline scenario to the mitigation scenario.
2. Apply Emission Factors: Use standard EPA AP-42 emissions factors for each fuel type to estimate how much NOx, SO_2, Lead, CO, and PM would have been emitted if the fuel had been used.
3. Calculate Emissions Reductions: Multiply the amount of each fuel saved by its corresponding emission factor to estimate the avoided emissions for each pollutant.

TRANSPORTATION

For COG's on-road transportation sector, co-pollutant reductions were quantified using emission factors derived from 2020 EPA NEI data and VMT estimates. Emission factors were calculated by dividing total 2020 emissions by total 2020 VMT, disaggregated by county, pollutant, vehicle type, and fuel type, resulting in mass per mile (e.g., metric tons CO per diesel truck mile).

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61 https://www.lung.org/clean-air/outdoors/what-makes-air-unhealthy/buildings

For the mitigation scenario, these emission factors are applied to projected VMT through 2050 to estimate gross emissions under the mitigation pathway. Specifically, the emissions factor (EF) for each pollutant and vehicle/fuel category is multiplied by the corresponding VMT in the mitigation scenario. The resulting emissions are then subtracted from the 2020 NEI-based BAU emissions to estimate net reductions in co-pollutants attributable to the mitigation strategy.

For Aviation, the methodology uses an emissions factor approach. Gross emissions reductions are calculated by multiplying the amount of jet fuel saved (from baseline minus mitigation scenario) by GREET emissions factors for conventional jet fuel. Emissions from SAF are also calculated from GREET factors. The SAF emissions are subtracted from the gross emissions reductions to calculate net emissions reductions.

Rail electrification co-pollutant reductions were quantified by finding the diesel fuel reduced in the mitigation scenario from the baseline. The passenger miles travelled using diesel fueled rail was found by multiplying the diesel usage by the gallons of diesel per passenger mile factor (0.1) for both scenarios and then subtracting the BAU from the mitigation scenario passenger miles. The passenger miles reduced was then multiplied by the GREET EFs for commuter rails using diesel as fuel (in grams per passenger mile).

WASTE

Waste reduction measures lead to less waste ending up in landfills. This not only reduces GHG emissions but also decreases emissions of other harmful pollutants, specifically NOx, CO, and $PM_{2.5}$, that are released when landfill gas is flared.

1. Quantify Waste Diverted: Determine the amount of waste that is prevented from entering landfills due to the waste reduction measure.
2. Estimate Methane Generation Avoided: Calculate how much methane would have been produced by this diverted waste if it had been landfilled. Assuming that about 50 percent of landfill gas is methane.
3. Apply Emission Factors: Use standard EPA emission factors to estimate how much NOx, CO, and $PM_{2.5}$ would have been emitted from flaring the methane generated by the landfilled waste.

NWL

For COG's NWL sector, co-pollutant removals are quantified using data from the i-Tree Landscape Module[62], accessed county by county. Annual pollutant removal estimates are converted from pounds to metric tons and downscaled to a per-tree basis using the total number of trees in the MSA, as quantified in the NWL measure modeling output.

These per-tree removal rates are then multiplied by the number of new trees projected to be planted across the MSA under the mitigation scenario and aggregated by locality. This approach yields cumulative co-pollutant removal estimates attributable to tree planting efforts, representing added benefits from natural sequestration and air quality improvements.

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[62] https://landscape.itreetools.org/

ELECTRICITY DEMAND CHANGES

Mitigation measures such as building and transportation electrification and solar installations lead to changes in electricity demand. This in turn changes how power plants across the broader regions – within and outside of the MSA – operate. Because the changes in power plants occur across a broader region and not just within the MSA, these co-pollutant emission changes are reported separately, although a portion would likely occur within the region.

The net electricity demand increases with measure implementation of building and transportation electrification, leading to increased co-pollutant emissions. This is a potential disbenefit to communities that live around power plants that increase their output to meet this increased electricity demand and emphasizes the importance of measures focusing on increasing the amount of clean energy capacity deployed.

ICF estimated the net change in co-pollutant emissions across the broader power grid (which extends beyond the MSA) based on projected changes in the electricity grid mix. These projections were informed by data from EPA's National Emissions Inventory, EIA's form EIA-923, and power sector modeling data from the Virginia State CCAP, which reflect the increased demand.

FACTORS

The tables below show the factors and sources used for this analysis.

Table 49. Building and Industry Fuels Emissions Factors

Fuel	Notes	Units	NO_x	SO_2	PM	CO	Lead
Natural Gas[63]	Uncontrolled small boiler or controlled (recirculation) large boiler	Boiler Ef (lb/1000000 scf)	100	0.6	7.6	84	0.0005
Natural Gas	Residential furnace	Ef lb/1000000 scf	94	0.6	7.6	40	0.0005
Natural Gas	Assume large industrial boiler, low NOx burner	Ef lb/1000000 scf	140	0.6	7.6	84	0.0005
Fuel Oil[64]	<100 MMBTU	Boiler Distillate oil fired Ef (lb/1000 gal)	20	7.1	2	5	0.0015
Fuel Oil	>100 MMBTU	Boiler #2 oil fired Ef (lb/1000 gal)	24	7.1	2	5	0.0015

[63] https://www.epa.gov/sites/default/files/2020-09/documents/1.4_natural_gas_combustion.pdf
[64] https://www.epa.gov/sites/default/files/2020-09/documents/1.3_fuel_oil_combustion.pdf

Fuel	Notes	Units	NO_x	SO_2	PM	CO	Lead
Fuel Oil	>100 MMBTU	Boiler (assume #6 oil) fired Ef (lb/1000 gal)	47	78.5	7.815	5	0.0015
LPG[65]		Propane Ef (lb/1000 gal)	13	0.05	0.7	7.5	-

Table 50. Conversion and Heat Factors

Fuel Type	Value	Units	Source
Natural gas	1036	BTU/scf	EIA
Distillate oil heating value	140	MMBTU/1000 gal	EPA
Residual oil heating value	150	MMBTU/1000 gal	EIA
Propane heating value	91.5	MMBTU/1000 gal	EIA

Table 51. Sulfur (S) Content Estimates

Fuel Type	Value	Unit
Assumed S content of distillate oil	0.05	% by weight (500 Parts Per Million)
Assumed S content of propane	0.5	% by weight
Assumed S content of 6 oil	0.5	% by weight

Table 52. Aviation Emissions Factors from GREET1 2024[66]

Pollutant	HEFA SAF EF (g/MJ)	Petroleum Conventional Jet EF (g/MJ)
CO	0.010	0.019
NO_x	0.015	0.024
PM_{10}	0.001	0.002
$PM_{2.5}$	0.001	0.001
SO_x	0.004	0.008

Table 53. Waste Emissions Factors from EPA AP-42[67]

Control Device	Notes	Units	NO_x	PM (Primary)	CO
Flare	Emission rates for secondary compounds exiting control devices	$Lb/10^6$ dscf Methane	40	17	750

65 https://www.epa.gov/sites/default/files/2020-09/documents/1.5_liquefied_petroleum_gas_combustion.pdf
66 JetFuel_WTWa tab, "Passenger Aircraft, Singl Aisle (SA): HEFA from Soybean" table; JetFuel_WTWa tab, "Passenger Aircraft, Singl Aisle (SA): Petroleum Conventional Jet" table
67 https://www3.epa.gov/ttnchie1/ap42/ch02/final/c02s04.pdf

Table 54. Passenger Rail Emissions Factors from GREET1 2024[68]

Pollutant	Pump-to-Wheel (g/passenger mile)
CO	0.13
NO_x	1.07
PM_{10}	0.02
$PM_{2.5}$	0.02

Benefits Assessment

As part of the benefits analysis, COG assessed the different benefits impacts the measures are projected to have on different sectors – namely in the form of health impacts and avoided costs for stormwater management.

ECOSYSTEM SERVICES

Impacts from the NWL sector were derived from the i-Tree landscape model. The i-Tree Landscape module is a web-based tool that spatially estimates ecosystem services provided by trees across different landscapes, such as urban or rural areas. It uses tree cover data, leaf area index, weather, pollution levels, and local population data to estimate benefits like air pollution removal and stormwater management. Specifically, it quantifies how much air pollutants such as nitrogen dioxide, sulfur dioxide, ozone, carbon monoxide, and particulate matter are removed by trees, using deposition rates and leaf surface area. It also estimates stormwater runoff reduction by calculating how trees intercept rainfall based on canopy cover and local weather conditions.

Table 55. Total NWL Co-Pollutant Removals

Pollutant	Cumulative Removals (MT) 2025-2050
NO_x	19,335
SO_2	10,647
PM	47,178
CO	3,809

Table 56. NWL Avoided Stormwater Runoff Added Monetary Benefit of 50% Tree Canopy Cover

MSA	2050 Monetary Value
Total MSA	$15,680,289

The results highlight the significant co-benefits of NWL investments in the region, both for air quality and water management. Cumulatively, trees are projected to remove tens of thousands of metric tons of pollutants such as PM, NOx, SO2, and CO between 2025 and 2050, improving public health

[68] GREET1 2024 for Commuter Rails Using Diesel as Fuel

and regional air quality. In addition, expanding tree canopy cover to 50 percent yields substantial economic value for stormwater management, with avoided runoff benefits reaching millions of dollars in several counties, particularly Frederick, Loudoun, and Montgomery. The results show that urban tree canopy expansion and forest conservation strategies provide not only GHG mitigation but also measurable local benefits in air pollution reduction and infrastructure cost savings.

HEALTH IMPACTS

The table below presents the cumulative health benefits and associated monetary values resulting from quantified co-pollutant reductions in the MSA between 2025 and 2050. These estimates are derived from the COBRA model and reflect the total change in incidence, the number of avoided cases, for each health impact category. The monetary benefits represent the economic value of these avoided outcomes, including reduced mortality, fewer hospital visits, and improved productivity through fewer missed school and workdays. This summary provides an MSA-wide overview, which is followed by sector-specific results detailing pollutant reductions and health impacts at a more granular level.

At the MSA level, the table below provides a range of estimates, low and high, for both health outcomes and their monetized benefits for mortality. These ranges reflect uncertainty in the underlying epidemiological and economic assumptions, such as the sensitivity of populations to air pollution and the valuation of avoided health outcomes. The low estimate represents a more conservative scenario, while the high estimate assumes stronger health effects and higher economic valuations. This range helps contextualize the potential variability in benefits.

Table 57. Health Impact Results for the MSA

Health Impact	Cumulative Monetary Benefits (2025-2050)	Cumulative Incidence Reduction (2025-2050)
Mortality	$10,072,227,657 – $19,115,223,757	690 – 1,309
Hospital Visits	$10,080,365	1,895
Missed School/Work or Restricted Activity	$471,024,579	940,281
Cardiovascular Conditions	$32,880,196	451
Respiratory Conditions	$485,640,926	738,822

In the sector-specific results that follow, only the low-end estimates from COBRA are shown. This approach is intended to maintain a conservative and cautious interpretation of the data. By focusing on the lower bound of potential benefits, the analysis avoids overstating impacts while still capturing the meaningful health and economic gains associated with co-pollutant reductions.

Buildings

In the Buildings sector, the modeled strategies have led to significant cumulative reductions in key pollutants from 2025 to 2050. The buildings sector has the highest cumulative reductions for NOx.

These reductions are primarily driven by a suite of building-focused strategies aimed at improving energy efficiency and electrification. Measures included in this modeling are; accelerate the deployment of energy efficiency solutions and decarbonization of residential, institutional, municipal, and commercial buildings, and accelerate the deployment of clean and renewable energy, study, plan for, and deploy district energy and microgrid opportunities.

Table 58. Total Buildings Co-Pollutant Reductions

Pollutant	Cumulative Reductions (MT) (2025-2050)
NO_x	95,241.84
SO_2	1,428.41
PM	9,388.23
CO	102,022.94
Lead	0.75

Translated into health impact quantification, using the results provided from COBRA, the building residential sector is estimated to achieve substantial public health benefits between 2025 and 2050. These include avoided mortality valued at approximately $2.17 billion, along with reductions in hospital visits, missed school and workdays, cardiovascular conditions, and respiratory conditions.

Table 59. Buildings Residential Sector COBRA Benefits

Health Impact	Cumulative Monetary Benefits (2025-2050)	Cumulative Incidence Reduction (2025-2050)
Mortality	$2,172,100,902	149
Hospital Visits	$1,972,906	494
Missed School/Work or Restricted Activity	$157,931,363	193,942
Cardiovascular Conditions	$5,137,947	70
Respiratory Conditions	$88,627,660	199,370

The buildings–commercial sector shows strong health co-benefits, with cumulative mortality benefits estimated at $1.27 billion, slightly lower than the residential sector. It also shows comparable reductions in hospital visits, missed activity days, and respiratory conditions. Buildings remain a key contributor to MSA-wide health improvements. The incidence reductions reflect consistent annual gains, particularly in respiratory and productivity-related outcomes, reinforcing the sector's importance in air quality and health policy planning.

Table 60. Buildings Commercial Sector COBRA Benefits

Health Impact	Cumulative Monetary Benefits (2025-2050)	Cumulative Incidence Reduction (2025-2050)
Mortality	$1,274,354,095	87
Hospital Visits	$1,156,801	290
Missed School/Work or Restricted Activity	$92,909,498	113,753
Cardiovascular Conditions	$3,005,327	41
Respiratory Conditions	$88,627,660	117,138

Transportation

In the Transportation sector, the modeled strategies have led to substantial cumulative reductions. . The largest CO emission reductions come from the transportation sector due to decreased tailpipe emissions with ZEV adoption.

