CLIMATE ACTION PLAN

Navigating Towards a More Equitable & Resilient Transit System

MDOT
MARYLAND DEPARTMENT OF TRANSPORTATION

MARYLAND TRANSIT ADMINISTRATION

FEBRUARY 2024

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ACRONYMS

APTA	American Public Transportation Association
ARToolbox	Adaptation and Resiliency Toolbox
BEB	Battery Electric Bus
BGE	Baltimore Gas and Electric
CAP	Climate Action Plan
CMRTP	Central Maryland Regional Transit Plan
CNI	Capital Needs Inventory
CO2	Carbon Dioxide
CO2e	Carbon Dioxide Equivalent
CSNA	Climate Solutions Now Act
CTP	Consolidated Transportation Program
ESRGC	Eastern Shore Regional GIS Cooperative
EPA	US Environmental Protection Agency
EPC	Energy Performance Contract
EPD	Environmental Planning Division
EV	Electric Vehicle
FCEB	Fuel Cell Electric Bus
FEMA	Federal Emergency Management Agency
FTA	Federal Transit Administration
FY	Fiscal Year
GGRA	Maryland's Greenhouse Gas Reduction Act
GHG	Greenhouse Gas
GIS	Geographic Information System
kWh	Kilowatt-hour
LED	Light Emitting Diode
LCCA	Life Cycle Cost Assessment
LOTS	Locally Operated Transit Systems
MARC	Maryland Area Regional Commuter
MCCC	Maryland Commission on Climate Change
MDE	Maryland Department of the Environment
MAA	Maryland Aviation Administration
MDOT	Maryland Department of Transportation
MdTA	Maryland Transportation Authority
MPA	Maryland Port Administration
MSL	Mean Sea Level Rise
MTA	Maryland Transit Administration
MTP	2050 Maryland Transportation Plan
MVA	Maryland Motor Vehicle Administration
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Protection Act
NOAA	National Oceanic and Atmospheric Administration
NOx	Nitrogen Oxides
NZGE	Net-Zero GHG Emissions
OLTS	Locally Operated Transit Systems
PSC	Maryland Public Service Commission
PV	Photovoltaic
PM	Project Manager
PM10	Particulate Matter 10
PM2.5	Particulate Mater 2.5
LOTS	Locally Operated Transit Systems
RFP	Request For Proposals
RPS	Renewable Portfolio Standard
RTP	Regional Transit plan, Maryland
SHA	Maryland State Highway Administration
SO	Sulfur Monoxide
SRE	Sustainability, Resiliency, and Equity Team
STIIM	Sustainable Transportation Investment Index Mapping
STIP	Statewide Transportation Improvement Program
STP	Maryland Statewide Transit Plan
TSO	Transportation Secretary's Office, MDOT
UHI	Urban Heat Islands
VMT	Vehicle Miles Traveled
VOC	Volatile Organic Compounds
WMATA	Washington Metropolitan Area Transit Authority
ZEB	Zero Emission Busses

I. EXECUTIVE SUMMARY

Transportation is a significant contributor to climate change, and the reduction of greenhouse gas (GHG) emissions from the U.S. transportation sector is a top concern for both the federal and Maryland state governments. In 2021, the Biden-Harris Administration set a goal for the U.S. to reduce its net GHG emissions economy-wide by 50 percent of 2005 levels by 2030. Maryland has a similar goal for the transition to zero-emission buses (ZEBs), school buses, and passenger vehicles to reduce transportation-related pollution.

In April 2023, the Federal Transit Administration (FTA) launched the third phase of the Sustainable Transit for a Healthy Planet Climate Challenge. The third phase builds on the initial Climate Action Plan (CAP) while incorporating resilience, helping to protect infrastructure, and improving mobility.

This CAP outlines the MTA goals, strategies, and anticipated outcomes for reducing the overall amount of GHGs to improve air quality, promote energy efficiency, mitigate and adapt to asset vulnerabilities, and create awareness and education within the agency and beyond.

A. Goals

The 2024 MTA CAP is an efficient and effective path to meeting the following overarching goals:

Reduce GHGs From the Transportation System

- Facilitate modal shift from passenger cars to transit by enhancing infrastructure that decreases travel time such as dedicated bus lanes, transit signal priority, expedited boarding, enhanced passenger amenities, and optimized routes.
- Support increasing transit capacity such as by using larger vehicles and increasing trip frequency.
- Facilitate modal shift from passenger cars to biking, walking, and other modes of active transportation by supporting the enhancement of bike network facilities, and providing additonal provisions for bikes on transit vehicles and at transit stops.
- Explore and plan for zero-emission revenue vehicles and supporting infrastructure.
- Support the expansion of transit-oriented development.
- Leverage micro mobility to help meet first and last mile connectivity needs.
- Educate and engage communities to raise awareness about environmental benefits of public transit and supporting sustainable transit initiatives.

Reduce Regional GHGs

- Expand public transit service.
- Educate and engage in partnerships and collaboration
- Monitor and report emission data and report progress to stakeholders.

Incorporate Resilience Into Transit

- Identify potential risks and vulnerabilities to transit infrastructure and services.
- Explore and plan infrastructure retrofits to withstand extreme weather events.
- Plan for backup systems such as power systems, communication networks, and alternative transportation options.
- Develop emergency response plans for maintaining essential services and evacuation.
- Factor in climate change projections when planning infrastructure upgrades or expansions.
- Provide ongoing training and capacity-building programs for all employees.
- Assess existing resilience plans and strategies on a regular basis.

B. Strategies & Actions

MTA's 2024 Climate Action Plan (CAP) provides a suite of strategies that will support MTA in reducing its carbon footprint, complying with regulations, and contribute to broader emission reduction goals set forth my MDOT. Documented strategies also provide opportunities for cost savings and increased resilience of assets/infrastructure while fostering sustainability and accountability. As MTA is an agency under the MDOT umbrella, final authority for the implementation strategies documented in the CAP will be coordinated with the MDOT The Secretary's Office (TSO) and not intended to set policy. Instead, MTA's CAP is focused on informing the decision-making process for transit capital investment and planning collaboratively with TSO.

C. How This Plan Will Be Used

MTA intends to use this plan to identify an agency vision and outline actions that will move the agency toward a more sustainable infrastructure and services. The plan will be updated every five years and shared with stakeholders, communities, and agencies.

II. INTRODUCTION

The State of Maryland is home to more than 6 million residents and has more than 3 million jobs and counting. The high population density and concentration of jobs helps drive transit demand. With the fifth-highest transit mode share in the United States, public transportation is essential for mobility in Maryland (Maryland Statewide Transit Plan, Draft January 2022).

MTA is one of the largest multi-modal transit systems in the United States with a goal to provide safe, efficient, and reliable transit across Maryland with world-class customer service. MTA operates Bus, Light Rail, Metro Subway, Maryland Area Regional Commuter (MARC) Train Service, and a comprehensive Paratransit system. MTA also manages the Taxi Access system and directs funding and statewide assistance to Locally Operated Transit Systems (LOTS).

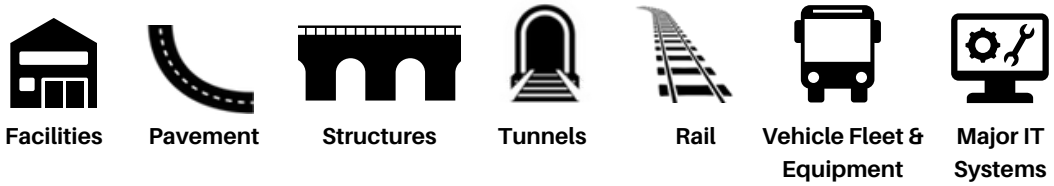
The purpose of MTA's 2024 Climate Action Plan (CAP) is to assess the agency's current emissions level, set attainable reduction goals and develop implementation strategies for agency programs, processes, and projects. This CAP also folds in the importance of resiliency and equity planning. Development of the 2024 CAP includes past MTA projects and initiatives, considering both successes and challenges. This includes the agency's Resilient and Sustainable Transportation Programs already established within MTA as well supporting MDOT Policy Manual (Appendix B).

This CAP will be used in conjunction with the 2050 Maryland Transportation Plan (2050 MTP), Central Maryland Regional Transit Plan (CMRTP), the STIP (Statewide Transportation Improvement Program), and the 10-Year Capital Needs Inventory and Prioritization Report (CNI) to ensure that future capital projects and potential service expansion decisions align with the agency's and MDOT-wide climate goals.

A. MTA Agency Overview

As a larger multi-modal transit systems, MTA also manages the Taxi Access system and directs funding and statewide assistance to Locally Operated Transit Systems (LOTS) in each of Maryland's 23 counties, Baltimore City, Annapolis and Ocean City.

Aligned with MDOT's overall classification for all the state's transportation assets, MTA assets are classified into seven over-arching categories with additional sub-sets:



MTA's Capital Needs Inventory (CNI) outlines the unconstrained investment needs between 2022 and 2031 that will preserve Maryland's significant investment in transit to date and help MTA meet current and future service demands.

MTA operates and maintains $12.6 billion in assets to provide transportation services throughout Maryland. Since the last assessment in 2019 [2], total funding needs for the next ten years increased by $600 million for inflation, the cost of zero-emission busses, garage modernizations, light rail vehicle replacements, and aging rail systems.

B. MTA Emission Profile

MDOT tracks the total share of CTP funding dedicated to projects that will help Maryland meet its climate change goals. Within the FY 2021–2026 CTP, 65 percent (approximately $8.01 billion) of Maryland's $12.39 billion six-year major capital program are investments that will reduce MTA GHG emissions through 2030 and beyond. This share excludes spending by the MDTA and minor capital programs, such as system preservation and maintenance activities.

When looking at the entire capital program, the total share is 51 percent. This incorporates both major and minor capital projects, which include MDOT and MTA asset preservation and maintenance activities. The 35 percent of major capital investments and the 49 percent of all capital investments not considered GHG beneficial are primarily associated with spending that enhances customer service across MDOT's modal administrations and preserves and maintains Maryland's multimodal transportation system.