Table 61. Total Transportation Co-Pollutant Reductions

Pollutant	Cumulative Reductions (MT) (2025-2050)
NO_x	7,944.81
SO_2	1,413.85
PM	13,356.68
CO	244,196.42

Table 62. On-Road Transportation Co-Pollutant Reductions

Pollutant	Cumulative Reductions (MT) (2025-2050)
NO_x	432
SO_2	1,231
PM	13,065
CO	242,997

Table 63. Off-Road Transportation Co-Pollutant Reductions

Pollutant	Cumulative Reductions (MT) (2025-2050)
NO_x	7,513
SO_2	183
PM	291
CO	1,200

The Transportation sector stands out as the most impactful in terms of health-related co-benefits from pollutant reductions. It leads all sectors in cumulative monetary benefits across every health category, including mortality ($6.61 billion), hospital visits, missed school/workdays, cardiovascular conditions, and respiratory conditions. These benefits are accompanied by the highest incidence reductions MSA-wide, with thousands of avoided cases in missed school/workdays and respiratory conditions. The scale and consistency of these outcomes highlight Transportation as a critical sector for maximizing public health gains through air quality improvements.

Table 64. Total Transportation Sector COBRA Benefits

Health Impact	Cumulative Monetary Benefits (2025-2050)	Cumulative Incidence Reduction (2025-2050)
Mortality	$6,613,282,640	453
Hospital Visits	$6,937,764	1,108
Missed School/Work or Restricted Activity	$219,689,562	631,421
Cardiovascular Conditions	$24,691,071	339
Respiratory Conditions	$245,793,088	421,450

Waste

In the Waste sector, the modeled strategies have led to modest cumulative reductions in pollutants from 2025 to 2050. These reductions are achieved through strategies that improve waste management practices and reduce methane and fossil fuel emissions. Modeled measures include reducing GHG emissions from waste and wastewater treatment.

Table 65. Waste Co-Pollutant Reductions

Pollutant	Cumulative Reductions (MT) (2025-2050)
NO_x	230
PM	98
CO	4,315

The Waste sector yields less health benefits in comparison to other sectors. Cumulative monetary values are low across all categories, with mortality benefits totaling $12 Million and negligible gains in hospital visits and missed activity days. Incidence reductions are similarly limited, suggesting that co-pollutant reductions in this sector have a relatively small impact on public health outcomes. While not a major driver of MSA-wide benefits, the Waste sector may still offer localized improvements.

Table 66. Waste COBRA Benefits

Health Impact	Cumulative Monetary Benefits (2025-2050)	Cumulative Incidence Reduction (2025-2050)
Mortality	$12,490,020	1
Hospital Visits	$12,893	2
Missed School/Work or Restricted Activity	$494,155	1,164
Cardiovascular Conditions	$45,851	1
Respiratory Conditions	$535,358	864

Electricity Demand Changes

In the electricity sector, demand has increased from various measures. This increase in demand leads to an increase in co-pollutant emissions from power plants and therefore is a disbenefit to the local community surrounding electricity generating power plants in the region. The disbenefit reduces over time as the grid shifts to a greater share of clean energy resources. ICF estimated the net change in co-pollutant emissions across the broader power grid (which extends beyond the MSA) based on projected changes in the electricity grid mix. These projections were informed by data from EPA's National Emissions Inventory, EIA's Form EIA-923, and power sector modeling from the Virginia State CCAP, which reflect the increased demand.

Table 67. Electricity Co-Pollutant Emissions Increase

Pollutant	Cumulative Increases (MT) (2025-2050)
CO	3,457.98
NH_3	552.58
NO_x	9,967.37
PM_{10}	2,075.20
$PM_{2.5}$	2,017.99
SO_2	1,182.29
VOC	737.25

APPENDIX H. WORKFORCE ANALYSIS

This technical appendix outlines the approach and methodology for each component of the workforce analysis, which integrates labor market data to project future workforce gaps and inform strategic planning. This analysis forms a foundation for the subsequent sections where labor gaps, certifications, education and training providers, and workforce solutions are examined to address occupational shifts and ensure alignment with CCAP measures.

Workforce Analysis Approach/Methodology

The workforce analysis examines the occupations that can be affected by Washington, DC MSA CCAP measures by collecting and analyzing employment trends and conducting a workforce gap analysis to identify potential shortages that may hinder the successful implementation of those measures. Information on credential requirements and educational and training providers was collected for selected targeted occupations to help inform a workforce development strategy that can address any potential labor shortages. The workforce analysis concludes with potential workforce solutions that can be implemented to address shortages and other workforce challenges.

The workforce analysis began with examining COG's CCAP measures and associated activities and identifying the occupations that could be affected by the implementation of those measures. The measures were mapped to relevant occupations under the standard occupational classification (SOC) code system.[69] The impacted occupations are listed below in Table 68.

COG used Lightcast, a labor market analytics tool, to collect labor market data for relevant occupations of the Washington DC MSA. Among the labor market data collected was historic and projected employment, employment concentration, wages, typical education and training requirements, turnover rates, the number of hires, and openings.

To estimate workforce gaps, ICF used data on projected growth in employment, occupational separations (using the turnover rate), and new hires for each occupation. Based on this data, workforce supply and demand were calculated to estimate shortages or surpluses in employment for each occupation. The new growth (additional demand for new jobs) and separation (employees leaving their job) were summed to estimate demand, while hires represent supply. The difference between workforce supply and demand represents the gap. The gap can either be negative or positive. A negative gap indicates a shortage of workers while a positive gap indicates a surplus.

Information on the certifications that employers seek from their workforce was collected for a set of priority occupations that are projected to be affected by the CCAP measures. These occupations include: 1) EV maintenance; 2) energy auditor; 3) construction laborer; 4) rooftop solar installers; 5) heat pump installers; 6) HVAC; 7) farmers; 8) landscaping workers; 9) electricians; 10) electrical engineers; 11) heavy tractor-trailer drivers; and 12) bus drivers, transit. The data was collected from Lightcast's real-time job postings analytics for employers hiring for those occupations in the Washington DC MSA.

The workforce analysis also identified education and training providers in the Washington DC MSA that have programs that led to credentials in the priority occupations listed above. This data was

[69] The 2018 Standard Occupational Classification (SOC) system is a federal statistical standard used by federal agencies to classify workers into occupational categories. See https://www.bls.gov/soc/.

collected from the Integrated Postsecondary Education Data System (IPEDS) from the National Center for Education Statistics (NCES).

Employment Trends

Examining employment trends over time will identify patterns of growth, decline, or stability in different occupations, offering insights into which occupations are expanding and contracting in response to technological advances, economic factors, and changes in industry demand. A total of 48 occupations could be affected by the implementation of the CCAP measures, including engineering, construction and skilled trades, transportation, and agricultural jobs, among others. In total, these occupations represent roughly 258,000 jobs or 7.1% of the 3,609,000 total jobs in the Washington DC MSA region.

Table 68 shows the CCAP occupations that have grown the most in employment over the past 10 years. Heavy tractor-trailer drivers leads in growth, adding 5,411 jobs in the past 10 years, a 30.5% growth rate. This is followed by electricians, laborers and freight, stock, and material movers, HVAC workers, construction laborers, and construction trades supervisors, all which added over 2,000 workers in the past 10 years. These roles are especially critical for supporting the buildings and clean energy, data centers, and waste measures.

Table 68. CCAP Occupations with the Greatest Job Growth – Washington, DC MSA 2015-2025

SOC	Description	Relevant Sectors	2015 Jobs	2025 Jobs	Change	Percent Change
53-3032	Heavy and Tractor-Trailer Truck Drivers	Waste	17,765	23,176	5,411	30.5%
47-2111	Electricians	Buildings and Clean Energy, Transportation, Data Centers	12,787	17,552	4,765	37.3%
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	Waste	24,073	26,892	2,819	11.7%
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	Buildings and Clean Energy, Data Centers	6,534	8,900	2,366	36.2%
47-2061	Construction Laborers	Buildings and Clean Energy	22,879	25,202	2,323	10.2%
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	Buildings and Clean Energy	14,841	17,150	2,308	15.6%
13-1041	Compliance Officers	Buildings and Clean Energy, Data Centers	11,813	13,599	1,786	15.1%

SOC	Description	Relevant Sectors	2015 Jobs	2025 Jobs	Change	Percent Change
17-2199	Engineers, All Other	Buildings and Clean Energy	7,651	9,431	1,779	23.3%
53-7051	Industrial Truck and Tractor Operators	Waste	3,378	4,765	1,387	41.1%
47-2073	Operating Engineers and Other Construction Equipment Operators	Transportation	5,486	6,822	1,337	24.4%

Table 69 provides an overview of CCAP occupations in the region that have undergone the most significant reductions in employment between 2015 and 2025. Notably, carpenters have experienced the steepest decline, losing over 2,600 positions over the decade, a considerable drop of 16.4%. This downward trend is likely the result of shifting demands within the construction and building sectors. Relatedly, carpenters' helpers declined considerably as well. Other CCAP occupations that have experienced job loss employ far less workers, but the percentage decrease is even more pronounced in some cases, ranging from 67% for tree trimmers and pruners to 7.5% for bus drivers, transit and intercity.

Table 69. CCAP Occupations with the Greatest Loss in Jobs Washington, DC MSA 2015-2025

SOC	Description	Relevant Sectors	2015 Jobs	2025 Jobs	Change	Percent Change
47-2031	Carpenters	Buildings and Clean Energy	18,608	15,981	(2,627)	-16.4%
49-9052	Telecommunications Line Installers and Repairers	Data Centers	4,153	2,935	(1,219)	-41.5%
47-3012	Helpers--Carpenters	Buildings and Clean Energy	1,518	651	(867)	-133.2%
47-3015	Helpers--Pipelayers, Plumbers, Pipefitters, and Steamfitters	Buildings and Clean Energy, Data Centers	1,833	1,152	(682)	-59.2%
17-2141	Mechanical Engineers	Data Centers	5,397	4,800	(596)	-12.4%
37-3013	Tree Trimmers and Pruners	Land Use	1,367	817	(550)	-67.3%
51-8021	Stationary Engineers and Boiler Operators	Buildings and Clean Energy	1,711	1,193	(518)	-43.5%
53-3052	Bus Drivers, Transit and Intercity	Transportation	5,479	5,095	(384)	-7.5%
47-2071	Paving, Surfacing, and Tamping Equipment Operators	Transportation	1,219	851	(368)	-43.2%

SOC	Description	Relevant Sectors	2015 Jobs	2025 Jobs	Change	Percent Change
17-2081	Environmental Engineers	Data Centers	1,367	1,025	(342)	-33.4%

Table 70 provides an overview of the CCAP occupations within the region that are expected to experience the greatest projected job growth from 2025 to 2035. This is led by heavy and tractor-trailer drivers and laborers and freight, stock, and material movers, which are expected to add 1,144 and 902 jobs, respectively, over the next 10 years. This projected growth underscores a broader trend within the region's labor market, reflecting the ongoing importance of logistics, transportation, and material handling sectors to the local economy. These occupations play a vital role in supporting supply chains and facilitating the movement of goods throughout the area. The projected growth in laborers and freight, stock, and material movers and construction laborers will help fill some of labor shortages in those occupations, although gaps are still expected in 2035.

Table 70. CCAP Occupations with the Greatest Projected Job Growth – Washington, DC MSA 2025-2035

SOC	Description	Relevant Sectors	2025 Jobs	Projected 2035 Jobs	Change	Percent Change
53-3032	Heavy and Tractor-Trailer Truck Drivers	Waste	23,176	24,320	1,144	4.9%
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	Waste	26,892	27,794	902	3.4%
47-2111	Electricians	Buildings and Clean Energy, Transportation, Data Centers	17,552	18,150	598	3.4%
53-3052	Bus Drivers, Transit and Intercity	Transportation	5,095	5,535	440	8.6%
37-3011	Landscaping and Groundskeeping Workers	Land Use	21,147	21,524	377	1.8%
47-2073	Operating Engineers and Other Construction Equipment Operators	Transportation	6,822	7,052	229	3.4%
17-2141	Mechanical Engineers	Data Centers	4,800	5,029	229	4.8%
53-7051	Industrial Truck and Tractor Operators	Waste	4,765	4,964	199	4.2%
47-2061	Construction Laborers	Buildings and Clean Energy	25,202	25,398	195	0.8%
13-1041	Compliance Officers	Buildings and Clean Energy, Data Centers	13,599	13,739	140	1.0%

Table 71 highlights the CCAP occupations with the greatest projected decline in jobs between 2025 and 2035. This is led by telecommunication line installers and repairers, carpenters, and construction trade supervisors, which are expected to decline by 599, 540, and 407 jobs, respectively, over the next 10 years in the region.

Table 71. CCAP Occupations with the Greatest Projected Decline in Jobs – Washington, DC MSA 2025-2035

SOC	Description	Relevant Sectors	2025 Jobs	Projected 2035 Jobs	Change	Percent Change
49-9052	Telecommunications Line Installers and Repairers	Data Centers	2,935	2,336	(599)	-20.4%
47-2031	Carpenters	Buildings and Clean Energy	15,981	15,441	(540)	-3.4%
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	Buildings and Clean Energy	17,150	16,742	(407)	-2.4%
11-9013	Farmers, Ranchers, and Other Agricultural Managers	Land Use	1,935	1,714	(221)	-11.4%
47-2152	Plumbers, Pipefitters, and Steamfitters	Buildings and Clean Energy	9,275	9,081	(194)	-2.1%
17-1011	Architects, Except Landscape and Naval	Buildings and Clean Energy	3,977	3,837	(140)	-3.5%
17-2199	Engineers, All Other	Buildings and Clean Energy	9,431	9,305	(125)	-1.3%
47-2181	Roofers	Buildings and Clean Energy	2,673	2,551	(122)	-4.6%
47-3013	Helpers--Electricians	Buildings and Clean Energy, Transportation, Data Centers	1,851	1,777	(75)	-4.0%
47-3012	Helpers--Carpenters	Buildings and Clean Energy	651	592	(59)	-9.1%

Gap Analysis

The gap analysis evaluates the difference between workforce supply and employer demand. Demand is driven by both projected job growth and the need to replace workers who retire or change occupations, while supply is the actual number of hires made by employers. The gap analysis does take into account the increased demand for these jobs that may result from implementing the CCAP measures, it only considers current conditions.

Assessing labor surpluses provides insight into where there could be opportunities for workers to transition their skills from one occupation to another that may be in greater demand. For example, Landscaping Workers, where there is a surplus, can transition to Construction Laborers, where there is a shortage, or Heavy Tractor-Trailer Drivers can transition to Industrial Truck and Tractor Operators. These skill transfers can often be accomplished with minimal additional training.

Table 72 shows the CCAP occupations that are estimated to have the greatest workforce shortages in 2025 for the Washington, DC MSA. The region generally has good equilibrium in its labor market for the CCAP occupations, with only some relatively minor shortages or surpluses of workers. Laborers and Freight, Stock, and Material Movers, however, does have a fairly large shortage of workers, 563 or 2.1% of the total workforce for that occupation.

Other shortages among the CCAP occupations are clustered in the construction sector, particularly building trades. These include shortages in construction laborers, plumbers, carpenters, construction trades supervisors, and roofers. These occupations will be needed to implement measures in the Buildings and Transportation sectors of the CCAP.

Table 73 shows the CCAP occupations that are estimated to have the greatest surpluses in workers in 2025 for the Washington, DC MSA. Although, it is projected that there will be enough labor for these occupations to effectively implement the CCAP measures, as noted above the gap analysis does not include the labor force demand that the CCAP measures may generate.

The occupations with the largest surplus of workers include several in the Buildings and Clean Energy sector, including Civil Engineers, Compliance Officers, Engineers (other), Electricians, and Construction and Building Inspectors. Two occupations in the Waste sector are estimated to have surpluses of labor, Heavy and Tractor-Trailer Truck Drivers and Refuse and Recyclable Material Collectors.

Assessing labor surpluses provides insight into where there could be opportunities for workers to transition their skills from one occupation to another that may be in greater demand. For example, Landscaping Workers, where there is a surplus, can transition to Construction Laborers, where there is a shortage, or Heavy Tractor-Trailer Drivers can transition to Industrial Truck and Tractor Operators. These skill transfers can often be accomplished with minimal additional training.

The gap analysis will inform workforce development strategies, ensuring that they focus on areas with the greatest need.

Table 72. CCAP Occupations with the Largest Projected Workforce Shortages in 2025 in the MSA

Occupation	Relevant Sector	Projected Employment 2025	*Projected Supply*	*Projected Demand Subtotals*		*Projected Shortage*	
			Hires 2025	Growth (New Jobs) 2025	Projected Separations 2025	Workforce Shortage 2025	Shortage as a Percent of Total Employment
Heavy and Tractor-Trailer Truck Drivers	Waste	11,624	8,395	244	8,370	-219	1.9%
Construction Laborers	Buildings	6,204	4,031	85	3,978	-32	0.5%
Miscellaneous Assemblers and Fabricators	Industry	2,572	2,014	27	2,017	-31	1.2%
Chemical Equipment Operators and Tenders	Industry	471	128	4	137	-13	2.7%
Carpenters	Industry, Buildings	3,592	1,711	20	1,703	-12	0.3%
First-Line Supervisors of Construction Trades and Extraction Workers	Transportation, Buildings	4,636	1,743	38	1,715	-10	0.2%
Chemical Plant and System Operators	Industry	236	59	2	63	-6	2.5%
Farmers, Ranchers, and Other Agricultural Managers	AFOLU	882	89	8	87	-6	0.7%
Operating Engineers and	Transportation, Buildings	2,491	1,273	41	1,236	-4	0.2%

Occupation	Relevant Sector	Projected Employment 2025	*Projected Supply*	*Projected Demand Subtotals*		*Projected Shortage*	
			Hires 2025	Growth (New Jobs) 2025	Projected Separations 2025	Workforce Shortage 2025	Shortage as a Percent of Total Employment
Other Construction Equipment Operators							
Helpers–Carpenters	Industry, Buildings	157	337	1	339	-3	1.8%

Table 73. CCAP Occupations with the Largest Estimated Workforce Surpluses in 2025 – Washington, DC MSA

Occupation	Relevant Sector	Projected Employment	*Projected Supply*	*Projected Demand Subtotals*		*Projected Surplus*	
			Hires	Growth (New Jobs)	Projected Separation	Workforce Surplus	Surplus as a Percent of Total Employment
Heavy and Tractor-Trailer Truck Drivers	Waste	23,176	15,024	329	14,492	**204**	0.9%
Civil Engineers	Buildings and Clean Energy, Transportation, Data Centers	8,986	3,040	35	2,801	**204**	2.3%
Compliance Officers	Buildings and Clean Energy, Data Centers	13,599	3,864	66	3,608	**190**	1.4%
Engineers, All Other	Buildings and Clean Energy	9,431	2,580	17	2,414	**148**	1.6%
Electricians	Buildings and Clean Energy,	17,552	7,682	201	7,393	**88**	0.5%

Occupation	Relevant Sector	Projected Employment	*Projected Supply*	*Projected Demand Subtotals*		*Projected Surplus*	
			Hires	Growth (New Jobs)	Projected Separation	Workforce Surplus	Surplus as a Percent of Total Employment
	Transportation, Data Centers						
Landscaping and Groundskeeping Workers	Land Use	21,147	12,900	173	12,642	**85**	0.4%
Refuse and Recyclable Material Collectors	Waste	2,624	2,194	47	2,066	**81**	3.1%
Helpers–Electricians	Buildings and Clean Energy, Transportation, Data Centers	1,851	3,218	4	3,138	**77**	4.1%
Telecommunications Line Installers and Repairers	Data Centers	2,935	908	(126)	967	**67**	2.3%
Construction and Building Inspectors	Buildings and Clean Energy, Data Centers	3,142	1,094	19	1,014	**62**	2.0%

Effective management of workforce imbalances involves proactive measures, such as targeted recruitment, training, and education initiatives tailored to CCAP needs. Partnerships between government, industry, and educational institutions can help align labor supply with emerging demands, ensuring that the region is equipped to meet CCAP goals. Ultimately, understanding and addressing workforce shortages and surpluses is crucial for successful CCAP implementation.

Certifications

A comprehensive analysis was conducted to evaluate the most sought-after skills and certifications for key CCAP occupations. This review focused on roles such as EV maintenance technicians, energy auditors, construction laborers, rooftop solar installers, heat pump installers, HVAC specialists, farmers, landscaping workers, electricians, electrical engineers, heavy tractor-trailer drivers, and transit bus drivers. Real-time job posting data from Lightcast for the Washington, DC MSA provided insight into employer requirements for these positions.

Findings revealed that, for many CCAP-related jobs, employers are consistently seeking candidates with specific certifications and skills. This trend is especially notable for electric vehicle mechanics, energy auditing, rooftop solar installation, and building trades such as electricians, HVAC technicians, and heat pump installers.

Key certifications include the Electric Vehicle Fundamentals (EVF) Certification for EV mechanics, the Certified Energy Auditor (CEA) for energy auditors, the PV Installation Professional (PVIP) Certification for solar installers, the EPA Section 608 Technician Certification for HVAC and heat pump specialists, and the Journeyman Electrician License for electricians.

On the other hand, employers hiring for occupations such as construction laborers, landscapers, and agricultural workers typically do not require formal certifications.

For a detailed breakdown of the top certifications required for each key CCAP occupation, see the Workforce Data Appendix, Tables 14-25.

Education and Training Providers

Education and training providers across the Washington, DC MSA have been identified as key resources for supplying the credentials and certifications prioritized by employers in the key CCAP occupations.

While the region boasts a strong array of training programs for traditional building trades, there are notably fewer options in newer fields like energy auditing, rooftop solar installation, and EV maintenance. For building trades, a variety of pathways are available, including high school and technical education, community colleges, apprenticeship programs, and private training providers. However, specialized training in energy auditing, rooftop solar, and EV maintenance is more limited. These training providers will play a pivotal role in bridging workforce gaps by updating curricula, incorporating the latest technologies, and expanding programs to align with industry and CCAP implementation demands.

See the Workforce Data Appendix, Tables 91-101, for a comprehensive list of educational and training providers relevant to each major CCAP occupation.

Workforce Solutions

Addressing the workforce challenges associated with CCAP implementation will involve four key components: 1) identify needs, stakeholders, and priorities; 2) developing solutions and partnerships; 3) promoting interagency and intergovernmental coordination; and 4) setting and continually refining goals.

IDENTIFYING NEEDS, STAKEHOLDERS, AND PRIORITIES

The labor market and workforce gap analysis identified some of the current needs that should be addressed to successfully implement the Washington, DC MSA CCAP. These include the following:

- Workforce shortages in some key CCAP occupations
- A lack of training opportunities for key CCAP skills and credentials in the region
- The need for upskilling and reskilling segments of the current workforce

Some Key Workforce Shortages:

- Laborers and Freight, Stock, and Material Movers, Hand
- Construction Laborers
- Plumbers
- Carpenters

Some Key Certifications:

- EVF Certification for EV mechanics
- Certified Energy Auditor (CEA) for energy auditors
- PVIP Certification for solar installers
- EPA Section 608 Technician Certification for HVAC and heat pump specialists
- Journeyman Electrician License for electricians

Some Key Upskilling and Reskilling Opportunities:

- Heavy Tractor-Trailer Drivers
- Landscaping Workers
- Electricians
- Refuse and Recyclable Material Collectors

Addressing these needs, to ensure successful CCAP implementation, will be a main priority of the workforce solution.

Effective workforce development demands collaboration among a diverse array of stakeholders. Stakeholders in education and training will be critical. It is vital to make workforce education and training accessible to current workers, as well as those seeking to transition from other fields. Forming partnerships with colleges and training providers offering programs in key CCAP-related occupations can help meet the emerging needs.

Other stakeholders include employers, workforce development boards and other state and local workforce organizations, and labor organizations. Building new partnerships and strengthening existing ones are crucial for successful CCAP implementation.

Developing Solutions and Partnerships

To develop solutions to address workforce challenges it is important to build new partnerships for effective implementation. The Washington, DC MSA features a rich landscape of education and training resources, particularly for traditional building trades. Pathways include high school and technical education programs, community colleges, apprenticeships, and private institutions. However, in emerging fields like energy auditing, rooftop solar, and EV maintenance, specialized training is more limited. Expanding these offerings and updating curricula with the latest technology is key to closing workforce gaps.

Preparing the future workforce might involve early education and outreach, developing tailored training materials for apprenticeships and pre-apprenticeships, and connecting with local businesses and contractors about upcoming opportunities and evolving workforce needs. Using these strategies can help prepare the workforce for the changes brought about by implementation of the CCAP measures.

Promoting Interagency and Intergovernmental Coordination

To promote interagency and intergovernmental coordination, relevant state and local agencies will be engaged to prepare for CCAP measures, share progress updates, and coordinate data exchange. This collaborative approach fosters the alignment of resources and objectives.

Setting and Continually Refining Goals

The Washington, DC CCAP will also set and refine goals throughout implementation. Establishing clear, measurable goals—and regularly revisiting them—is crucial. Metrics will include:

- Number of jobs created
- Number of workers trained
- Training programs developed
- New partnerships established

By tracking these benchmarks, stakeholders can measure progress and maintain alignment with CCAP priorities throughout the process.

Labor Market Data

Table 74. Occupations Impacted by CCAP Measures

SOC	Occupation	Relevant Sectors
11-9013	Farmers, Ranchers, and Other Agricultural Managers	Land Use
13-1041	Compliance Officers	Buildings and Clean Energy, Data Centers
17-1011	Architects	Buildings and Clean Energy
17-2051	Civil Engineers	Buildings and Clean Energy, Transportation, Data Centers
17-2071	Electrical Engineers	Buildings and Clean Energy, Data Centers
17-2081	Environmental Engineers	Data Centers
17-2141	Mechanical Engineers	Data Centers
17-2199	Engineers, All Other	Buildings and Clean Energy
19-1032	Foresters	Land Use
19-3051	Urban and Regional Planners	Transportation, Data Centers

SOC	Occupation	Relevant Sectors
37-3011	Landscaping and Groundskeeping Workers	Land Use
37-3013	Tree Trimmers and Pruners	Land Use
45-4011	Forest and Conservation Workers	Land Use
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	Buildings and Clean Energy
47-2031	Carpenters	Buildings and Clean Energy
47-2061	Construction Laborers	Buildings and Clean Energy
47-2071	Paving, Surfacing, and Tamping Equipment Operators	Transportation
47-2073	Operating Engineers and Other Construction Equipment Operators	Transportation
47-2111	Electricians	Buildings and Clean Energy, Transportation, Data Centers
47-2131	Insulation Workers, Floor, Ceiling, and Wall	Buildings and Clean Energy, Data Centers
47-2152	Plumbers, Pipefitters, and Steamfitters	Buildings and Clean Energy
47-2181	Roofers	Buildings and Clean Energy
47-2231	Solar Photovoltaic Installers	Buildings and Clean Energy
47-3012	Helpers--Carpenters	Buildings and Clean Energy
47-3013	Helpers--Electricians	Buildings and Clean Energy, Transportation, Data Centers
47-3015	Helpers--Pipelayers, Plumbers, Pipefitters, and Steamfitters	Buildings and Clean Energy, Data Centers
47-4011	Construction and Building Inspectors	Buildings and Clean Energy, Data Centers
49-2093	Electrical and Electronics Installers and Repairers, Transportation Equipment	Transportation
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	Buildings and Clean Energy
49-2096	Electronic Equipment Installers and Repairers, Motor Vehicles	Transportation
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	Buildings and Clean Energy, Data Centers
49-9031	Home Appliance Repairers	Buildings and Clean Energy
49-9051	Electrical Power-Line Installers and Repairers	Buildings and Clean Energy
49-9052	Telecommunication Line Installers and Repairers	Data Centers
51-8012	Power Distributors and Dispatchers	Buildings and Clean Energy
51-8013	Power Plant Operators	Buildings and Clean Energy, Data Centers
51-8021	Stationary Engineers and Boiler Operators	Buildings and Clean Energy
51-8031	Water and Wastewater Treatment Plant and System Operators	Waste
51-8092	Gas Plant Operators	Buildings and Clean Energy, Waste
53-3032	Heavy and Tractor-Trailer Truck Drivers	Waste
53-3052	Bus Drivers, Transit and Intercity	Transportation
53-7051	Industrial Truck and Tractor Operators	Waste