[1] MTA's Capital Needs Inventory (CNI) and Prioritization Report outlines the unconstrained investment needs between 2022 and 2031 that will preserve Maryland's significant investment in transit to date and help MTA meet current and future service demands.
[2] MDOT 2021 Climate Change Status Report.

These investments are critical to meeting MDOT's responsibilities to its customers and for keeping the system in a state of good repair. Many of the system preservation activities, such as bridge rehabilitation, stormwater management, and pavement preservation, also promote a more resilient transportation system, particularly to severe weather events – which is a priority objective of the Maryland Commission on Climate Change (MCCC).

The commitment to GHG-beneficial projects has increased during the last eight iterations of the CTP, with the current estimate of 65 percent for the FY 2021 – 2026 CTP representing the same share as the FY 2020 – 2025 CTP, which was the highest estimated share to date (increasing from 63 percent in the FY 2019 – 2024 CTP). This shows sustained support for MTA and WMATA, prioritizing investments addressing roadway bottlenecks and transit on-time performance, and expanding safe and accessible bicycle and pedestrian networks. This is all while the total CTP budget was reduced by more than $1 billion in the FY 2021 – 2026 CTP due to funding decreases associated with economic impacts of the pandemic.

Improving air quality protects public health and mitigates climate change by reducing human caused greenhouse gas (GHG) emissions, such as carbon dioxide and methane. Renewable energy technologies can replace fossil fuels by harnessing power from natural and abundant energy sources, such as the sun and wind. Locally, improving water quality helps stop the formation of "dead zones," or areas devoid of aquatic life due to low oxygen, within the Chesapeake Bay. Impervious surfaces, such as pavement and roofs, degrade water quality by preventing natural systems from filtering and slowing down stormwater runoff.

From 2017 to 2019, MTA reduced greenhouse gas emissions (Lbs. CO2-e) by 6.0 percent and therefore achieved its June 2020 performance target. Local Bus reduced GHG emissions by 14.1 percent, due to the bus fleet replacement program while the remaining modes' energy use increased. The discrepancy in 2018 MARC data is due to an abnormally large electric bill at a signaling system meter. MTA uses tools to convert energy use to GHG emissions, such as EnergyCap, U.S. EPA's GHG Equivalencies Calculator, and the American Public Transportation Association's Transit Emissions Quantifier Tool.

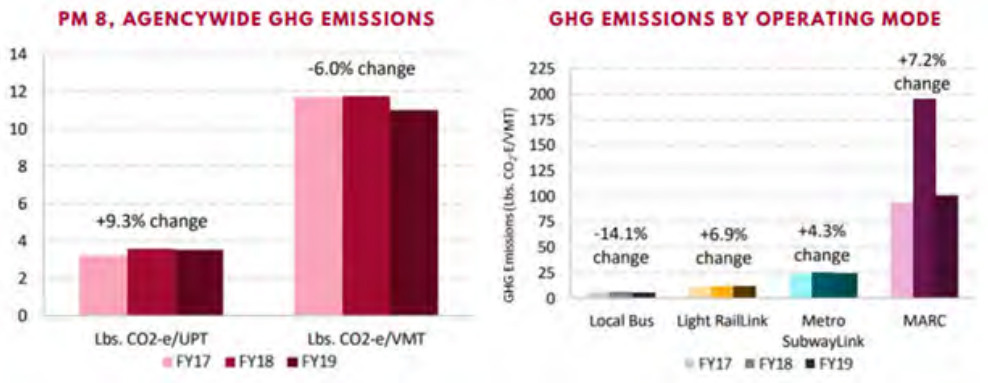


Figure 1: MTA GHG Emissions by Mode and Year
Source: MTA 2020 Sustainability Report: A 2017-2019 Update

III. POLICY & REGULATORY REQUIREMENTS

Maryland Commission on Climate Change Act

The 2015 Maryland Commission on Climate Change (MCCC) Act required the MCCC and its participating agencies, including the Maryland Department of Transportation (MDOT), to maintain a comprehensive action plan with 5-year benchmarks to achieve science-based reductions in Maryland's GHG emissions. Published yearly status reports meet the requirements of the MCCC Act (§2-1305) by sharing MDOT's, and by extension MTA's, progress towards achieving emission reduction targets and highlights recent and planned actions to continue to mitigate the impacts of climate change and reduce transportation sector GHG emissions. Yearly reports are publicly available on MDOT's website.

Maryland Greenhouse Gas Reduction Act (GGRA) / Climate Solutions Now Act

The Maryland Greenhouse Gas Reduction Act (GGRA) requires a statewide GHG emissions reduction of 40% from 2006 levels by 2030 ("40 by 30"). The Climate Solutions Now Act of 2022 (CSNA) adjusted these statewide GHG emissions goals to include a net-zero carbon emissions goal by 2045 and a requirement to reduce GHG emissions statewide by 60% from 2006 levels by 2031. MDOT has worked in coordination with other agencies and partners to develop strategies for the transportation sector of the state to achieve these goals.

Renewable Portfolio Standard (RPS) - HB1106

Maryland's Renewable Portfolio Standard (RPS) was established in 2004 to capture the economic, environmental, fuel diversity, and security benefits of renewable energy; establish a market for renewable energy in Maryland; and lower the cost of obtaining electricity generated from renewable sources. Maryland's RPS Program does this by gradually increasing the amount of renewable energy electricity suppliers must procure from renewable sources by 2030 to 50 percent as most recently updated by the Clean Energy Jobs Act of 2019. As the RPS increases, fewer and fewer pollutants enter our air and water, and the state's array of renewable energy resources grows. Eligible renewable energy sources include Tier 1 and Tier 2 resources. Tier 1 includes solar, wind, qualifying biomass; methane from a landfill or wastewater treatment plant; geothermal; ocean; certain fuel cells; small hydroelectric power; poultry litter-to-energy; waste-to-energy; refuse-derived fuel; thermal energy from thermal biomass; and wastewater used for heating or cooling systems. Tier 2 includes large hydroelectric power.

[3] Maryland Renewable Energy Fact Sheet.

IV. INITIATIVES ALIGNING WITH EXISTING REGULATIONS

A. MDOT Statements on Sustainability

The Maryland Department of Transportation (MDOT) is a customer-driven agency that delivers safe, sustainable, intelligent, exceptional, and inclusive transportation solutions in order to connect our customers to life's opportunities.

There are seven goals supporting MDOT's mission as documented in the MTP:

1. Ensure a safe, secure, and resilient transportation system.
2. Facilitate economic opportunity and reduce congestion in Maryland through strategic system expansion.
3. Maintain a high standard and modernize Maryland's multimodal transportation system.
4. Improve the quality and efficiency of the transportation system to enhance the customer experience.
5. Ensure environmental protection and sensitivity.
6. Promote fiscal responsibility.
7. Provide better transportation choices and connections.

The seven goals also help advance MDOT's approach to adapt to and combat climate change, including:

- Delivery of the state's transportation infrastructure program that conserves and enhances Maryland's natural, historic, and cultural resources;
- System preservation, safety and security, and quality of service goals that drive MDOT's progress towards improving resilience and transitioning to a more efficient transportation system, and
- Commitment to multimodal accessibility and mobility for all transportation system users, helping to mitigate congestion and shift travel to less emission intensive modes.

[4] 2022 MDOT Status Report (https://www.mdot.maryland.gov/OPCP/MDOT_MCCC_State_Agency_Report_MSAR_14367.pdf)

MTA's Sustainable Transportation Program Vision and Mission Statement

The MTA Sustainable Transportation Program has developed the following:

Vision: Improve our environment – and maximize employee, agency, and community co-benefits – through effective and equitable program, project, and purchasing decisions.

Mission: Empower and equip managers with the solutions, recommendations, resources, tools, and technical expertise they need to integrate sustainability throughout the agency's processes.

MTA's APTA Commitment

On November 2, 2023, MTA signed the American Public Transportation Association (APTA) Commitment letter to making sustainability a part of the MTA strategic objectives. This includes a commitment to progress reports of steps made to achieve the core sustainability principals.

MDOT Vision and Framework for a Sustainable Multimodal Transportation System

Signed on December 9, 2019, by the Deputy Secretary, MDOT Supporting Policy Document 606.4 establishes the MDOT's vision for a sustainable multimodal transportation system and a framework designed to attain that vision (Table 2). The Sustainability Work Group, comprised of representatives from each Transportation Business Unit and the Secretary's Office, collaboratively drafted the Sustainability Framework. The Sustainability Work Group will provide oversight to ensure the implementation of this framework aligns with organizational goals.

A sustainable multimodal transportation system maximizes the efficacy of investments and supports current and future generations by enhancing community quality of life, environmental health, and economic growth. To advance sustainability, MDOT will integrate sustainability in business processes, implement a performance management approach, and leverage innovative resources.

MDOT MARYLAND DEPARTMENT OF TRANSPORTATION

Supporting Document: MDOT 606.4
Effective Date: December 9, 2019

Approved by: _____ Date: 12/9/19
Deputy Secretary of Policy, Planning, and Enterprise Services

Framework for a Sustainable Transportation System

This supporting document establishes the Maryland Department of Transportation's (MDOT) vision for a sustainable multimodal transportation system and a framework designed to attain that vision. The Sustainability Work Group, composed of representatives from each Transportation Business Unit and the Secretary's Office, collaboratively drafted the Sustainability Framework. The Sustainability Work Group will provide oversight to ensure the implementation of this framework aligns with organizational goals.

Vision for a Sustainable Multimodal Transportation System

A sustainable multimodal transportation system maximizes the efficacy of investments and supports current and future generations by enhancing community quality of life, improving environmental health, and enabling a robust economy. To advance sustainability, MDOT will integrate sustainability in business processes, implement a performance management approach, and leverage innovative resources.