SOC	Occupation	Relevant Sectors
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	Waste
53-7081	Refuse and Recyclable Material Collectors	Waste
53-4011	Locomotive Engineers	Transportation
53-4022	Railroad Brake, Signal, and Switch Operators and Locomotive Firers	Transportation
53-4031	Railroad Conductors and Yardmasters	Transportation
53-4041	Subway and Streetcar Operators	Transportation

Table 75. Employment Trends and Projections 2015-2035

SOC	Description	Relevant Sectors	2015 Jobs	2020 Jobs	2025 Jobs	2030 Jobs	2035 Jobs
11-9013	Farmers, Ranchers, and Other Agricultural Managers	Land Use	2,128	2,783	1,935	1,801	1,714
13-1041	Compliance Officers	Buildings and Clean Energy, Data Centers	11,813	13,647	13,599	13,738	13,739
17-1011	Architects, Except Landscape and Naval	Buildings and Clean Energy	4,042	3,896	3,977	3,900	3,837
17-2051	Civil Engineers	Buildings and Clean Energy, Transportation, Data Centers	8,894	9,011	8,986	9,022	8,980
17-2071	Electrical Engineers	Buildings and Clean Energy, Data Centers	4,134	4,295	4,041	4,055	4,023
17-2081	Environmental Engineers	Data Centers	1,367	1,207	1,025	1,045	1,044
17-2141	Mechanical Engineers	Data Centers	5,397	5,464	4,800	4,957	5,029
17-2199	Engineers, All Other	Buildings and Clean Energy	7,651	9,171	9,431	9,401	9,305
19-1032	Foresters	Land Use	194	319	324	332	337
19-3051	Urban and Regional Planners	Transportation, Data Centers	1,134	1,009	1,092	1,124	1,139
37-3011	Landscaping and Groundskeeping Workers	Land Use	20,372	19,210	21,147	21,503	21,524
37-3013	Tree Trimmers and Pruners	Land Use	1,367	1,335	817	821	814
45-4011	Forest and Conservation Workers	Land Use	99	140	147	159	167

SOC	Description	Relevant Sectors	2015 Jobs	2020 Jobs	2025 Jobs	2030 Jobs	2035 Jobs
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	Buildings and Clean Energy	14,841	15,033	17,150	17,046	16,742
47-2031	Carpenters	Buildings and Clean Energy	18,608	18,312	15,981	15,773	15,441
47-2061	Construction Laborers	Buildings and Clean Energy	22,879	22,751	25,202	25,449	25,398
47-2071	Paving, Surfacing, and Tamping Equipment Operators	Transportation	1,219	965	851	868	870
47-2073	Operating Engineers and Other Construction Equipment Operators	Transportation	5,486	6,065	6,822	7,007	7,052
47-2111	Electricians	Buildings and Clean Energy, Transportation, Data Centers	12,787	14,822	17,552	18,016	18,150
47-2131	Insulation Workers, Floor, Ceiling, and Wall	Buildings and Clean Energy, Data Centers	779	996	719	739	755
47-2152	Plumbers, Pipefitters, and Steamfitters	Buildings and Clean Energy	8,937	8,856	9,275	9,226	9,081
47-2181	Roofers	Buildings and Clean Energy	2,395	2,863	2,673	2,626	2,551
47-2231	Solar Photovoltaic Installers	Buildings and Clean Energy	194	235	367	391	402
47-3012	Helpers--Carpenters	Buildings and Clean Energy	1,518	950	651	621	592
47-3013	Helpers--Electricians	Buildings and Clean Energy, Transportation, Data Centers	1,707	1,935	1,851	1,823	1,777
47-3015	Helpers--Pipelayers, Plumbers, Pipefitters, and Steamfitters	Buildings and Clean Energy, Data Centers	1,833	1,512	1,152	1,134	1,105
47-4011	Construction and Building Inspectors	Buildings and Clean Energy, Data Centers	3,203	3,033	3,142	3,156	3,129
49-2093	Electrical and Electronics	Transportation	678	474	337	348	357

SOC	Description	Relevant Sectors	2015 Jobs	2020 Jobs	2025 Jobs	2030 Jobs	2035 Jobs
	Installers and Repairers, Transportation Equipment						
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	Buildings and Clean Energy	651	605	533	551	557
49-2096	Electronic Equipment Installers and Repairers, Motor Vehicles	Transportation	220	92	59	59	57
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	Buildings and Clean Energy, Data Centers	6,534	7,584	8,900	9,004	8,982
49-9031	Home Appliance Repairers	Buildings and Clean Energy	511	474	549	542	533
49-9051	Electrical Power-Line Installers and Repairers	Buildings and Clean Energy	2,249	1,955	1,963	2,035	2,049
49-9052	Telecommunications Line Installers and Repairers	Data Centers	4,153	3,938	2,935	2,561	2,336
51-8012	Power Distributors and Dispatchers	Buildings and Clean Energy	184	149	119	121	121
51-8013	Power Plant Operators	Buildings and Clean Energy, Data Centers	401	466	336	326	318
51-8021	Stationary Engineers and Boiler Operators	Buildings and Clean Energy	1,711	1,325	1,193	1,221	1,235
51-8031	Water and Wastewater Treatment Plant and System Operators	Waste	1,450	1,417	1,498	1,548	1,558
51-8092	Gas Plant Operators	Buildings and Clean Energy, Waste	224	217	206	200	193
53-3032	Heavy and Tractor-Trailer Truck Drivers	Waste	17,765	21,081	23,176	23,994	24,320
53-3052	Bus Drivers, Transit and Intercity	Transportation	5,479	5,360	5,095	5,392	5,535

SOC	Description	Relevant Sectors	2015 Jobs	2020 Jobs	2025 Jobs	2030 Jobs	2035 Jobs
53-7051	Industrial Truck and Tractor Operators	Waste	3,378	3,538	4,765	4,930	4,964
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	Waste	24,073	24,954	26,892	27,579	27,794
53-7081	Refuse and Recyclable Material Collectors	Waste	2,185	2,160	2,624	2,725	2,759
53-4011	Locomotive Engineers	Transportation	476	458	500	528	556
53-4022	Railroad Brake, Signal, and Switch Operators and Locomotive Firers	Transportation	194	197	259	268	277
53-4031	Railroad Conductors and Yardmasters	Transportation	883	557	787	828	866
53-4041	Subway and Streetcar Operators	Transportation	665	671	585	608	623

Table 76. Percent Change in Employment

SOC	Description	Relevant Sectors	% Change 2015-2020	% Change 2020-2025	% Change 2025-2030	% Change 2030-2035
11-9013	Farmers, Ranchers, and Other Agricultural Managers	Land Use	30.7%	-30.5%	-6.9%	-4.8%
13-1041	Compliance Officers	Buildings and Clean Energy, Data Centers	15.5%	-0.3%	1.0%	0.0%
17-1011	Architects, Except Landscape and Naval	Buildings and Clean Energy	-3.6%	2.1%	-1.9%	-1.6%
17-2051	Civil Engineers	Buildings and Clean Energy, Transportation, Data Centers	1.3%	-0.3%	0.4%	-0.5%
17-2071	Electrical Engineers	Buildings and Clean Energy, Data Centers	3.9%	-5.9%	0.3%	-0.8%
17-2081	Environmental Engineers	Data Centers	-11.7%	-15.1%	2.0%	-0.1%
17-2141	Mechanical Engineers	Data Centers	1.2%	-12.1%	3.3%	1.4%
17-2199	Engineers, All Other	Buildings and Clean Energy	19.9%	2.8%	-0.3%	-1.0%

SOC	Description	Relevant Sectors	% Change 2015-2020	% Change 2020-2025	% Change 2025-2030	% Change 2030-2035
19-1032	Foresters	Land Use	64.5%	1.7%	2.2%	1.6%
19-3051	Urban and Regional Planners	Transportation, Data Centers	-11.1%	8.3%	2.9%	1.3%
37-3011	Landscaping and Groundskeeping Workers	Land Use	-5.7%	10.1%	1.7%	0.1%
37-3013	Tree Trimmers and Pruners	Land Use	-2.4%	-38.8%	0.5%	-0.9%
45-4011	Forest and Conservation Workers	Land Use	41.5%	4.9%	8.3%	4.6%
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	Buildings and Clean Energy	1.3%	14.1%	-0.6%	-1.8%
47-2031	Carpenters	Buildings and Clean Energy	-1.6%	-12.7%	-1.3%	-2.1%
47-2061	Construction Laborers	Buildings and Clean Energy	-0.6%	10.8%	1.0%	-0.2%
47-2071	Paving, Surfacing, and Tamping Equipment Operators	Transportation	-20.9%	-11.8%	2.0%	0.2%
47-2073	Operating Engineers and Other Construction Equipment Operators	Transportation	10.6%	12.5%	2.7%	0.6%
47-2111	Electricians	Buildings and Clean Energy, Transportation, Data Centers	15.9%	18.4%	2.6%	0.7%
47-2131	Insulation Workers, Floor, Ceiling, and Wall	Buildings and Clean Energy, Data Centers	27.9%	-27.8%	2.7%	2.1%
47-2152	Plumbers, Pipefitters, and Steamfitters	Buildings and Clean Energy	-0.9%	4.7%	-0.5%	-1.6%
47-2181	Roofers	Buildings and Clean Energy	19.6%	-6.6%	-1.8%	-2.8%
47-2231	Solar Photovoltaic Installers	Buildings and Clean Energy	21.1%	56.2%	6.7%	2.6%
47-3012	Helpers--Carpenters	Buildings and Clean Energy	-37.5%	-31.4%	-4.7%	-4.7%
47-3013	Helpers--Electricians	Buildings and Clean Energy, Transportation, Data Centers	13.3%	-4.3%	-1.5%	-2.6%

SOC	Description	Relevant Sectors	% Change 2015-2020	% Change 2020-2025	% Change 2025-2030	% Change 2030-2035
47-3015	Helpers--Pipelayers, Plumbers, Pipefitters, and Steamfitters	Buildings and Clean Energy, Data Centers	-17.5%	-23.8%	-1.5%	-2.6%
47-4011	Construction and Building Inspectors	Buildings and Clean Energy, Data Centers	-5.3%	3.6%	0.5%	-0.9%
49-2093	Electrical and Electronics Installers and Repairers, Transportation Equipment	Transportation	-30.1%	-28.9%	3.4%	2.4%
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	Buildings and Clean Energy	-7.1%	-11.9%	3.4%	1.1%
49-2096	Electronic Equipment Installers and Repairers, Motor Vehicles	Transportation	-58.4%	-35.8%	1.0%	-3.7%
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	Buildings and Clean Energy, Data Centers	16.1%	17.3%	1.2%	-0.2%
49-9031	Home Appliance Repairers	Buildings and Clean Energy	-7.2%	15.9%	-1.3%	-1.6%
49-9051	Electrical Power-Line Installers and Repairers	Buildings and Clean Energy	-13.1%	0.4%	3.7%	0.7%
49-9052	Telecommunications Line Installers and Repairers	Data Centers	-5.2%	-25.5%	-12.8%	-8.8%
51-8012	Power Distributors and Dispatchers	Buildings and Clean Energy	-19.2%	-20.0%	1.4%	0.5%
51-8013	Power Plant Operators	Buildings and Clean Energy, Data Centers	16.3%	-28.0%	-2.8%	-2.5%
51-8021	Stationary Engineers and Boiler Operators	Buildings and Clean Energy	-22.5%	-10.0%	2.4%	1.1%
51-8031	Water and Wastewater Treatment Plant and System Operators	Waste	-2.3%	5.7%	3.3%	0.6%
51-8092	Gas Plant Operators	Buildings and Clean Energy, Waste	-2.9%	-5.1%	-2.7%	-3.5%

SOC	Description	Relevant Sectors	% Change 2015-2020	% Change 2020-2025	% Change 2025-2030	% Change 2030-2035
53-3032	Heavy and Tractor-Trailer Truck Drivers	Waste	18.7%	9.9%	3.5%	1.4%
53-3052	Bus Drivers, Transit and Intercity	Transportation	-2.2%	-4.9%	5.8%	2.7%
53-7051	Industrial Truck and Tractor Operators	Waste	4.8%	34.7%	3.5%	0.7%
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	Waste	3.7%	7.8%	2.6%	0.8%
53-7081	Refuse and Recyclable Material Collectors	Waste	-1.1%	21.4%	3.9%	1.2%
53-4011	Locomotive Engineers	Transportation	-3.8%	9.3%	5.5%	5.3%
53-4022	Railroad Brake, Signal, and Switch Operators and Locomotive Firers	Transportation	1.9%	31.4%	3.3%	3.5%
53-4031	Railroad Conductors and Yardmasters	Transportation	-36.9%	41.4%	5.1%	4.6%
53-4041	Subway and Streetcar Operators	Transportation	0.9%	-12.8%	4.0%	2.4%

Table 77. Employment Concentration – Location Quotient (LQ) 2015-2035

SOC	Description	Relevant Sectors	2015 LQ	2020 LQ	2025 LQ	2030 LQ	2035 LQ
11-9013	Farmers, Ranchers, and Other Agricultural Managers	Land Use	0.17	0.21	0.16	0.15	0.15
13-1041	Compliance Officers	Buildings and Clean Energy, Data Centers	2.03	1.87	1.62	1.59	1.57
17-1011	Architects, Except Landscape and Naval	Buildings and Clean Energy	1.60	1.40	1.37	1.30	1.26
17-2051	Civil Engineers	Buildings and Clean Energy, Transportation, Data Centers	1.40	1.29	1.18	1.14	1.12
17-2071	Electrical Engineers	Buildings and Clean Energy, Data Centers	1.05	1.06	1.01	0.98	0.97
17-2081	Environmental Engineers	Data Centers	1.18	1.10	1.17	1.16	1.14
17-2141	Mechanical Engineers	Data Centers	0.88	0.85	0.78	0.77	0.76

SOC	Description	Relevant Sectors	2015 LQ	202 0 LQ	2025 LQ	2030 LQ	2035 LQ
17-2199	Engineers, All Other	Buildings and Clean Energy	2.41	2.43	2.59	2.5 3	2.49
19-1032	Foresters	Land Use	0.92	1.34	1.23	1.2 4	1.24
19-3051	Urban and Regional Planners	Transportation, Data Centers	1.46	1.23	1.18	1.2 0	1.20
37-3011	Landscaping and Groundskeeping Workers	Land Use	0.76	0.75	0.80	0.8 1	0.81
37-3013	Tree Trimmers and Pruners	Land Use	1.00	0.93	0.57	0.5 7	0.57
45-4011	Forest and Conservation Workers	Land Use	0.31	0.33	0.31	0.3 4	0.35
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	Buildings and Clean Energy	1.10	1.01	0.93	0.9 1	0.90
47-2031	Carpenters	Buildings and Clean Energy	0.85	0.82	0.75	0.7 4	0.73
47-2061	Construction Laborers	Buildings and Clean Energy	0.81	0.79	0.84	0.8 3	0.82
47-2071	Paving, Surfacing, and Tamping Equipment Operators	Transportation	1.02	0.96	0.84	0.8 4	0.84
47-2073	Operating Engineers and Other Construction Equipment Operators	Transportation	0.68	0.67	0.67	0.6 7	0.67
47-2111	Electricians	Buildings and Clean Energy, Transportation, Data Centers	0.87	0.94	1.01	1.0 0	0.99
47-2131	Insulation Workers, Floor, Ceiling, and Wall	Buildings and Clean Energy, Data Centers	1.34	1.37	0.85	0.8 7	0.89
47-2152	Plumbers, Pipefitters, and Steamfitters	Buildings and Clean Energy	0.91	0.85	0.86	0.8 4	0.82
47-2181	Roofers	Buildings and Clean Energy	0.76	0.83	0.73	0.7 1	0.69
47-2231	Solar Photovoltaic Installers	Buildings and Clean Energy	0.78	0.62	0.61	0.5 7	0.54
47-3012	Helpers--Carpenters	Buildings and Clean Energy	1.79	1.39	1.35	1.3 1	1.28

SOC	Description	Relevant Sectors	2015 LQ	2020 LQ	2025 LQ	2030 LQ	2035 LQ
47-3013	Helpers--Electricians	Buildings and Clean Energy, Transportation, Data Centers	1.07	1.19	1.22	1.20	1.19
47-3015	Helpers--Pipelayers, Plumbers, Pipefitters, and Steamfitters	Buildings and Clean Energy, Data Centers	1.48	1.27	1.14	1.09	1.06
47-4011	Construction and Building Inspectors	Buildings and Clean Energy, Data Centers	1.47	1.12	1.02	1.01	1.01
49-2093	Electrical and Electronics Installers and Repairers, Transportation Equipment	Transportation	1.69	1.75	1.51	1.53	1.54
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	Buildings and Clean Energy	1.15	1.08	0.86	0.89	0.90
49-2096	Electronic Equipment Installers and Repairers, Motor Vehicles	Transportation	0.74	0.39	0.31	0.34	0.36
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	Buildings and Clean Energy, Data Centers	0.95	0.90	0.92	0.90	0.88
49-9031	Home Appliance Repairers	Buildings and Clean Energy	0.53	0.60	0.65	0.65	0.65
49-9051	Electrical Power-Line Installers and Repairers	Buildings and Clean Energy	0.88	0.78	0.74	0.74	0.75
49-9052	Telecommunications Line Installers and Repairers	Data Centers	1.71	1.45	1.34	1.15	1.03
51-8012	Power Distributors and Dispatchers	Buildings and Clean Energy	0.66	0.62	0.53	0.55	0.56
51-8013	Power Plant Operators	Buildings and Clean Energy, Data Centers	0.47	0.62	0.48	0.48	0.49
51-8021	Stationary Engineers and Boiler Operators	Buildings and Clean Energy	1.89	1.77	1.41	1.42	1.42

SOC	Description	Relevant Sectors	2015 LQ	2020 LQ	2025 LQ	2030 LQ	2035 LQ
51-8031	Water and Wastewater Treatment Plant and System Operators	Waste	0.58	0.55	0.59	0.62	0.64
51-8092	Gas Plant Operators	Buildings and Clean Energy, Waste	0.59	0.65	0.58	0.58	0.59
53-3032	Heavy and Tractor-Trailer Truck Drivers	Waste	0.42	0.47	0.47	0.48	0.48
53-3052	Bus Drivers, Transit and Intercity	Transportation	1.42	1.51	1.17	1.21	1.23
53-7051	Industrial Truck and Tractor Operators	Waste	0.28	0.25	0.29	0.29	0.29
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	Waste	0.43	0.40	0.42	0.42	0.42
53-7081	Refuse and Recyclable Material Collectors	Waste	0.79	0.77	0.84	0.85	0.86
53-4011	Locomotive Engineers	Transportation	0.47	0.55	0.62	0.65	0.67
53-4022	Railroad Brake, Signal, and Switch Operators and Locomotive Firers	Transportation	0.43	0.60	0.77	0.78	0.79
53-4031	Railroad Conductors and Yardmasters	Transportation	0.75	0.53	0.65	0.67	0.69
53-4041	Subway and Streetcar Operators	Transportation	1.83	2.05	1.34	1.38	1.41

Table 78. Wages 2025

SOC	Description	Relevant Sectors	Pct. 10 Annual Earnings	Pct. 25 Annual Earnings	Median Annual Earnings	Pct. 75 Annual Earnings	Pct. 90 Annual Earnings
11-9013	Farmers, Ranchers, and Other Agricultural Managers	Land Use	$5,399	$18,493	$31,429	$60,348	$127,906
13-1041	Compliance Officers	Buildings and Clean Energy, Data Centers	$59,013	$72,627	$95,259	$121,188	$145,233
17-1011	Architects, Except Landscape and Naval	Buildings and Clean Energy	$62,100	$77,025	$101,401	$132,775	$167,111
17-2051	Civil Engineers	Buildings and Clean Energy, Transportation, Data Centers	$66,533	$78,554	$96,312	$121,229	$149,931
17-2071	Electrical Engineers	Buildings and Clean Energy, Data Centers	$82,822	$102,162	$129,992	$160,602	$188,391
17-2081	Environmental Engineers	Data Centers	$78,368	$97,020	$121,606	$147,476	$192,978
17-2141	Mechanical Engineers	Data Centers	$77,656	$93,250	$117,436	$149,509	$182,798
17-2199	Engineers, All Other	Buildings and Clean Energy	$78,932	$113,012	$152,827	$181,210	$191,266
19-1032	Foresters	Land Use	$60,067	$60,138	$67,941	$92,754	$112,720
19-3051	Urban and Regional Planners	Transportation, Data Centers	$63,658	$76,794	$97,682	$124,343	$145,870
37-3011	Landscaping and Groundskeeping Workers	Land Use	$30,614	$35,998	$40,094	$47,845	$55,941
37-3013	Tree Trimmers and Pruners	Land Use	$29,590	$43,908	$53,712	$64,033	$79,779
45-4011	Forest and Conservation Workers	Land Use	$24,961	$28,773	$35,716	$47,051	$68,523
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	Buildings and Clean Energy	$54,380	$64,123	$79,503	$99,273	$121,584
47-2031	Carpenters	Buildings and Clean Energy	$32,471	$42,704	$55,838	$68,409	$84,761
47-2061	Construction Laborers	Buildings and Clean Energy	$29,345	$36,308	$43,207	$51,914	$62,080

SOC	Description	Relevant Sectors	Pct. 10 Annual Earnings	Pct. 25 Annual Earnings	Median Annual Earnings	Pct. 75 Annual Earnings	Pct. 90 Annual Earnings
47-2071	Paving, Surfacing, and Tamping Equipment Operators	Transportation	$39,632	$46,260	$53,675	$62,675	$71,860
47-2073	Operating Engineers and Other Construction Equipment Operators	Transportation	$41,983	$48,155	$58,553	$69,994	$81,285
47-2111	Electricians	Buildings and Clean Energy, Transportation, Data Centers	$43,261	$54,268	$71,375	$98,031	$119,459
47-2131	Insulation Workers, Floor, Ceiling, and Wall	Buildings and Clean Energy, Data Centers	$38,156	$42,504	$49,827	$62,728	$70,553
47-2152	Plumbers, Pipefitters, and Steamfitters	Buildings and Clean Energy	$40,796	$50,634	$65,322	$83,938	$104,543
47-2181	Roofers	Buildings and Clean Energy	$32,894	$42,213	$55,024	$68,842	$88,567
47-2231	Solar Photovoltaic Installers	Buildings and Clean Energy	$43,225	$48,611	$59,303	$73,262	$82,986
47-3012	Helpers--Carpenters	Buildings and Clean Energy	$34,310	$37,320	$43,419	$52,619	$57,494
47-3013	Helpers--Electricians	Buildings and Clean Energy, Transportation, Data Centers	$34,204	$38,104	$43,292	$50,641	$57,184
47-3015	Helpers--Pipelayers, Plumbers, Pipefitters, and Steamfitters	Buildings and Clean Energy, Data Centers	$34,052	$37,625	$43,664	$50,882	$58,764
47-4011	Construction and Building Inspectors	Buildings and Clean Energy, Data Centers	$49,240	$61,260	$75,480	$92,884	$110,391
49-2093	Electrical and Electronics Installers and Repairers, Transportation Equipment	Transportation	$63,612	$71,220	$79,577	$88,071	$94,471
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	Buildings and Clean Energy	$54,779	$70,847	$87,524	$99,127	$115,199

SOC	Description	Relevant Sectors	Pct. 10 Annual Earnings	Pct. 25 Annual Earnings	Median Annual Earnings	Pct. 75 Annual Earnings	Pct. 90 Annual Earnings
49-2096	Electronic Equipment Installers and Repairers, Motor Vehicles	Transportation	$35,521	$43,163	$44,852	$50,089	$59,507
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	Buildings and Clean Energy, Data Centers	$44,213	$53,738	$66,479	$81,458	$96,733
49-9031	Home Appliance Repairers	Buildings and Clean Energy	$32,442	$41,378	$53,764	$68,017	$84,883
49-9051	Electrical Power-Line Installers and Repairers	Buildings and Clean Energy	$51,102	$62,381	$85,008	$101,253	$113,785
49-9052	Telecommunications Line Installers and Repairers	Data Centers	$51,547	$62,426	$86,646	$97,290	$106,562
51-8012	Power Distributors and Dispatchers	Buildings and Clean Energy	$74,883	$86,624	$105,237	$116,386	$129,366
51-8013	Power Plant Operators	Buildings and Clean Energy, Data Centers	$57,324	$69,332	$92,613	$113,194	$125,411
51-8021	Stationary Engineers and Boiler Operators	Buildings and Clean Energy	$52,057	$63,767	$79,094	$93,783	$102,855
51-8031	Water and Wastewater Treatment Plant and System Operators	Waste	$41,080	$47,170	$59,075	$74,426	$90,265
51-8092	Gas Plant Operators	Buildings and Clean Energy, Waste	$48,467	$67,285	$87,879	$104,919	$119,877
53-3032	Heavy and Tractor-Trailer Truck Drivers	Waste	$35,736	$44,405	$54,018	$64,894	$78,803
53-3052	Bus Drivers, Transit and Intercity	Transportation	$41,347	$47,804	$57,653	$68,919	$76,966
53-7051	Industrial Truck and Tractor Operators	Waste	$38,711	$43,371	$51,848	$63,349	$75,718
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	Waste	$32,102	$35,865	$41,334	$49,095	$58,505
53-7081	Refuse and Recyclable Material Collectors	Waste	$30,066	$34,615	$40,192	$49,379	$61,084
53-4011	Locomotive Engineers	Transportation	$68,797	$79,117	$81,074	$84,565	$94,113

SOC	Description	Relevant Sectors	Pct. 10 Annual Earnings	Pct. 25 Annual Earnings	Median Annual Earnings	Pct. 75 Annual Earnings	Pct. 90 Annual Earnings
53-4022	Railroad Brake, Signal, and Switch Operators and Locomotive Firers	Transportation	$54,196	$61,314	$67,777	$71,793	$76,037
53-4031	Railroad Conductors and Yardmasters	Transportation	$56,499	$63,683	$69,069	$76,011	$83,095
53-4041	Subway and Streetcar Operators	Transportation	$50,911	$62,731	$71,293	$80,209	$92,873

Table 79. Gap Analysis

SOC Code	Occupation	Relevant Sector	*Supply*	*Demand Subtotals*		*Shortage or Surplus*		
			2025 Hires	Growth (New Jobs) 2025	Projected Separations 2025	Potential Workforce Shortage 2025	Potential Workforce Shortage 2035	Shortage/Surplus as Percent of Total Employment 2025
11-9013	Farmers, Ranchers, and Other Agricultural Managers	Land Use	225	(42)	213	**55**	**27**	2.8%
13-1041	Compliance Officers	Buildings and Clean Energy, Data Centers	3,864	66	3,608	**190**	**275**	1.4%
17-1011	Architects, Except Landscape and Naval	Buildings and Clean Energy	1,023	(19)	983	**59**	**49**	1.5%
17-2051	Civil Engineers	Buildings and Clean Energy, Transportation, Data Centers	3,040	35	2,801	**204**	**252**	2.3%
17-2071	Electrical Engineers	Buildings and Clean Energy, Data Centers	1,239	17	1,173	**49**	**76**	1.2%
17-2081	Environmental Engineers	Data Centers	343	10	319	**15**	**26**	1.4%
17-2141	Mechanical Engineers	Data Centers	1,407	49	1,314	**45**	**91**	0.9%
17-2199	Engineers, All Other	Buildings and Clean Energy	2,580	17	2,414	**148**	**187**	1.6%
19-1032	Foresters	Land Use	104	2	97	**5**	**8**	1.6%