Framework to Realize the Vision

Pillars	Commitments	Goals
Community Quality of Life	Promote livable communities	Provide transportation options that address accessibility and mobility.
		Strengthen local and regional connections to opportunity
		Work with local governments to support local land use choices that optimize the efficacy of transportation investments
		Engage communities impacted by transportation investments
	Foster employee wellness	Enhance employee morale
		Enhance employee health
Environmental Health	Create, restore, and enhance environmental quality and ecosystems	Restore and enhance land, water, and air quality
		Reduce and eliminate waste and hazardous materials
		Promote nature-based solutions to enhance operational efficiency and infrastructure resiliency
	Conserve resources and support environmental stewardship	Reduce water and energy consumption while increasing the renewable energy portfolio
		Leverage responsible sourcing procurement practices
Robust Economy	Support economic growth and development	Support job creation to benefit all socioeconomic levels
		Increase freight capacity and strengthen multimodal freight connections
	Optimize financial resources	Ensure assets meet the needs of the transportation system and are kept in a State of Good Repair
		Minimize an asset's total cost of ownership while maximizing performance
		Leverage the value of underutilized and underperforming properties and assets of the transportation system
	Build system resiliency	Incorporate resiliency to reduce risk and ensure quick recovery from disruptions

Figure 2: MDOT's Framework for a Sustainable Multimodal Transportation System
Source: MTA 2020 Sustainability Report: A 2017-2019 Update

MTA's Resilient Transportation Program Mission Statement

Approved February 2023, the agency's Resilient Transportation Program Mission Statement is "MTA committed to managing increased climate change risk – by evaluating risk, assessing risk management strategy lifecycle impacts, and implementing priority strategies – through effective and equitable program, project, and purchasing decisions."

2040 Maryland Transportation Plan (MTP)

The 2040 Maryland Transportation Plan (MTP) establishes a 20-year vision for multimodal transportation in Maryland that outlines the state's transportation policies and priorities and helps guide statewide investment decisions for all modes of transportation. There are seven goals supporting MDOT's mission as documented in the MTP as well as help advance MDOT's approach to adapt and combat climate change, including "system Preservation, safety and security, and quality of service goals that drive MDOT's progress towards improving resilience and transitioning to a more efficient transportation system."

The Climate Solutions Now Act & The MDOT GGRA Plan

In 2009, Maryland adopted the Greenhouse Gas Emissions Reduction Act (GGRA), which required the State to reduce GHG emissions and submit an annual report to the Governor and General Assembly to communicate progress towards meeting GHG reduction mandates. While GHG reductions were expanded in 2016, the 2022 Climate Solutions Now Act requires the state to reach net-zero GHG emissions by 2045. Net-zero GHG emissions includes, but not limited to, agency operations, capital programming, and procurement decisions.

B. MDOT Statements on Equity

MTA's Strategic Plan

Approved September 2021. Titled "Rebuilding Better, Committed to an Equitable Transit Future,"1 Equity must continue to be a focus of everything [MTA does]. [MTA's] work to rebuild better will center around providing full and equitable transportation for Marylanders of diverse races, ethnicities, ages, genders, abilities, and incomes.

MDOT Environmental Justice Statement

MDOT is committed to ensuring the equitable delivery of public transportation products, services, and solutions to all its users and stakeholders. MDOT will accomplish this by engaging with communities in a transparent and fair way regardless of race, culture, and income with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies in transportation decision making.

Environmental Justice is a critical investment for MDOT to ensure the sustainability of its residents, employees, environment, and the diverse communities in which we live. In pursuit of this commitment, MDOT will align its strategic direction with efforts that make environmental justice the way we do business.

C. MTA Plans & Studies

MTA Statewide Transit Plan (STP) Draft

MTA released a draft Statewide Transit Plan (STP) that will provide a 50-year vision of coordinated local, regional, and intercity transit across the state. This plan will define public transportation goals and strategies for Maryland's rural, suburban, and urban regions with a vision toward increasingly coordinated, equitable, and innovative mobility. MTA is developing the STP with input from a broad range of partners, including other state agencies, local and regional governments, public and private transit providers, business and non-governmental organizations, and the public. The STP will build from existing state, regional, and local plans and identify and address several strategic themes such as economic opportunity, safety, resiliency, and equity.

MTA 2016 Climate Change Vulnerability Assessment

MTA's 2016 Climate Change Vulnerability was developed in response to Maryland's Climate Action Plan (2008), produced by the Maryland Climate Change Commission and the Climate Change and Coast Smart Construction Executive Order (2012). The purpose of the assessment was to identify MTA sensitive locations and assets that are vulnerable to three expected results of global climate change: sea level rise, increased hurricane storm surge, and flooding due to major rain events.

Assessing vulnerability began with the identification of existing stressors facing MTA assets/locations and how climate change will impact and/or introduce new stressors in the future. The findings were then ranked to assess, prioritize and address vulnerabilities.

- Assessing risk was determined by evaluating "likelihood" and "consequence" which are defined as the following:

- Likelihood – Possibility that a sensitive location/asset would be impacted from a climate change scenario

- Consequence – Rating based on a set of potential consequences (e.g., costs, service interruption, reputation/image of MTA) to an impacted vulnerable site.

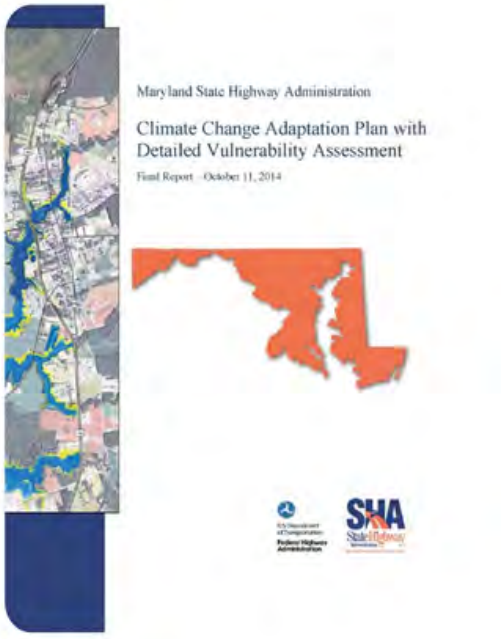
The MTA Climate Change Vulnerability Assessment incorporated a risk assessment of each of the identified vulnerable locations/assets and documented which sites are high priorities and most at risk of being impacted due to a changing climate, consequently impacting the continual provision of MTA's services.

Results of the study determined that seventy-five (75) sensitive locations and assets were vulnerable to inundation under one or more of the three scenarios evaluated. Of these, twenty-five were considered to pose a "very high" risk to MTA service and operations should they become inundated. Twenty-two posed a "high" risk and fifteen posed a "moderate" risk.

MTA Climate Change Vulnerability Assessment 2019 Update

Since the development of MTA's 2016 Vulnerability Assessment, 2018 data was incorporated into the 2016 assessment to update the identification of assets and locations at risk. Vulnerability assessment results were incorporated into a GIS viewer for ease in access across the agency. Working group sessions were conducted with the modes/divisions within the agency, to confirm or supplement the findings of the assessment update.

The 2018 data included hurricane storm surge from the National Oceanic and Atmospheric Administration (NOAA) and Sea Level Rise/Floodplain sets developed by MDOT SHA Climate Risk and Resiliency Program at Office of Planning and Preliminary Engineering, in collaboration with the Eastern Shore Regional GIS Cooperative (ESRGC).



The outcome data of this update was compiled into an interactive GIS Mapping Tool. Results of the following can be found depicted on Figure 3:

- Displays MTA's assets that are vulnerable to flooding from hurricane storm surge, sea level rise, and flooding events.
- Allows viewers to overlay MTA assets with a variety of inundation layers, filter assets, and review detailed information related to inundation levels.
- Includes
  - Hurricane Storm Surge- Inundation due to hurricane force winds pushing water towards the shore. Classification is based on a category 1-4 hurricane rating.
  - Maryland Effective FEMA Floodplain- Inundation due to 100 and 500-year flooding events.
  - Past conditions (2015)
  - Mean sea level (MSL) 0.2% Annual Chance- Inundation due to a 500-year flooding event in the present.
  - MSL 1% Annual Chance- Inundation due to a 100-year flooding event in the present.
  - 2050 predictions
    - MSL prediction for 2050.
    - MSL 0.2% Annual Chance- Inundation due to a 500-year flooding event in 2050.
    - MSL 1% Annual Chance- Inundation due to a 100-year flooding event in 2050.
  - 2100 predictions
    - Mean sea level (MSL) prediction for 2100. Classification is based on one-foot intervals.
    - MSL 0.2% Annual Chance- Inundation due to a 500-year flooding event in 2100.
    - MSL 1% Annual Chance- Inundation due to a 100-year flooding event in 2100.
- Provides users with further details associated with the degree of asset inundation. Each asset marker includes the exact estimate of inundation (in Feet) for each flooding scenario.

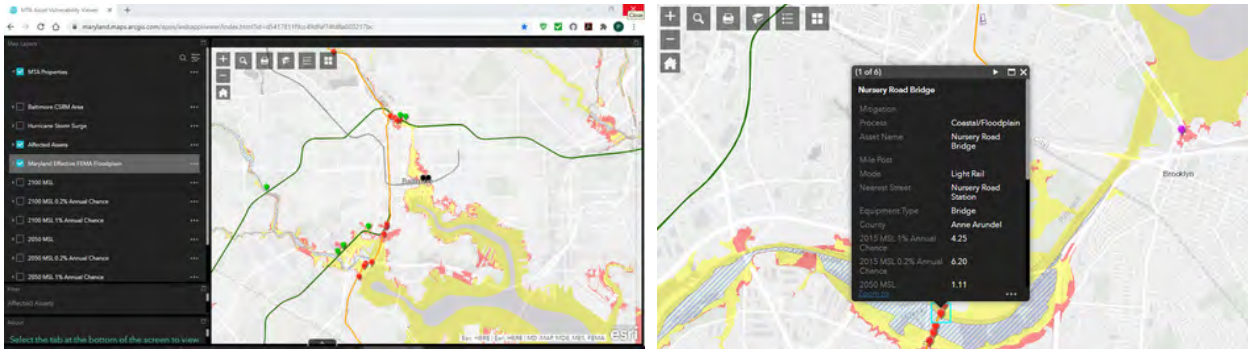


Figure 3: MTA's GIS Mapping Tool

MTA's Adaptation and Resiliency Toolbox (ARToolbox)

In 2020, MTA developed an online, real-time Adaptation and Resiliency Toolbox (ARToolbox) to proactively prepare, plan, design, and implement preparedness measures for MTA assets. The ARToolbox, adapted from the U.S. Climate Resilience Toolkit framework and other state DOTs across the country, is an interactive resource to understand hazards facing MTA assets, document vulnerability and risk from the 2019 Assessment, and identify potential adaptation measures that could be implemented at vulnerable assets through a four-step process.