SOC Code	Occupation	Relevant Sector	*Supply*	*Demand Subtotals*		*Shortage or Surplus*		
			2025 Hires	Growth (New Jobs) 2025	Projected Separations 2025	Potential Workforce Shortage 2025	Potential Workforce Shortage 2035	Shortage/Surplus as Percent of Total Employment 2025
19-3051	Urban and Regional Planners	Transportation, Data Centers	316	13	284	**20**	**32**	1.8%
37-3011	Landscaping and Groundskeeping Workers	Land Use	12,900	173	12,642	**85**	**283**	0.4%
37-3013	Tree Trimmers and Pruners	Land Use	491	9	486	**-4**	**6**	0.5%
45-4011	Forest and Conservation Workers	Land Use	67	6	59	**2**	**9**	1.5%
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	Buildings and Clean Energy	6,229	33	6,230	**-34**	**77**	0.2%
47-2031	Carpenters	Buildings and Clean Energy	6,867	(17)	6,967	**-82**	**-17**	0.5%
47-2061	Construction Laborers	Buildings and Clean Energy	15,065	136	15,160	**-231**	**-68**	0.9%
47-2071	Paving, Surfacing, and Tamping Equipment Operators	Transportation	478	8	472	**-1**	**8**	0.1%
47-2073	Operating Engineers and Other	Transportation	3,462	76	3,375	**11**	**90**	0.2%

SOC Code	Occupation	Relevant Sector	*Supply*	*Demand Subtotals*		*Shortage or Surplus*		
			2025 Hires	Growth (New Jobs) 2025	Projected Separations 2025	Potential Workforce Shortage 2025	Potential Workforce Shortage 2035	Shortage/Surplus as Percent of Total Employment 2025
	Construction Equipment Operators							
47-2111	Electricians	Buildings and Clean Energy, Transportation, Data Centers	7,682	201	7,393	**88**	**302**	0.5%
47-2131	Insulation Workers, Floor, Ceiling, and Wall	Buildings and Clean Energy, Data Centers	462	6	460	**-4**	**3**	0.5%
47-2152	Plumbers, Pipefitters, and Steamfitters	Buildings and Clean Energy	3,985	23	4,073	**-110**	**-53**	1.2%
47-2181	Roofers	Buildings and Clean Energy	1,404	(4)	1,430	**-23**	**-7**	0.9%
47-2231	Solar Photovoltaic Installers	Buildings and Clean Energy	207	6	208	**-7**	**-3**	2.0%
47-3012	Helpers–Carpenters	Buildings and Clean Energy	1,387	(4)	1,423	**-31**	**-24**	4.8%
47-3013	Helpers–Electricians	Buildings and Clean Energy, Transportation, Data Centers	3,218	4	3,138	**77**	**92**	4.1%
47-3015	Helpers–Pipelayers, Plumbers,	Buildings and Clean Energy, Data Centers	1,867	1	1,886	**-19**	**-11**	1.7%

SOC Code	Occupation	Relevant Sector	*Supply*	*Demand Subtotals*		*Shortage or Surplus*		
			2025 Hires	Growth (New Jobs) 2025	Projected Separations 2025	Potential Workforce Shortage 2025	Potential Workforce Shortage 2035	Shortage/Surplus as Percent of Total Employment 2025
	Pipefitters, and Steamfitters							
47-4011	Construction and Building Inspectors	Buildings and Clean Energy, Data Centers	1,094	19	1,014	**62**	**88**	2.0%
49-2093	Electrical and Electronics Installers and Repairers, Transportation Equipment	Transportation	170	4	158	**8**	**12**	2.4%
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	Buildings and Clean Energy	202	6	181	**14**	**20**	2.7%
49-2096	Electronic Equipment Installers and Repairers, Motor Vehicles	Transportation	36	(2)	35	**3**	**2**	5.2%
49-9021	Heating, Air Conditioning, and Refrigeration	Buildings and Clean Energy, Data Centers	3,998	55	3,925	**18**	**92**	0.2%

SOC Code	Occupation	Relevant Sector	*Supply*	*Demand Subtotals*		*Shortage or Surplus*		
			2025 Hires	Growth (New Jobs) 2025	Projected Separations 2025	Potential Workforce Shortage 2025	Potential Workforce Shortage 2035	Shortage/Surplus as Percent of Total Employment 2025
	Mechanics and Installers							
49-9031	Home Appliance Repairers	Buildings and Clean Energy	227	(0)	221	**6**	**8**	1.2%
49-9051	Electrical Power-Line Installers and Repairers	Buildings and Clean Energy	853	36	816	**1**	**29**	0.1%
49-9052	Telecommunications Line Installers and Repairers	Data Centers	908	(126)	967	**67**	**-13**	2.3%
51-8012	Power Distributors and Dispatchers	Buildings and Clean Energy	24	2	23	**0**	**2**	0.2%
51-8013	Power Plant Operators	Buildings and Clean Energy, Data Centers	69	(3)	62	**9**	**9**	2.7%
51-8021	Stationary Engineers and Boiler Operators	Buildings and Clean Energy	333	10	303	**20**	**31**	1.7%
51-8031	Water and Wastewater Treatment Plant and System Operators	Waste	410	27	364	**18**	**48**	1.2%
51-8092	Gas Plant Operators	Buildings and Clean Energy, Waste	53	(1)	52	**2**	**2**	1.0%

SOC Code	Occupation	Relevant Sector	*Supply*	*Demand Subtotals*		*Shortage or Surplus*		
			2025 Hires	Growth (New Jobs) 2025	Projected Separations 2025	Potential Workforce Shortage 2025	Potential Workforce Shortage 2035	Shortage/Surplus as Percent of Total Employment 2025
53-3032	Heavy and Tractor-Trailer Truck Drivers	Waste	15,024	329	14,492	**204**	**575**	0.9%
53-3052	Bus Drivers, Transit and Intercity	Transportation	1,796	110	1,678	**8**	**115**	0.2%
53-4011	Locomotive Engineers	Transportation	238	6	238	-5	-6	1.1%
53-4022	Railroad Brake, Signal, and Switch Operators and Locomotive Firers	Transportation	105	1	106	-2	-3	0.7%
53-4031	Railroad Conductors and Yardmasters	Transportation	337	9	338	-10	-9	1.3%
53-4041	Subway and Streetcar Operators	Transportation	99	8	87	**4**	**11**	0.7%
53-7051	Industrial Truck and Tractor Operators	Waste	3,133	77	3,074	-19	**69**	0.4%
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	Waste	24,645	284	24,923	-563	-235	2.1%
53-7081	Refuse and Recyclable Material Collectors	Waste	2,194	47	2,066	**81**	**136**	3.1%

Top Certifications

Table 80. EV Maintenance

Certification
Electric Vehicle Infrastructure Training Program (EVITP)
Electric Vehicle Fundamentals (EVF) Certification
ASE xEV Certification
Automotive Service Excellence (ASE) Certification
ASE Advanced Engine Performance Certification
ASE Medium-Heavy Truck Certification
Automobile Parts Specialist Certification
ASE Auto Maintenance and Light Repair Certification
ASE Automobile Service Consultant

Table 81. Energy Auditor

Certification
BPI Home Energy Professional Energy Auditor certification
Certified Energy Auditor (CEA)
Home Energy Professional (HEP) Energy Auditor
Building Energy Assessment (BEAP) certification
Home Energy Auditor InterNACHI
Certified Industrial Energy Auditor (CEIA)
LEED Accredited Professional (AP)
Certified Energy Manager
Building Energy Modeling Professional Certification
Certified Electrical Safety Compliance Professional
Certified Building Commissioning Professional
Professional Engineer (PE) License
Operator Certification
System Operator Certification

Table 82. Construction Laborer

Certification
10-Hour OSHA General Industry Card
Commercial Driver's License (CDL)
CDL Class A License
30-Hour OSHA General Industry Card
NICET Certification (National Institute for Certification In Engineering Technologies)
OSHA Certification
Flagger Certification
ASNT Non-Destructive Tester
10-Hour OSHA Construction Card

Certification
Certified Crane Operator
Tanker And Hazmat Combo X Endorsement
Hazmat Endorsement
Tanker Endorsement
Forklift Certification
CDL Class C License
National Center For Construction Education & Research (NCCER) Core Curriculum
NCCER Construction Craft Laborer

Table 83. Rooftop Solar

Certification
NABCEP PV Installation Professional (PVIP) Certification
Photovoltaics Installer/Designer (PV2) certification
PVIP Board Certification
PV Installer Specialist (PVIS) Board Certification
PV Technical Sales (PVTS) Board Certification
NABCEP Solar Installation Company Accreditation
SEI Solar Professionals Certificate Program (SPCP)
OSHA Construction Safety for Solar Installers
30-Hour OSHA General Industry Card
10-Hour OSHA General Industry Card
NCCER Electrical
NCCER Solar Photovoltaics

Table 84. Heat Pump

Certification
EPA Section 608 Technician Certification
North American Technician Excellence (NATE) Certification with Heat Pump Installation Specialty
NATE Certification with Heat Pump Service Specialty
HVAC Excellence Heat Pump Service
HVAC Excellence Heat Pump Installer
HVAC Excellence Employment
Ready Heat Pump Certification
EPA Universal Certification
NCCER Certification
3rd Class Power Engineer Certificate
EPA 608 Technician Certification
10-Hour OSHA General Industry Card
HVAC Certification

Table 85. HVAC

Certification
EPA 608 Technician Certification
EPA 608 Certification
HVAC Excellence Certification
NATE Certification
Refrigeration Service Engineers Society (RSES) Certification
HVAC/R Certification
EPA Universal Certification
HVAC Excellence Professional Level Certification
Master HVAC License
10-Hour OSHA General Industry Card
30-Hour OSHA General Industry Card

Table 86. Farmers

Certification
Pesticide Applicator License
Accredited Farm Manager (AFM)

Table 87. Landscapers

Certification
Landscape Industry Certified (LIC) Programs (NALP)
Landscape Industry Certified Horticultural Technician (LIC-HT)
Landscape Industry Certified Lawn Care Technician (LIC-LCT)
Certified Landscape Irrigation Auditor (CLIA)
Certified Irrigation Technician (CIT)
Certified Landscape Irrigation Water Manager
Certified Arborist (ISA):
Certified Professional Landscape Designer (CPLD)
Certified Horticultural Technician (CHT)
Pesticide Applicator License
Commercial Driver's License (CDL)
CDL Class B License
Herbicide Applicator License

Table 88. Electricians

Certification
Certified Electrical Safety Compliance Professional (CESCP)
Master Electrician Certificate
Certified Electrical Safety Worker (CESW)
Electrical Project Management Institute (EPMI) Certification
Certified Electrical Safety Technician (CEST)
Journeyman Electrician License

Certification
Certified Energy Manager
LEED Green Associate
NCCER Solar Photovoltaics
Apprentice Electrician
Green Energy Certification
NCCER Electrical
NCCER Pipeline Electrical & Instrumentation
NICET Certification (National Institute For Certification In Engineering Technologies)
NICET Electrical Power Testing

Table 89. Electrical Engineers

Certification
Bachelor of Science (BS), Electrical Engineering
Bachelor of Engineering (BEng)
Professional Engineer (PE) License
Certified Energy Manager (CEM)
Certified Automation Professional
National Institute for Certification in Engineering Technologies (NICET)
LEED Accredited Professional (AP)
Project Management Professional Certification
Certified Information Systems Security Professional
Institute of Electrical and Electronics Engineers (IEEE)
Engineer in Training (EIT)
Certified Power Quality Professional

Table 90. Heavy Tractor-Trailer Drivers

Certification
Commercial Driver's License (CDL)
CDL Class A License
CDL Class B License
Tanker Endorsement
Transportation Worker Identification Credential (TWIC) Card
Hazmat Endorsement
Tanker And Hazmat Combo X Endorsement
Forklift Certification
CDL Class C License
Doubles Endorsement
DOT Certification
Triples Endorsement
Hazardous Materials Certification
Certified Crane Operator

Certification
Flagger Certification
Pallet Jack Certification

Table 91. Bus Drivers Transit

Certification
Commercial Driver's License (CDL)
Passenger Endorsement
CDL Class B License
Cardiopulmonary Resuscitation (CPR) Certification
First Aid Certification
CDL Class A License
Automated External Defibrillator (AED) Certification
CDL Class C License

Educational/Training Programs

Table 92. EV Maintenance

Institution	Type	County	Course/Program
University of DC-Community College	Community College	Washington, DC	Electric Vehicle Fundamentals
NVCC	Community College	Alexandria	Automotive Technology: Electric, Hybrid, and Autonomous Vehicles, C.S.C.
Montgomery College	Community College	Montgomery	Automotive Electrical Systems Specialist Certificate
Prince George's Community College	Community College	Prince George's County	ASE L3 Hybrid/Electric Vehicle Prep
James Rumsey Technical Institute	CTE	Berkley	9247A Alternative Fuels

Table 93. Energy Auditor

Institution	Type	County	Course/Program
Community Housing Partners	Private	DC Metro	BPI Home Energy Professional Energy Auditor certification
Everblue Training	Private	DC Metro	BPI Home Energy Professional Energy Auditor certification

Table 94. Construction Laborer

Institution	Type	County	Course/Program
Associated Builders and Contractors, Metropolitan Washington Chapter	Apprenticeship	Metro Wide	Construction Laborer
International Union of Operating Engineers Local 77	Apprenticeship	Prince George's County	Construction

Institution	Type	County	Course/Program
International Union of Operating Engineers Local 99	Apprenticeship	Prince George's County	Construction
LIUNA Mid-Atlantic	Apprenticeship	Fairfax County	Construction Craft Laborer
NVCC	Community College	Northern Virginia	Construction Trades, General
Montgomery College	Community College	Montgomery	Construction Trades, Other
College of Southern Maryland	Community College	Calvert County	Pre-Apprenticeship: Construction
Monroe Advanced Technical Academy	High School CTE	Loudoun	Building Construction
Fauquier High School	High School CTE	Fauquier County	Building & Trades
Catholic Charities DC	Pre-Apprenticeship	Washington, DC	Pre-Apprenticeship Green Construction Program

Table 95. Rooftop Solar

Institution	Type	County	Course/Program
Blue Ridge Community and Technical College	Community College	Berkley	Solar Energy Technology/Technician

Table 96. Heat Pump and HVAC

Institution	Type	County	Course/Program
Associated Builders and Contractors, Metropolitan Washington Chapter	Apprenticeship	Metro Wide	HVAC/R
Association of Air Conditioning Professionals	Apprenticeship	Metro Wide	HVAC/R Technician
Cropp Metcalfe	Apprenticeship	Fairfax	HVAC/R Technician
HACC Heating & Air Conditioning Contractors of Maryland	Apprenticeship	Maryland Counties	HVAC/R Technician
Fairfax County Public Schools	Apprenticeship	Fairfax	HVAC/R Technician
Trane Commercial HVAC Service Technician Apprenticeship Program	Apprenticeship	Metro Wide	HVAC/R Technician
Colonial Webb Contractors	Apprenticeship	Fairfax	HVAC/R Technician
Residential Systems	Apprenticeship	Fairfax	HVAC/R Technician
Reddick and Sons, Inc.	Apprenticeship	Prince William County	HVAC/R Technician
INOVA Loudoun Hospital	Apprenticeship	Loudoun	HVAC/R Technician
Loudoun County Public Schools Maintenance Department	Apprenticeship	Loudoun	HVAC/R Technician
Mary Washington Hospital - Facilities	Apprenticeship	Fredericksburg	HVAC/R Technician

Institution	Type	County	Course/Program
SOME Center for Employment Training	Apprenticeship	Washington, DC	HVAC/R Technician
CET-Alexandria	CTE	Alexandria	Heating, Air Conditioning, Ventilation and Refrigeration Maintenance Technology/Technician (HAC, HACR, HVAC, HVACR)
James Rumsey Technical Institute	CTE	Berkley	Heating, Air Conditioning, Ventilation and Refrigeration Maintenance Technology/Technician (HAC, HACR, HVAC, HVACR)
NVCC	Community College	Prince William County	HVAC Excellence
NVCC	Community College	Fairfax	Heating, Air Conditioning, Ventilation and Refrigeration Maintenance Technology/Technician (HAC, HACR, HVAC, HVACR)
Montgomery College	Community College	Montgomery	Heating, Air Conditioning, Ventilation and Refrigeration Maintenance Technology/Technician (HAC, HACR, HVAC, HVACR)
College of Southern Maryland	Community College	Calvert County	HVAC Mechanic Certificate
Prince George's County Community College	Community College	Prince George's County	HVAC/R (Heating, Ventilation, Air Conditioning/Refrigeration) [NCCER]
Frederick Community College	Community College	Frederick County	HVAC Foundation/HVAC Advanced
UDC-CC	Community College	Washington, DC	Construction Craf Skills and NCCER HVAC Level 1-A
UDC-CC	Community College	Washington, DC	Construction Craf Skills and NCCER HVAC Level 1-B
Academies of Loudoun	High School CTE	Loudoun	HVAC Excellence
Edison Academy	High School CTE	Fairfax	HVAC Excellence
Roosevelt STAY High School	High School CTE	Washington, DC	HVAC/R
Phelps Architecture, Construction and Engineering High School	High School CTE	Washington, DC	HVAC/R
Monroe Advanced Technical Academy	High School CTE	Loudoun County	Heating, Ventilation, and Air Conditioning
Spotsylvania Career & Technical Center	High School CTE	Spotsylvania County	HVAC/R

Institution	Type	County	Course/Program
Culpeper Technical Education Center	High School CTE	Culpeper County	HVAC/R
Thomas Edison School of Technology	High School CTE	Montgomery County	HVAC/R
Seneca Valley High School	High School CTE	Montgomery County	HVAC/R
Crossland High School	High School CTE	Prince George's County	HVAC/R
Frederick County Career and Technology Center	High School CTE	Frederick County	HVAC/R
Stethem Educational Center	High School CTE	Charles County	HVAC/R
AHRI	Private	Arlington	North American Technician Excellence
Richards A/C	Private	Falls Church	North American Technician Excellence
D+R International	Private	Montgomery County	North American Technician Excellence
Air Conditioning Contractors of America	Private	Alexandria	North American Technician Excellence
ELPP INC	Private	Falls Church	North American Technician Excellence
Ace Tech Institute	Private	Falls Church	North American Technician Excellence
CroppMetcalfe	Private	Fairfax	North American Technician Excellence
ACR Construction Education	Private	Alexandria	North American Technician Excellence
International Training Institute	Private	Fairfax	North American Technician Excellence
McCrea Equipment Company	Private	Prince George's County	North American Technician Excellence
Harry Eklof & Associates	Private	Prince George's County	North American Technician Excellence
Johnstone Supply Alexandria	Private	Alexandria	North American Technician Excellence
Washington Gas	Private	Prince George's County	North American Technician Excellence
Quality One Service Network	Private	Montgomery County	North American Technician Excellence
Green Training USA	Private	Fairfax	North American Technician Excellence
Safe & Healthy Environments, LLC	Private	Prince George's County	North American Technician Excellence
Association of Air Conditioning Professionals	Private	Montgomery County	North American Technician Excellence
SPAcademy	Private	Fairfax	North American Technician Excellence

Institution	Type	County	Course/Program
SU'COY Community Learning Center	Private	Charles County	North American Technician Excellence
ARS/Rescue Rooter	Private	Manassas	North American Technician Excellence
MABTEC	Private	Loudoun	North American Technician Excellence
Brennan's Htg & A/C	Private	Prince William County	North American Technician Excellence

Table 97. Farming

Institution	Type	County	Course/Program
CSMD	Community College	Calvert County	Vertical Agriculture Systems Certificate
Prince George's County	Community College	Prince George's County	Agriculture/Urban Farming
Stethem Educational Center	CTE	Charles County	Natural Resources and Agriculture
Monroe Advanced Technical Academy	High School CTE	Loudoun County	Environmental Plant Science
Fauquier High School	High School CTE	Fauquier County	Agriculture Education
Culpeper County High School	High School CTE	Culpeper County	Agriculture Education
Eastern View High School	High School CTE	Culpeper County	Agriculture Education
Maurice J. McDonough High School	High School CTE	Charles County	Natural Resources and Agriculture
UDC	University	Washington, DC	Urban Agriculture Technician Certificate
UDC	University	Washington, DC	Sustainable Urban Agriculture Certificate
University of Maryland College Park	University	Prince George's County	Agriculture, General

Table 98. Landscaping

Institution	Type	County	Course/Program
Landscape Contractors Association	Private	Alexandria	Landscape Industry Certified Technician
Brentsville District High School	High School CTE	Prince William County	Landscaping I & II
Frederick County Career and Technology Center	CTE	Frederick County	Environmental Landscape and Design

Table 99. Electricians

Institution	Type	County	Course/Program
Associated Builders and Contractors, Metropolitan Washington Chapter	Apprenticeship	Metro-Wide	Electrician
IEC Chesapeake Apprenticeship and Training	Apprenticeship	Prince George's County	Electrician

Institution	Type	County	Course/Program
Electrical Joint Apprenticeship and Training Committee, N.E.C.A/IBEW, Local Union #26	Apprenticeship	Prince William County	Electrician
Fairfax County Public Schools	Apprenticeship	Fairfax	Electrician
Colonial Webb Contractors	Apprenticeship	Fairfax	Electrician
Capitol Boiler Works	Apprenticeship	Fairfax	Electrician
George Mason University	Apprenticeship	Fairfax	Electrician
Perry Aire Services	Apprenticeship	Fredericksburg	Electrician
R & M Electric	Apprenticeship	Prince William County	Electrician
Turner VA Corp	Apprenticeship	Fairfax	Electrician
IBEW Local Union 26	Apprenticeship	Prince William County	Electrician
Montgomery College	Community College	Montgomery	Electrician
UDC-CC	Community College	Washington, DC	Electrical 1- B
Prince George's County Community College	Community College	Prince George's County	Electrical and Residential Wiring (NCCER)
Frederick Community College	Community College	Frederick County	Electrical Foundation/Electrical Advanced
College of Southern Maryland	Community College	Calvert County	Electrical Helper Workforce Training Certificate
Arlington Career Center	CTE	Arlington County	Electricity & Network Cabling
Spotsylvania Career & Technical Center	CTE	Spotsylvania County	Electricity
Culpeper Technical Education Center	CTE	Culpeper County	Electricity
Frederick County Career and Technology Center	CTE	Frederick County	Electrical
James Rumsey Technical Institute	CTE	Berkley	Electrician
Phelps Architecture, Construction and Engineering High School	High School CTE	Washington, DC	Electrical Technology
Alexandria High School	High School CTE	Alexandria, VA	Electronic Systems I & II
Unity Reed High School	High School CTE	Prince William County	Electricity I & II
Fauquier High School	High School CTE	Fauquier County	Electricity
Thomas Edison School of Technology	High School CTE	Montgomery County	Electricity
Seneca Valley High School	High School CTE	Montgomery County	Electricity

Institution	Type	County	Course/Program
Bladensburg High School	High School CTE	Prince George's County	Electrical
Non-Traditional Program South	High School CTE	Prince George's County	Electrical
Crossland High School	High School CTE	Prince George's County	Electrical
North Point High School	High School CTE	Charles County	Electrical Construction

Table 100. Electrical Engineers and Technicians

Institution	Type	County	Course/Program
DeVry University-Virginia	College	Arlington	Electrical, Electronic, and Communications Engineering Technology/Technician
Capitol Technology University	College	Prince George's County	Electrical, Electronic, and Communications Engineering Technology/Technician
NVCC	Community College	Fairfax	Electrical, Electronic, and Communications Engineering Technology/Technician
Frederick Community College	Community College	Frederick County	Electrical, Electronic, and Communications Engineering Technology/Technician
College of Southern Maryland	Community College	Calvert County	Electrical, Electronic, and Communications Engineering Technology/Technician
Montgomery College	Community College	Montgomery	Electrical, Electronic, and Communications Engineering Technology/Technician
College of Southern Maryland	Community College	Calvert County	Electrical Engineering, Associate
Montgomery College	Community College	Montgomery	Electrical Engineering, Associate
Phelps Architecture, Construction and Engineering High School	High School CTE	Washington, DC	Electrical Technology
George Washington University	University	Washington, DC	Electrical Engineering, undergraduate and graduate
Georgetown University	University	Washington, DC	Electrical Engineering, undergraduate and graduate
The Catholic University of America	University	Washington, DC	Electrical Engineering, undergraduate
Howard University	University	Washington, DC	Electrical Engineering, undergraduate

Institution	Type	County	Course/Program
University of the District of Columbia (UDC)	University	Washington, DC	Electrical Engineering, undergraduate and graduate
University of Maryland	University	Prince George's County	Electrical Engineering, undergraduate
George Mason University	University	Fairfax	Electrical Engineering, undergraduate

Table 101. Heavy Tractor-Trailer Drivers

Institution	Type	County	Course/Program
Laurel Ridge Community College	Community College	Fauquier	Commercial Driver's License
Prince George's County Community College	Community College	Prince George's County	Commercial Driver's License
College of Southern Maryland	Community College	Calvert County	Commercial Driver's License
James Rumsey Technical Institute	CTE	Berkley	Truck and Bus Driver/Commercial Vehicle Operation.

Table 102. Bus Drivers Transit

Institution	Type	County	Course/Program
Amalgamated Transit Union (ATU) Local 689	Apprenticeship	Prince George's County	Bus Mentorship Program
Laurel Ridge Community College	Community College	Fauquier	Commercial Driver's License
Prince George's County Community College	Community College	Prince George's County	Commercial Driver's License
College of Southern Maryland	Community College	Calvert County	Commercial Driver's License
James Rumsey Technical Institute	CTE	Berkley	Truck and Bus Driver/Commercial Vehicle Operation.

APPENDIX I. DATA CENTER BACKGROUND INFORMATION

A data center is a facility that houses and supports computer systems and related infrastructure, enabling storage and processing of digital data. It contains various components, including servers, storage devices, networking equipment, power systems, cooling systems, and physical security measures. The following background information is compiled from multiple resources, including:

- LBNL's Center of Expertise for Energy Efficiency in Data Centers https://datacenters.lbl.gov/
- Graphics from: LBNL 2024 United States Data Center Energy Usage Report, December 2024
- "As generative AI asks for more power, data centers seek more reliable, cleaner energy solutions" Deloitte

Data Center Types

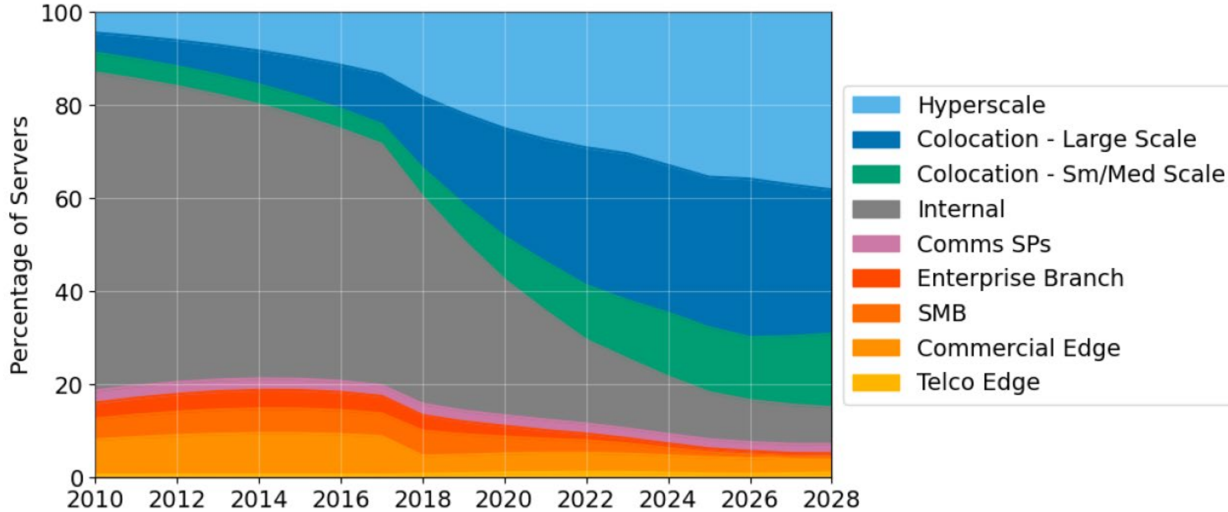
There are multiple ways to categorize data centers, including based on IT equipment, ownership (internal vs service provider), or the facility space type. Different space types can have varying operational characteristics and cooling systems. The LBNL report categorizes them by space type: small, with an average square footage of less than 150; midsize, with an average square footage of 2,700 – 6,900; or large-scale, with average square footages of 11,000 for the colocation space types and 30,000 for hyperscale facilities.