The following strategies and innovative techniques were implemented during the ARToolbox development process: address a need for a comprehensive tool for resiliency through internal collaboration and input; conduct extensive research on existing resiliency measures across the country; identify ways to incorporate equity/Justice40 and resiliency; document and georeferenced previous/ongoing agency resiliency efforts and develop a funding resource tool.

The primary objective of the ARToolbox is to be an interactive resource for MTA that will be continually updated with new data, implemented adaptation/resiliency measures, and lessons learned to assist in prioritizing funding, programming, and project development. Developing a comprehensive database of potential adaptation measures that can be implemented at the asset level assists designers, planners, engineers, and maintenance staff with the resources needed to establish a proactive approach to a changing climate. Other elements of ARToolbox include an "Asset Navigation Tool" which provides an overview of identified vulnerable assets per mode/division, why each asset is vulnerable (e.g., sea level rise), listing of potential adaptation/resiliency measures, and next steps to incorporate measures into the project planning process (Figure 4). The ARToolbox also includes a vulnerability mapping tool, interactive "case study" mapping tool highlighting previous/current resiliency projects developed by MTA, a funding resource tool (e.g., grant vehicle overview), an overview of incorporating equity into resiliency, and a comprehensive library of online resources.

Figure 4: ARToolbox Process

Development of the toolbox ensured that the process is flexible and repeatable for other MDOT Modal Administrations and other interested government entities to implement a similar toolbox within their respective agencies. The ARToolbox was developed in consultation with the MDOT Transportation Secretary's Office (TSO) and has both a public facing and internal-only online platforms.

MTA Sustainability Program

MTA developed and manages the Transit Roots: Sustainability Program to continuously enhance its world-class transit service and help balance the needs of a community's quality of life, environmental health, and a robust economy. The Sustainability Program's purpose is to support and implement the MDOT Policy Manual Supporting Document 606.4, which identifies a vision and goals for a sustainable multimodal transportation system. To systematically improve performance for each goal, the Sustainability Program has implemented a continuous improvement process based upon identifying, prioritizing, and implementing initiatives. Initiatives generally include: collaboration between stakeholders, integrating sustainable design principles into capital projects, and technologies that enhance data quality (Figure 5).

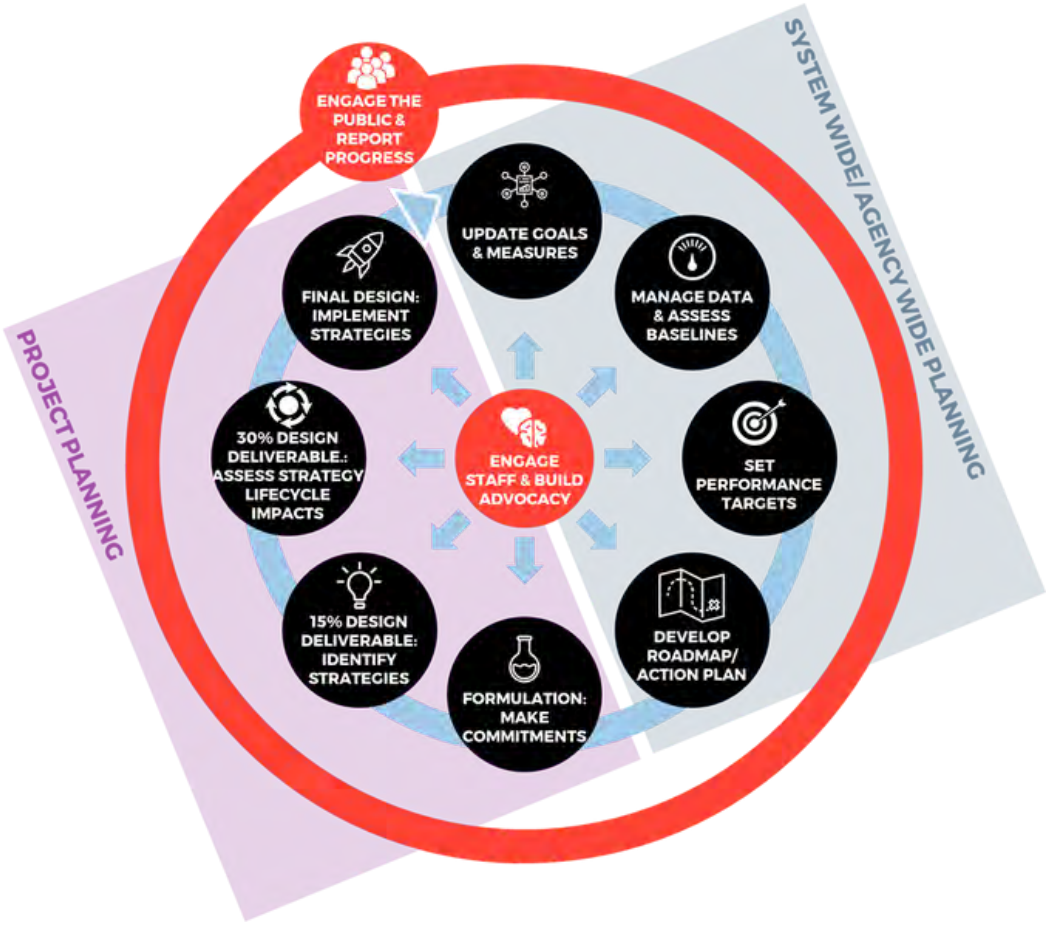


Figure 5: MTA Transit Roots: Sustainability Program Process

The MTA Sustainability Framework assesses community quality of life, environmental health. Figure 6 highlights MDOT supported commitments, goals, and strategic performance measures.

	Commitment	Goal		Performance Measure		Progress to 2020 Target
Community Quality of Life	Promote Livable Communities	1	Provide access to local and regional connections	1.1	Population within a 1/2 mile of fixed route transit	✓+
				1.2	Annual ridership	✓-
		2	Strengthen local and regional connections to opportunity	2.1	On-time performance	✓
				2.2	Customer satisfaction	✓
		3	Support local land use choices that optimize the efficacy of transportation investments			N/A
		4	Engage underrepresented communities to inform transportation investments			N/A
	Foster Employee Wellness	5	Enhance employee morale	5.1	Percent of employees that would recommend working at MDOT MTA	✓-
				5.2	Percent of employees that frequently find their job stressful	✓-
		6	Enhance employee health	6.1	Lost workdays due to injury	✓-
Environmental Health	Create, Restore, and Enhance Environmental Quality and Ecosystems	7	Restore and enhance land, water, and air quality	7.1	Pounds of GHG emitted	✓+
				7.2	Percent of impervious surfaces treated	✓
		8	Reduce and eliminate waste and hazardous materials	8.1	Percent of waste recycled	✓-
		9	Promote nature-based solutions to enhance operational efficiency and infrastructure resiliency			N/A
	Conserve Resources and Support Environmental Stewardship	10	Reduce water and energy use while increasing the renewable energy portfolio	10.1	Electricity and fuel used	✓+
				10.2	Percent of electricity used from renewable energy sources	✓-
				10.3	Water used	✓+
		11	Leverage responsible sourcing procurement practices			N/A
Robust Economy	Support Economic Growth and Development	12	Support job creation to benefit all socioeconomic levels	12.1	Number of jobs within a 1/2 mile of fixed route transit	✓+
		13	Increase freight capacity and strengthen multimodal freight connections			N/A
	Optimize Financial Resources	14	Ensure assets meet the needs of the transportation system and are kept in a state of good repair	14.1	Percent of transit assets in a state of good repair	✓
		15	Minimize an asset's total cost of ownership while maximizing performance	15.1	Noncontractual operating costs	✓+
				15.2	Fares purchased with electronic media	✓
		16	Leverage the value of underutilized and under-performing properties and assets of the transportation system			N/A
	Build System Resiliency	17	Incorporate resiliency to reduce risk and ensure quick recovery from disruptions			N/A

N/A: Performance measures are under consideration and development; ✓+: Performance met its June 2020 performance target; ✓: Performance is trending in a positive direction; ✓-: Performance is trending in a negative direction.

Figure 6: MTA Supported Commitments, Goals, and Performance Measures

MTA Sustainable Project Implementation Plan

The Sustainable Project Implementation Plan (SPIP), integrates sustainability, resilience, and equity (SRE) practices into MTA's project planning. MTA developed and piloted the plan in 2022.

The benefits of developing and implementing the SPIP include:

- Support the overall sustainability and resilience of the Baltimore region.
- Systematically dismantle barriers to transportation equity.
- Align the project with MTA's sustainability, resilience, and equity goals/ commitments.
- Access state and federal resources, capitalize on opportunities, and align with legal requirements.
- Makes investments that mean the most to the surrounding communities and customers.

MTA's SPIP is divided into system expansion. Figure 7 illustrates the roles and responsibilities of the Project Manager (PM), SRE Leads, and the Environmental Programs Division (EPD) Managers for system expansion-type projects, such as facility replacement and transit corridor projects. The process includes major milestones and activities for the project and associated responsible party and ultimate recipient of deliverables. The process ensures early and often collaboration with SRE and EPD to ensure sustainable, resilient, and equity considerations are included throughout the project planning process.