- **Edge data centers** are smaller facilities that are located closer to end users at the edge of a network to provide low-latency computing. They offer the same services as a traditional data center but have a smaller footprint.
- **Enterprise data centers** are owned or leased by a single organization and used to support that organization's internal IT needs. Enterprise data centers can be a full-capacity data hall built for a specific customer within a colocation data center or an on-premise data center built by an organization. Enterprise facilities are built to suit that organization's needs.
- **Internal data centers** are typically integrated into larger buildings and managed by businesses with their own IT systems.
- **Colocation data centers** provide space, power, cooling, and connectivity for the servers and other hardware of multiple organizations. The organizations that rent space at these facilities are known as tenants. Space in a colocation data center is often leased by the rack, cabinet, cage or room. These facilities are also referred to as multi-tenant data centers.
- **Hyperscale data centers** are usually built by or for one organization to meet the specific technical, operational, and pricing requirements of a hyperscale customer.

Hyperscale data centers are experiencing rapid growth, with Amazon, Microsoft, and Google collectively owning more than half of them. Distinct clusters emerge for colocation and hyperscale data center locations. These data centers strategically position themselves close to their clients and cloud services users to ensure high availability and low response times. Factors such as proximity to population centers, electricity cost, network infrastructures, and local utility prices influence their location choices.

According to the latest estimates, Virginia hosts the highest electricity demand associated with data centers in the U.S., serving as the primary hub for both colocation and hyperscale data centers, followed by California and Texas. Figure 19 shows the estimated distribution of data centers by type in the U.S.

Figure 19. Distribution of Servers by Data Center Type



Data Center Power Use

DEMAND DRIVERS

The key drivers of data center energy use are servers/IT equipment, and cooling systems. Other infrastructure elements such as storage systems, network devices, lighting, power distribution units, and uninterruptible power supplies represent smaller sources for electricity demand.

The energy used for **cooling** can represent a significant portion of a data center's total power consumption, sometimes nearly equaling the power utilized by the computing equipment. These systems are essential to manage the heat generated by the servers and other hardware.

The power consumption of **servers** varies based on their workload, with higher processing power demand leading to increased energy usage. The increasing power density of processing chips results in higher energy demand and heat per square foot compared to other data center designs. AI and hyperscale data centers are experiencing server rack power requirements exceeding 30 kW today, which is expected to continue rising. Rack power is the amount of power used per rack and illustrates the density of computing resources in a data center. Liquid cooling solutions are generally cost-effective or necessary at rack power densities greater than 20-40kW.

LARGE/AI DATA CENTER POWER DEMAND BREAKDOWN

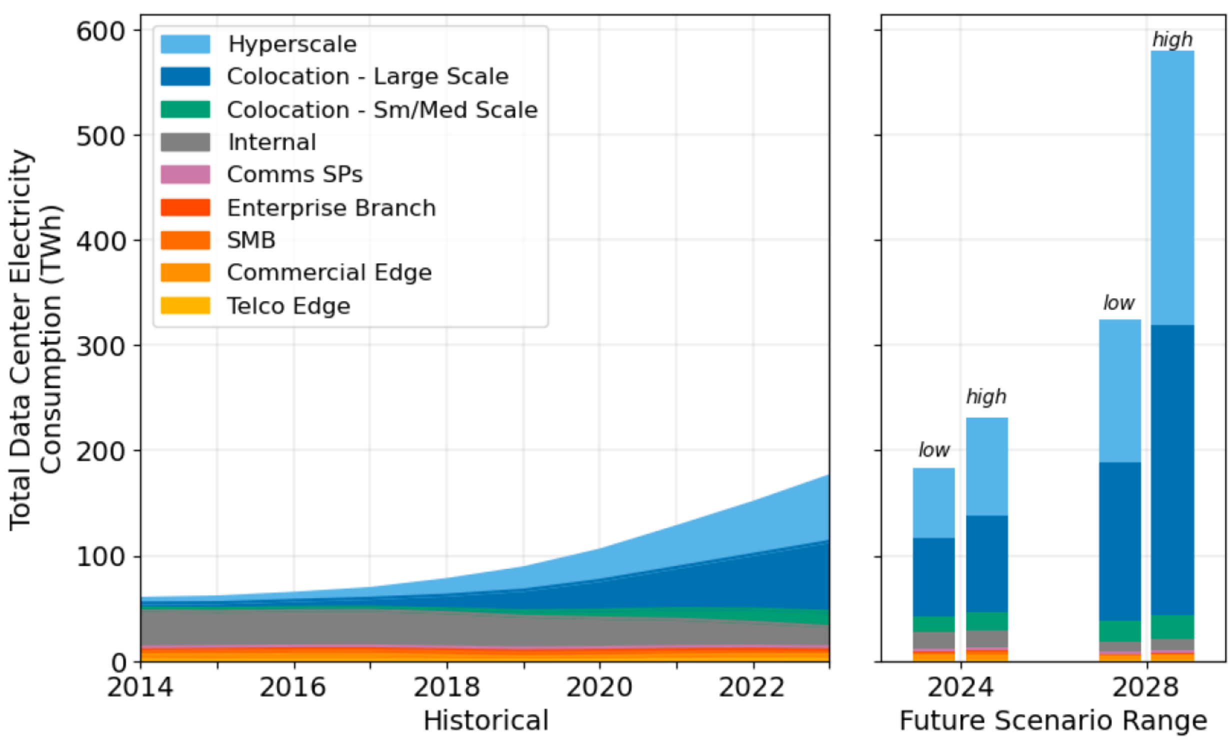
- **Servers and IT equipment** can drive 40% of power demand
- **Cooling systems** often drive another 40% of energy demand
- **Storage, lighting and other infrastructure:** Internal power conditioning systems represent 8-10% of data center's energy use, while network and communications equipment and storage systems comprise another 10%, and lighting usually takes just 1-2%

Hyperscalers are the most energy intensive data centers, with servers operating on average 50% of the time. When used for AI training, server utilization can reach 80%. Colocation and other small/medium size data centers typically see 15-30% average server operating times. Figure 20 shows the total annual electricity use by data center space type and by component, highlighting the demand from servers/IT equipment. In 2023, hyperscale and colocation data centers accounted for almost 80% of server energy use. The total range of energy use growth for 2024 and 2028 will be highly dependent on the quantity and operation of AI servers.

Reducing the IT power requirements through energy-efficiency improvements cascades through the data center and results in a multiplier effect through savings on infrastructure power: every unit of IT power saved reduces infrastructure power to energize and cool the IT equipment. Many energy efficiency opportunities involving IT equipment such as servers, network, and storage remain untapped. Data center owners and operators can take advantage of not only higher efficiency IT equipment, but also data center management strategies such as utilization, consolidation, and virtualization to prevent excessive IT energy consumption.

Encouraging data centers to identify savings opportunities through IT equipment upgrades is a relatively straightforward method to help reduce energy demand. LBNL has compiled a comprehensive list of energy efficiency actions data centers can take to improve energy management across IT equipment, cooling & air management, monitoring & controls, environmental conditions, and power (UPS, lighting).

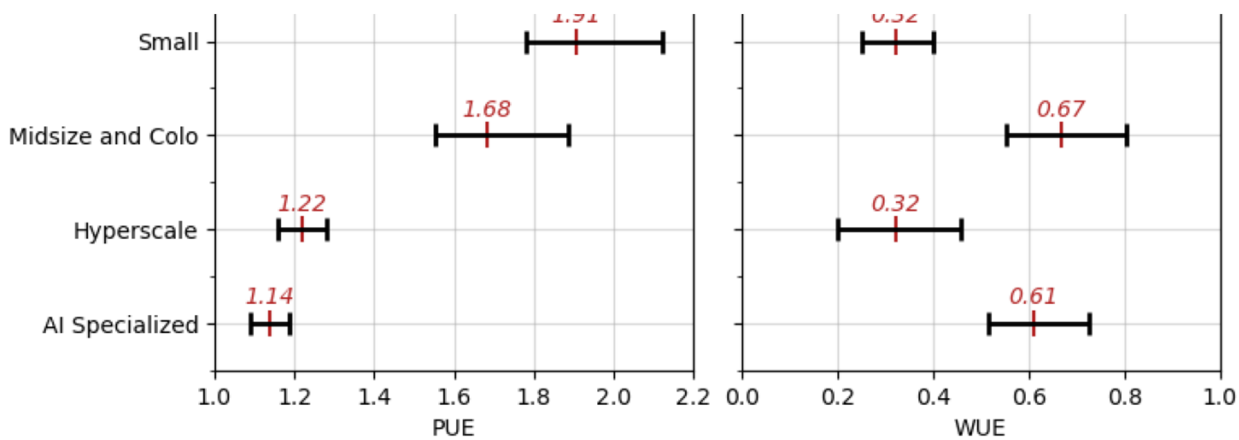
Figure 20. Total Data Center Electricity Use 2014 - 2023, Projected 2024 and 2028 by Space Type and by Equipment Type



MEASURING DATA CENTER EFFICIENCY

The range of calculated PUE and WUE metrics across data center types considering their location and cooling system type is shown in Figure 21. The average PUE was 1.4 in 2023. The closer the PUE value is to 1.0, the more efficient the data center is in utilizing its power solely for IT equipment, without wasting much on other infrastructures. The LBNL report estimates the average PUE will decline to 1.15 – 1.35 by 2028, driven by the shift to more efficient hyperscale and colocation facilities, combined with the increase in liquid-cooled (efficient) AI servers. However, this shift will also increase the average WUE, growing from 0.36 L/kWh today to 0.45 – 0.48 by 2028.

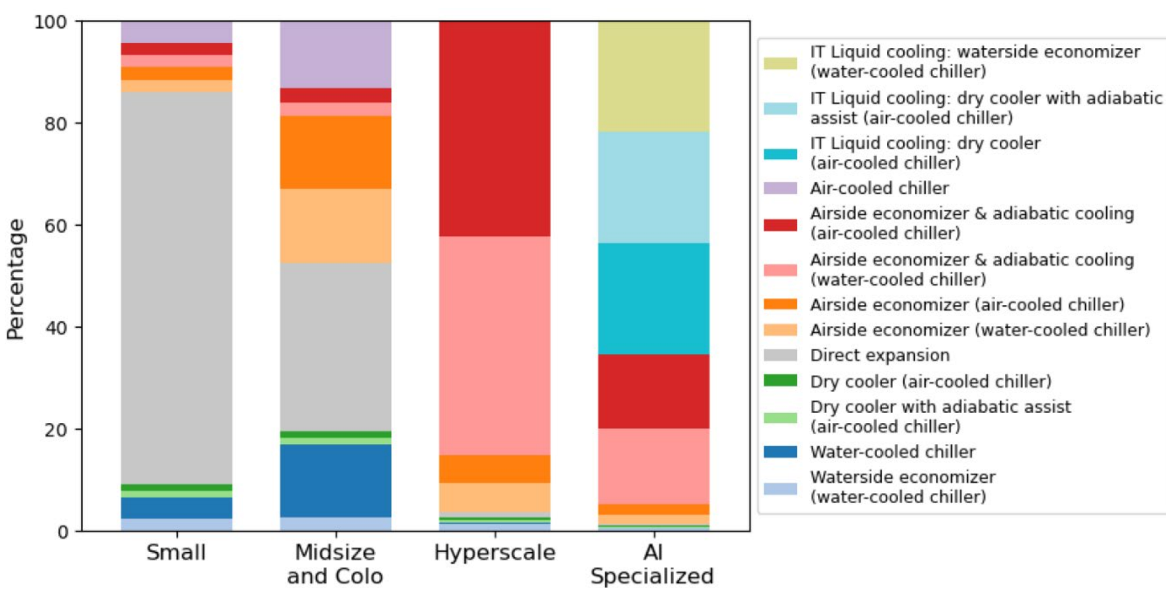
Figure 21. PUE and WUE by Data Center Type, 2023



DATA CENTER COOLING TECHNOLOGIES

LBNL estimated the nationwide distribution of cooling systems by data center space type (Figure 22), which illustrates the use of liquid/water cooling technology in medium/large data centers, and almost exclusively for hyperscale and AI data centers. Data centers typically cool computing equipment by blowing cold air over the components using a water-cooled fan coil or by directly cooling the computing equipment with cool water.

Figure 22. Data Center Cooling Systems Distributed by Space Category, 2023



Data Center Cooling & Air Management
Efficient and well-planned air management strategies are crucial for enhancing energy efficiency. Typically, air distribution involves mixing cooled air with air that has been heated by IT equipment. This can pose challenges in directing cool air precisely where it is needed, resulting in an inefficient cooling system. Effective management of cold and hot air streams is essential not only for optimizing the cooling infrastructure but also for maintaining the IT equipment's thermal environment. Improved air management can significantly reduce energy consumption and operational costs, as cooling demands constitute one of the largest energy expenditures in data centers.

Compared to air cooling, liquid cooling delivers up to 40% in energy savings, leading to lower PUE values. For many small and medium-sized data centers, with server loads under approximately 10-15 kW power density per rack, air cooling remains a viable option. However, as power densities increase, air cooling presents certain drawbacks, including elevated cooling costs, risks of performance throttling due to thermal issues, and limited scalability. Although liquid cooling solutions generally incur higher initial costs compared to air-cooled IT equipment within standard racks, these costs may be substantially offset by the enhanced energy efficiency and potential capital savings associated with liquid cooling near the heat source. Liquid cooling also provides opportunities for utilizing waste heat to warm adjacent offices or contribute to district heating systems.

Currently, liquid-cooled rack designs are bespoke and used in standalone data centers. LBNL has identified a goal of a liquid cooled rack specification that could accommodate multiple vendors and provide a reusable infrastructure for multiple refresh cycles with a variety of liquid cooled servers/suppliers. Note: Immersion cooling (submerging IT equipment in non-conducting fluid) is still being explored but typically voids IT hardware warranties at this time.

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