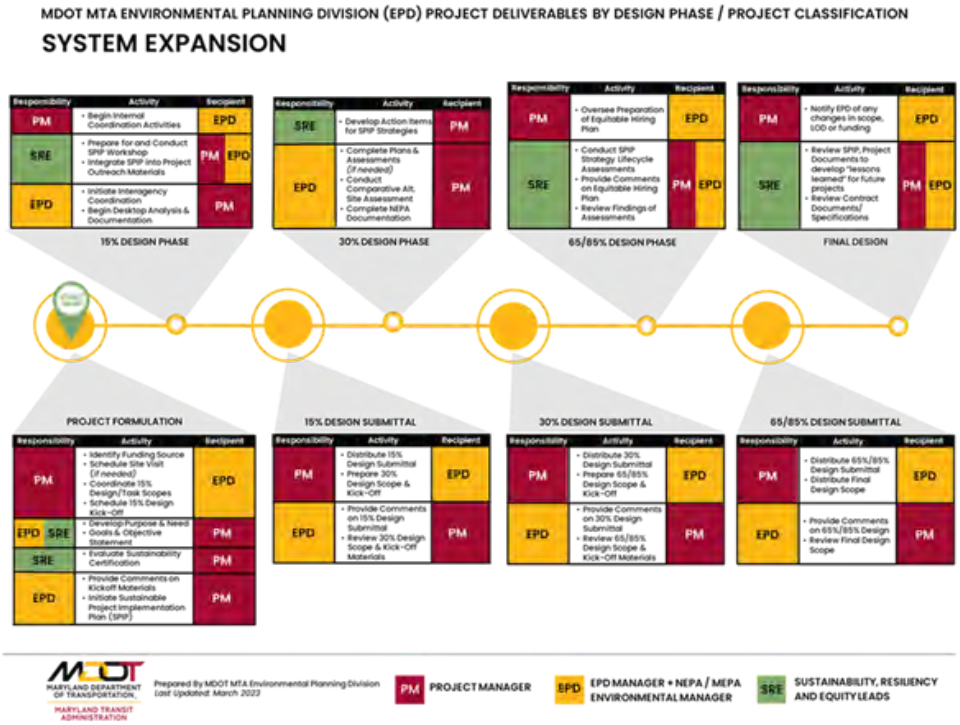


Figure 7: SPIP Framework and Process

MTA's Sustainability Team is piloting the SRE principles into several planning projects as the "Sustainability Planning Process." The Sustainability Planning Process uses a universal data-driven performance management model, which may also be applied to transit cooridor projects.

The Sustainability Team aspires to streamline how SRE is integrated into the Project Development Process, once the pilot studies are complete. As such, the Sustainability Team recommends referencing SRE commitments within the National Environmental Protection Act (NEPA)-driven Project's Purpose and Need Statement in lieu of developing a stand-alone SRE Project Commitment. It is also recommended to incorporate any commitments to using a third-party project certification system, such as EnvisionTM, within the Project's Purpose and Need Statement, as well.

MTA Sustainable Transportation Investment Index Mapping Tool

The Sustainable Transportation Investment Index Mapping (STIIM) Tool is a web-based tool that allows MTA to holistically evaluate and craft sustainable and resilient strategies to mitigate equity gaps using index of sustainability and resilience indicators on the community level, or Census Block Groups. For example, indicators consider transportation aspects such as walkability, affordability, asthma, particulate matter, GHGs, flooding, extreme heat, income, and others. In its first phase of development, the Tool identifies which equity gaps exist, locates the specific communities where those gaps exist, and quantifies the extent of those equity gaps. In the second phase of work, the team will craft modules that use initial equity findings for producing materials that helps a project manager integrate sustainability and resilience throughout their project's development. For example, the Tool helps project managers identify scope considerations that help formulate the project, identify feasible sustainability and resilience strategies, evaluate strategy lifecycle costs, integrate sustainability considerations into the community engagement process, and use staff education materials.

MTA Extreme Heat & Urban Heat Island (UHI) Studies

In general, cities such as Baltimore City, Maryland are warmer than rural areas because asphalt, concrete, steel, and bricks absorb sunlight and release heat back into the atmosphere resulting in "Urban Heat Islands (UHI)." According to the Environmental Protection Agency (EPA), UHIs occur when cities replace natural land cover with dense concentrations of pavement, buildings, and other surfaces that absorb and retain heat. This effect increases energy costs, air pollution levels, and heat-related illness and mortality.

Given the extent and possibility of assets and customers located within UHIs, MTA is currently evaluating UHIs and incorporating data/results into the agency's Resilient Transportation Program and ARToolbox. To utilize nationally accepted data sources for the UHI analyses, MTA applied for and was selected by the National Aeronautics and Space Administration (NASA) DEVELOP Program to partner with for MTA's UHI assessment. NASA DEVELOP projects are co-developed with partner organizations (such as MTA) and center on the decision-making needs of partner organizations and community priorities, tailoring products that apply NASA Earth science information to the decision at hand.

The current NASA DEVELOP project is focused on assessing UHI's in bus stops throughout Baltimore City. Future efforts and projects utilizing this program may result in additional UHI analyses on rail infrastructure and other MTA assets that are susceptible to these conditions.

Metro **Railcar Replacement**

Currently, MTA is repairing or completely replacing Metro and light rail vehicles. The Metro replacement project significantly further along, and the Light rail replacement program, in its early stages, recently secured $213M rail vehicle replacememt grant. The new railcars will be more reliable, more energy efficient, and provide enhanced passenger security and customer service capabilities. Further, the new railcar motors are more energy efficient, require less maintenance, and improve safety.

D. MTA Strategies for Emission Reduction

The majority of all GHG emissions are due to using fossil fuels (e.g., diesel, gas, propane, heating oil) to generate power. While MTA emits GHG emissions by managing transit assets throughout their lifecycles, MTA's supply chain uses energy and produces GHG emissions by extracting resources, using those resources to produce third-party transit assets, utility electricity, and materials and products, and distributing those items to market and subsequently to end-users, such as MTA. Figure 8 will be used as MTA's Net Zero Framework for categorizing GHG management strategies by identifying the emissions source that the strategy aims to manage or if absorb GHGs from the atmosphere through carbon offsets, and identifying when a GHG management strategy may be implemented during the lifecycle of MTA's asset.

Figure 8 provides MTA's NZGE framework for visualizing and managing energy use and sources of GHG emissions. As referenced above, Net-Zero means achieving a balance between GHGs produced by MTA and GHGs removed from the atmosphere through MTA Carbon Offset investments.

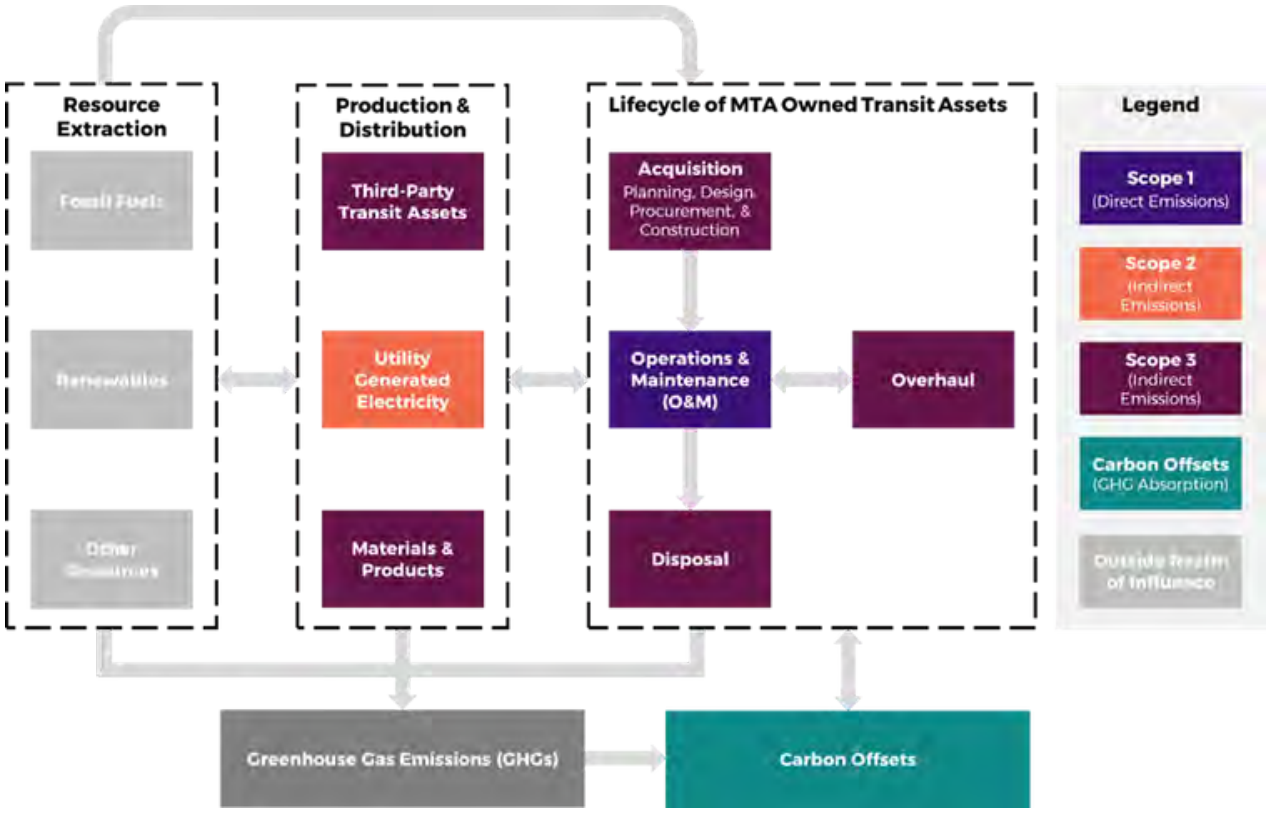


Figure 8: MTA's Framework to NZGE

Figure 8 also identifies how the industry prioritizes efforts based upon an organization's ability to easily manage GHG emissions, which are sorted into three categories, or scopes. Scope 1 focuses on direct GHG emissions from powering MTA transit assets, such as vehicles and facilities. Scope 2 looks at indirect GHG emissions by purchasing utility electricity derived from fossil fuel sources. Scope 3 considers other indirect GHG emissions from the production and delivery of MTA purchased building materials and products, third-party assets used for construction and transit service (e.g., Mobility, Commuter Bus), as well as disposal of MTA's waste since it emits GHGs from its decomposition and incineration. Industry widely recognizes that extracting resources is largely outside an organization's sphere of influence and is largely driven by economic factors.

Please refer to Table 1 for MTA strategies for obtaining NZGE. Appendix A provides additional supporting information for each documented strategy.

Zero Emission Bus (ZEB) Deployment

In 2016, the Maryland Greenhouse Gas Reduction Act Reauthorization set a 40 percent reduction target for statewide emissions by 2030 from 2006 levels. [5] The MTA subsequently is working forward converting 50 percent of its Core Bus fleet in Greater Baltimore to zero emission buses (ZEBs) as soon as possible.

ZERO EMISSIONS
Let's clear the air

[5] Maryland Zero Emissions Bus Transition Act Legislative Report, December 2022

Table 1: MTA's Potential Strategies to Obtain NZGE

No.	Potential Strategy	Rationale	Potential Actions
1	**Verify Utility Meter Data**	Existing utility meters may measure non-MTA assets or be documented with incorrect asset identifying information.	• Conduct gap analysis of utility meter and parent/child asset identifying information • Compare against and update the DGS EnergyStar/EnergyCap system • Use existing resources, when feasible
2	**Verify GHG Emissions Data Methodology**	The current baseline, while thorough, may not align with established standards.	• Evaluate existing GHG emission methodology against reporting standards • If necessary, update methodology and GHG emission data
3	**Refine GHG Emissions Measurement**	• Existing tools help model GHG emissions from bus diesel use • Lacking understanding of GHG impacts of on-board heaters	• ·Evaluate the GHG emissions of the current bus fleet by assessing one of each bus type, including on-board bus heaters • Update Dashboard based on findings
4	**Sub-meter MTA Energy Systems**	• Lacking real-time, revenue grade data by individual buildings, building systems, and/or EV chargers • Helps scope energy projects and maintain energy systems	• Develop sub-meter action plan, aligned with the 2018 Utility Sub-Meter Plan • Install and configure revenue grade sub-meters across MTA to evaluate energy use and quality in real-time by sub-metering individual building systems (if recommended), and BEV chargers • Develop guidelines for installation and communication procedures
5	**Implement Energy Data Sharing Contract Requirements**	• Lacking GHG emissions data from Commuter Bus, Mobility, and construction activities • Third parties are not required to share energy data with MTA	• Develop standard contract language, which requires third parties to routinely share energy use with MTA • Integrate the standard contract language into all new procurements • Applies to coach buses, paratransit vehicles, and construction equipment

Table 1: MTA's Strategies to Obtain NZGE

No.	Potential Strategy	Rationale	Actions
6	**Implement Embodied Carbon Tracking**	MTA lacks the capability to track emissions by the materials and products it purchases	• Evaluate the use of Environmental Product Disclosures (EPDs) and other methods to identify the emissions of purchased materials and products • Develop a method of tracking the emissions of purchased materials and products
7	**Electrify MTA Facilities**	Many MTA facilities currently burn fossil fuels to power mechanical systems	• ·Catalogue structures and equipment/systems that use fossil fuel power • Develop plan to electrify identified equipment • Implement building electrification plan
8	**Conduct Retro-commissioning (RCx) Assessments & Implement Priority Findings**	• Many MTA facilities never underwent commissioning (Cx), or their use has changed since design (e.g., conversion from maintenance to storage use) • RCx is a full systems approach to improving building performance through low-cost non-capital interventions • RCx assessments may include air conditioning, refrigerant, heating, ventilation, electrical, and lighting systems	• Conduct RCx assessments on remaining facilities, excluding Northwestern Bus Division (completed in 2017) and Wabash and Cromwell (In Progress) • Assess whether all priority RCx recommendations have been implemented at Northwestern • Assess whether RCx assessments may continue to be conducted through the Asset Management Program's facility inspection work, or expedited with consultant assistance • Once assessments have been completed, identify whether priority recommendations may be completed by the mode's on-site Facility staff or with consultant assistance • Implement priority recommendations

Table 1: MTA's Strategies to Obtain NZGE

No.	Potential Strategy	Rationale	Actions
9	**Implement Context Sensitive Capital Energy Efficiency Projects**	• Many opportunities exist to reduce energy use, but many are unknown due to the lack of asset-level, real-time data (e.g., sub-metering). • Energy Servicing Companies (ESCO) have conducted energy audits on MTA facilities and have proposed several projects which may be implemented through an Energy Performance Contract (EPC). However, the proposed projects lack scope, SME review, to ensure projects withstand transportation operations without degradation/failure	• Scope capital projects by implementing the "sub-metering" strategy, conducting RCx assessments, and leveraging existing facility energy audits (see Strategy 4, 7). Facility audits have been conducted by electricity providers with only residential and commercial expertise, and as such require review by transportation subject matter experts • Develop standard specifications or design guidelines, for specific equipment, to ensure projects align with MTA expectations and needs • See Strategy 14, "Reduce Facility to Exposure to Extreme Heat" strategy to consider other capital projects that are typically not evaluated within a facility energy audit

Table 1: MTA's Strategies to Obtain NZGE

No.	Potential Strategy	Rationale	Actions
10	**Investigate the Installation of Solar Panels on Rooftops**	MTA understands opportunities for parking lot canopy installations.	• Explore implementation of solar panel canopies over parking lots. • Consider how different roof elements may be integrated, see Strategy 19 "Reduce facility exposure to extreme heat"
11	**Transition to Zero Emission Buses (ZEBs)**	• State law requires MTA to begin purchasing net-zero buses • Explore reduction benefits.	• Leverage the ZEB team's work (See 2022 Maryland Zero Emission Bus Transition Act Legislative Report).
12	**Transition to Zero Emission Specialized Non-Revenue Vehicles**	• Specialized non-revenue vehicles are gas powered • The ZEB team's work does not currently consider these vehicles • May present procurement challenges due to a lack of manufacturers, which potentially complicate state competitive bidding requirements	• Expand the ZEB team's scope to include specialty non-revenue vehicles • Evaluate the risk for potential procurement challenges.

Table 1: MTA's Strategies to Obtain NZGE

No.	Potential Strategy	Rationale	Actions
13	**Transition to Zero Emission Mobility Revenue Vehicles**	• Existing Mobility vehicles are gas powered • The ZEB team's work does not currently consider these vehicles	• Build upon the ZEB team's work to include zero emission paratransit vehicles
14	**Transition to Zero Emission Agency-wide Light Duty Fleet Vehicles**	• The Department of General Services is in the process of replacing the state's light duty vehicle fleet with electric vehicles and install charging equipment	• Coordinate with the Department of General Services to replace vehicles and install EV charging equipment at MTA facilities
15	**Upgrade Facilities to be EV Charging Ready**	• Existing facility electrical infrastructure may not be able to accommodate additional demand loads due to electric vehicle bus charging needs	• Leverage the ZEB team's work (See 2022 Maryland Zero Emission Bus Transition Act Legislative Report)

Table 1: MTA's Strategies to Obtain NZGE

No.	Potential Strategy	Rationale	Actions
16	**Purchase Renewable Energy from Electricity Providers**	• Renewable Energy Portfolio Standard (RPS) enabling law requires electricity suppliers to provide 50 percent of their electricity from renewable sources by 2030, falling short of the CSNA mandate • Peer transit agencies directly negotiate with electricity suppliers for more favorable rates and to procure all their electricity from renewable sources. Negotiated rates are implemented through the Public Service Commission	• Begin negotiations with Baltimore Gas & Electric and/or Constellation Energy
17	**Reduce Facility Exposure to Extreme Heat**	• Extreme heat can significantly increase air conditioning and energy use	• Identify facilities with the highest exposure to extreme heat • Assess the efficacy of external window shading devices, tree plantings, cool roofs, cool pavements, and green walls • Consider how different roof elements may be integrated. For example, white roof in conjunction with rooftop solar. See Strategy 9 • Implement recommendations

Table 1: MTA's Strategies to Obtain NZGE

No.	Potential Strategy	Rationale	Actions
18	**Design Projects to Minimize GHG Emissions**	• The project development process historically lacked a procedure for assessing and enhancing sustainability, resilience, and equity outcomes. GHG reductions may be prioritized through this process • Lifecycle Cost Assessments (LCCAs) quantify a strategy's cost – beyond acquisition to include O&M, overhaul, and disposal – and the amount of GHG emissions that will be avoided across those lifecycle phases	• Refine, approve, and use the "Sustainable Project Implementation Plan (SPIP) Checklist" to systematically integrate GHG management into the project's design. This includes setting priorities, identifying sustainability and resilience strategies, evaluating LCCAs, and prioritizing and implementing strategies • Develop guidance for conducting LCCAs. • Apply the SPIP Checklist to priority MTA projects • Document the project's design decisions with the SPIP
19	**Use Materials and Products that are Low-Embodied Carbon Alternatives**	• A project's GHG emissions should also consider its materials and products – their raw materials, manufacture, and shipping – referred to as "embodied carbon."	• Develop guidance for conducting LCCAs on materials and products and evaluating the feasibility of adopting low-embodied carbon alternatives • Leverage the Federal Low-Carbon Transportation Materials Grant to offset the premium cost of using products with low-embodied carbon • Develop standard specifications or guidelines that help project managers routinely identify feasible high-quality materials and products with low-embodied carbon content • Consider the use of Environmental Product Disclosures (EPDs) to facilitate decision making

Table 1: MTA's Strategies to Obtain NZGE

No.	Potential Strategy	Rationale	Actions
20	**Develop and Implement a Zero-Waste Plan**	• Waste disposed in a landfill or incinerator generates GHG emissions	• Develop a plan to help MTA maximize the amount of waste diverted from landfill and incineration disposal methods
21	**Invest in Carbon Offset Projects**	• Carbon offsets are projects that remove GHGs from the atmosphere and, from an accounting standpoint, compensate for remaining GHG emissions generated during agency operations • Tree planting and wetland restoration are common types of carbon offset projects	• Assess different types of offset projects and their efficacy of removing GHGs from the atmosphere • Identify the extent to which MTA should rely on offset projects in lieu of transportation investments to meet net-zero GHG mandates • Determine whether carbon offset projects would be most effective if implemented 1) by the State or a non-profit 2) within an urban area, in the State, or in a developing country

In 2020, the MTA commenced a two-phase Zero-Emission Bus Transition Study that evaluated facility upgrades, utility infrastructure, rolling stock, and charging infrastructure. Since then, the MTA has undertaken extensive work toward preparing charging infrastructure, developing workforce training and procedures, and procuring zero-emission buses.

In 2022, the MTA contracted for its first zero-emission buses; MTA took delivery of seven buses and commenced revenue service in January 2024. Utility upgrades have been completed to power vehicle chargers at the Kirk Bus Division and implementation of a training plan has begun across the Administration. Additionally, in the fall of 2022, the MTA advanced engineering and operational planning for the ZEB transition by issuing a Request for Proposal (RFPs) for a new multiyear zero-emission bus contract, a bus depot, support chargers, and an electrification partner to install and support chargers.

Approximately 5 to 10 percent of the U.S. transit fleet currently consists of ZEBs. Transit agencies will be implementing larger ZEB fleets in the immediate future, and agencies are facing fast learning curves as ZEBs are integrated into fleets. Technology advancements are beginning to improve vehicle efficiency, such as battery capacity, but testing and evaluation will take time.

Further, global supply chain issues will constrain delivery timeframes from vehicle and infrastructure manufacturers for the next few years. Vehicle production lead times, as well as charging infrastructure and utility support equipment, are strained by material sourcing delays and can be over 12 months. Transit agencies nationwide are concurrently placing large ZEB orders as ZEB fleets continue to grow nationwide.

As ZEB technology is constantly changing, warranty terms for buses and chargers are critical to ensure transit service to the Greater Baltimore region is not disrupted. Where possible, the MTA is preparing contingency plans to mitigate external risk factors, including vehicle and charger delivery delays.

Fleet Transition

The MTA developed a transition schedule for which facilities will be partially or entirely retrofitted to support ZEB deliveries. More detailed transition planning analysis is ongoing, which will yield a quarterly phasing of charging infrastructure installation and vehicle delivery.

Several initiatives are underway to advance the upcoming phases of MTA's ZEB transition. A Charge Management Study, completed in March 2022, provided detailed recommendations for how much energy will be consumed, how much on-site power is needed, and how many BEBs may be required to complete existing service requirements. The MTA's first full procurement of exclusively zero-emission buses was released for bids in the fall of 2022, with award to a bus manufacturer anticipated in 2023 to support vehicle deliveries from 2025 through 2028 (the contract will have extension options through 2030).

The MTA is also preparing to onboard a developer in 2023 to support the design, construction, operations, and maintenance of BEB charging infrastructure at Kirk and Northwest Divisions, in an innovative arrangement that will provide turnkey bus charging, allowing MTA's workforce to maintain focus on operating service and maintaining the bus fleet. For the Eastern Division, which will be reconstructed into one of the first bus divisions purpose-built for BEBs in the U.S., a construction manager for pre-construction services is anticipated to be brought on board in Spring 2023 to support construction activities.

Evaluation of Charging Infrastructure

MTA intends to provide all BEB charging at the operating divisions where buses are stored and maintained while not in revenue service. However, the Administration continues to evaluate in-route fast charging stations and the viability and value of installing these at certain locations within the region.

Overhead pantograph charging was determined to be the optimal charging infrastructure method for the BEB pilot and initial facility conversions at the MTA. In this type of charging, the pantograph on the bus is automatically deployed to begin charging when the

bus parks and the emergency brake is engaged. Overhead pantograph charging provides the fewest disruptions to the existing site, is the least restrictive to future modifications, and minimizes additions to operations and maintenance staff workloads. As transit agencies nationwide begin to scale up their BEB fleets, overhead pantograph dispensers are becoming increasingly selected among the larger transit agencies due to the benefits.

Utility Upgrades

New, large-scale electrical service will be required to install the new charging stations. The new loads are greater than 10 times the existing electrical loads at the sites and will require significant investments by the MTA to support electrical service upgrades to each facility. The voltage and capacity of that service will be determined by Baltimore Gas and Electric (BGE), according to the power demand required by the new equipment. The MTA will apply for this new service with BGE and during this process, BGE will review the available capacity on the overhead or underground circuits near the location and will present the available alternatives and options for installing the new service. Installation plans will be site dependent – while the enhancements required for the seven-bus Kirk BEB Pilot included a new utility pole, transformer, and conduit, as well as some earthwork to level land, larger load enhancements later in the transition may require significantly more construction work to accommodate the additional equipment and redundancy required to support larger BEB fleets. The MTA and BGE are coordinating on long-term energy load planning for all three divisions that includes the scaling of utility infrastructure based on anticipated demand. Optimizing utility infrastructure sizing to align with daily service requirements, as opposed to total connected load, that will never be fully used, may save millions of dollars in capital investment at each depot.

The MTA is continuing to evaluate alternate energy systems, such as solar energy and microgrids, to ensure the resilient power supply needed to maintain 24/7 transit operations. The MTA will collaborate with BGE and the Maryland Public Service Commission (PSC) to determine innovative solutions that are appropriate for this purpose. Alternative energy systems will allow the MTA to benefit from cost savings and will enable the MTA to have reliable power during times of the year when the local utility is straining to supply power to its customers, such as during heat waves or serious storms.

While hydrogen fueling infrastructure will not be used for initial ZEB facility conversions between 2025 and 2030, the MTA is conducting a study of optimal hydrogen fuel storage, delivery, and generation methods for its operating facilities to continue evaluating future opportunities for this technology. The MTA will be evaluating the results of this study in 2023 and may elect to conduct a pilot deployment of Fuel Cell Electric Buses (FCEBs) to test vehicle performance and fueling.

V. EMISSION REDUCTION GOALS & TARGETS

A. Zero-Emission Fleet Transition Estimate of Carbon Dioxide Reduction

Transitioning the MTA's bus fleet to ZEBs with a 50 percent fleet conversion to BEBs by 2030 will reduce carbon dioxide emissions by an estimated 483 million pounds over the lifecycle of BEB operations. This calculation was developed based on grid power supply assumptions and projected a partial transition to renewable sources by the existing utility provider. [6]

Upstream emissions include considerations of diesel production through conventional petroleum refining and supply to the region for diesel buses, and of the production of electricity, based on current grid power for BEBs (Maryland State Law, Code Public Utilities Sec. 7-703). [7]

Tailpipe emissions include estimates of CO2, NOX, SO X, PM10, PM2.5, and VOC for clean diesel vehicles, as well as PM10 and PM2.5 emissions attributed to brake and tire wear. For BEB emissions, the MTA has considered PM10 and PM2.5 attributed to brake and tire wear. Emissions data was derived from the U.S. Department of Energy's Alternative Fuel Life-Cycle Environmental and Economic Transportation model, the Argonne National Laboratory's Greenhouse Gases, Regulated Emissions and Energy Use in Transportation model, and the EPA MOVES 2014b model. Emissions were compared and refined to incorporate actual operational experience from comparable transit agencies. Resulting per-unit emissions values were applied to MTA's fleet and operating environment with considerations of average vehicle efficiency and annual miles.

B. Net-Zero GHG Emissions (NZGE) Action Plan Development Strategy

MTA has already started developing key features of the NZGE Action Plan by implementing the MTA Sustainable Transportation Program, especially by publishing its 2020 Sustainability Report and this document, the Roadmap to Development a NZGE Action Plan. The Plan will build from this work to fully understand high-level scope, cost, and schedule to meet the state's NZGE Target by 2045 (Figure 9).

[6] Maryland Zero Emission Bus Transition Act Legislative Report. December 2022.
[7] Maryland State Law, Code Public Utilities Sec. 7-703).

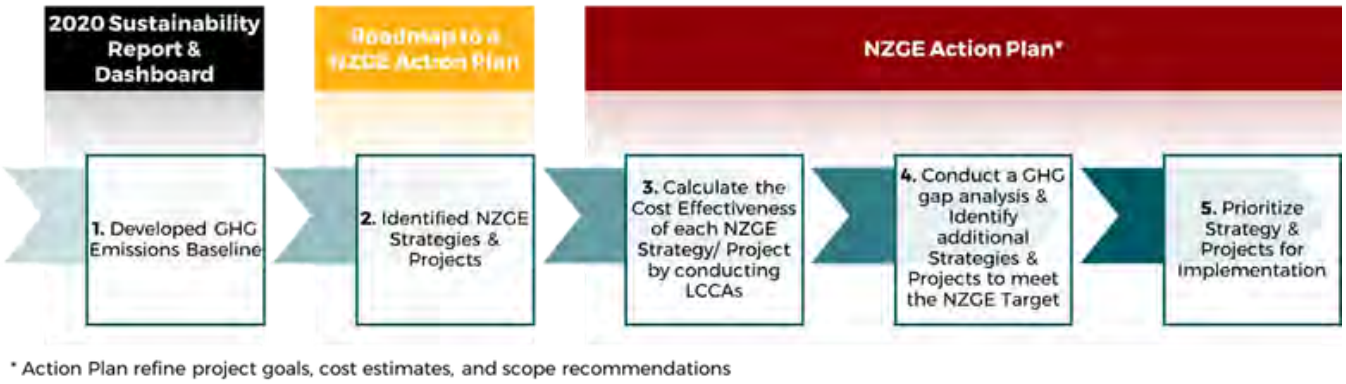


Figure 9: The NZGE Action Plan

After evaluating each strategy's lifecycle costs and carbon offset efficacy, MTA will be able to quantitatively understand how close the strategies bring MTA to its Net-Zero target, if completely implemented (Figure 10). The identified strategies may not completely achieve Net-Zero for MTA. Consequently, MTA may need to identify additional strategies that help bridge the potential gap, as well as assess their lifecycle costs and GHG offset capability.

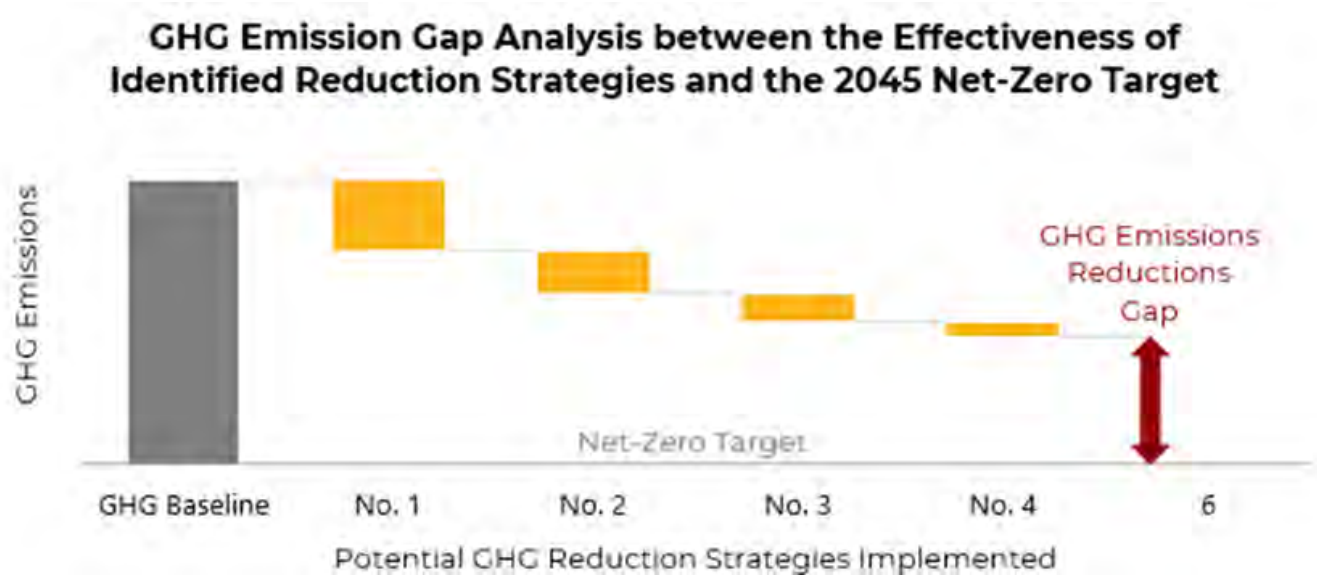


Figure 10: GHG Emission Gap Analysis

After MTA identifies the potential strategies that need to be implemented to achieve Net-Zero, MTA will then need to prioritize strategies and projects for implementation, as well as integrate those projects into its capital budget, also called the Consolidated Transportation Program (CTP).

Net-Zero strategies are frequently prioritized for implementation by cost effectiveness, which may be defined in two general ways:

- Lifecycle cost savings per ton of GHG emissions reduced.
- The amount of GHGs avoided from remaining in the atmosphere per dollar invested.

While GHG emission reduction strategies start as the most cost-effective, eventually the costs for implementing Carbon Offset strategies, implemented by a third party, reach parity. At this point, it becomes more cost effective to prioritize Carbon Offset strategies in lieu of GHG emission reduction strategies.

Other valuable factors to consider when establishing a prioritization method include, but are not limited to, asset management prioritization factors (e.g., safety, ridership, reliability, customer impact, condition), ease of implementation, and resource availability.
Not only do GHG reduction projects need to be prioritized within themselves, but MTA also needs to develop a process to routinely evaluate, integrate, and prioritize GHG reduction strategies within the CTP. Generally, MTA relies on its Asset Management Program to prioritize all its capital projects using the previously identified criteria, unless there's extenuating circumstances such as emergency repairs. However, the Asset Management Program's analytical capabilities constrain MTA's ability to continuously consider additional prioritization factors, such as GHG emissions. For example, the Asset Management Program indirectly reflects an asset's flooding vulnerability – if it's located within a flood map, then its useful life is reduced.

VI. MTA STRATEGIES FOR RESILIENCE

A. Potential Strategies & Actions

Table 2: MTA's Resilience Strategies & Actions

No.	Potential Strategy	Actions	Timeframe
1	**Verify/Update Vulnerable MTA Assets**	• Identify potential risks and vulnerabilities to transit infrastructure and services by conducting an updated vulnerability assessment with the latest available data • Identify and assess additional climatic hazards, such as extreme temperatures • Educate and inform personnel of updated vulnerability assessment	2023-2024
2	**Integrate Equity Considerations into Resiliency Planning & Programming**	• Identify specific categories of the population of MD transit customers that (1) may face a higher risk of disasters or climate change, related to the place they are living; (2) may have lower preparedness and coping capacity; (3) may have lower resilience/adaptation capacity because they lack access to economic and social support networks. • Identify and document Justice40 communities in relation to climatic vulnerabilities for targeted investment opportunities • Incorporate social vulnerability analysis and results into the updated vulnerability assessment • Utilize the STIIM tool, as appropriate for planning/programming	2022-2024
3	**Integrate Resiliency Into Asset Management**	• Explore and plan infrastructure retrofits to withstand extreme weather events by integrating resiliency into project prioritization • Develop and run a sensitivity analysis on integration of resiliency metrics into asset inventory/project prioritization • Identify cost and impacts to the agency's Capital Needs Inventory	2022-2025
4	**Provide Training & Education to Personnel**	• Conduct training sessions to educate personnel on resiliency, vulnerable assets, and impacts to project implementation	2024-2025

Table 2: MTA's Resilience Strategies & Actions

No.	Potential Strategy	Actions	Timeframe
5	**Incorporate Resiliency Into Emergency Operations Planning**	• Establish a working group with Emergency Operations personnel • Review existing plans, Standard Operating Procedures, protocols, etc. to identify ways to incorporate resiliency considerations	2025-2026
6	**Integrate Resiliency Into Project Planning**	• Form a Sustainability, Resiliency, and Equity (SRE) personnel team to review MTA projects • Develop a roadmap for resiliency efforts in the applicable phases of project development • Coordinate with other MTA modes/divisions within the agency to ensure acceptance of the revised project development process • Continuously monitor and evaluate effectiveness of project planning integration	2022-2025
7	**Increase External Collaboration**	• Engage external partners (Professional Organizations, Environmental Organizations, etc.) to remain up to date on current practices across the country • Connect with other transit agencies for peer reviews of resiliency programs • Engage with Local/City Governments where MTA assets are located • Strengthen ties with the academic community to review/assess recent tools, studies, research, etc. regarding resiliency	2023-2026+
8	**Identify and Implement Adaptation Measures**	• Review existing library of potential adaptation measures at the asset level • Incorporate new adaptation measures employed in Maryland and across the country that are applicable to MTA's assets	2024-2026+

Identification of Adaptation Strategies - Refining the ARToolbox

Adaptation measures should be considered for all MTA assets identified as “high” or “very high” risk. A variety of options may be suitable at a given asset location - a single adaptation measure will not effectively reduce climate change risk in every vulnerable location. Therefore, all types of solutions (long, mid, and short-term solutions) should be reviewed for applicability. In general, long-term solutions are considered to take the longest time/cost to implement, whereas short-term solutions are the shortest time/least expensive.

- **Long-Term Solutions** require the highest level of planning and design for implementation.
- **Mid-Term Solutions** require some level of design, approvals, etc.
- **Short-Term Solutions** are considered relatively easy to implement and little to no design efforts required.

MTA's ARToolbox includes a variety of potential adaptation/resiliency measures in the long-,mid-, and short-term timeframes that may be employed at assets classified as "high" or "very high risk." Measures can be viewed by mode/division or by solution.

B. Implementation & Monitoring

MTA will regularly update the Vulnerability Report as the climate change data is updated. For example, the vulnerability mapping includes sea level rise data from National Oceanic and Atmospheric Administration, hurricane surge data from US Army Corps of Engineers, flooding data from Federal Emergency Management Administration, and MTA asset management inventory.

In addition to MTA Vulnerability Report updates, MTA continues to update the ARToolbox to continually aid decision making in planning, design of projects, and emergency preparedness for each mode and division within the agency. Yearly updates include evaluating current resiliency tools, equity, funding opportunities, case studies, and resources.

VII. CONCLUSION

MTA's CAP responds to FTA's voluntary third phase of the Sustainable Transit for a Healthy Planet Climate Challenge. This Plan also documents the regional transit system's impact on reducing GHGs from the transportation system, regional GHGs, and heat related health outcomes and the role that transit can play in the mitigation of climate impacts in Maryland. As temperatures in Maryland continue to affect the lives of our riders, MTA will support national and local climate goals through the vision and strategies identified in this Plan.

Through MTA initiatives aligning with existing regulations, plans and current studies,MTA will continue to develop, track, and monitor the implementation of action Items aimed at reducing GHG emissions from transit, reducing regional GHG emissions and increasing heat resiliency. MTA looks forward to sharing our growth and achievements with the our constituents via transparent platforms such as the ARToolbox, STIIM, and Zero Emissions publications and website.