Appendix B: Strategy Definitions and Assumptions

2031 Committed Strategies and Policies

The 2031 Committed Strategies and Policies include the collection of all strategies that are currently projected to take place by 2031. This set of strategies and policies represents emission reductions based on Greenhouse Gas (GHG) trends and vehicle miles traveled (VMT) forecasts for 2031, and additional measures that the Maryland Department of Transportation (MDOT) has already committed to with plans, programs and business-as-usual investment levels and funding allocations. They can be explained as two parts: Standards and Current VMT Growth (SCVG) and Strategies in Progress (SP). SCVG includes federal and state fuel economy and vehicle technology standards such as the Corporate Average Fuel Economy (CAFE) and rollback of the Safer Affordable Fuel-Efficient (SAFE) rule that are projected to decrease on road emissions below the 2022 starting point by 2031. More details about SCVG can be found in Appendix A. SP includes the emission reductions that can be attributed to the implementation and continuation of strategies that reduce VMT growth, improve transportation system performance and increase sales of ZEVs in the state of Maryland. These strategies have documented funding availability, primarily through the Consolidated Transportation Program (CTP), or are mandates that original equipment manufacturers are expected to follow.

Strategies in Progress (SP)

SP evaluates the emission reductions from funded projects and programs. This includes projects and programs in the CTP, land development assumptions consistent with local plans and Maryland Department of Planning (MDP) goals and GHG reducing projects included in fiscally constrained Metropolitan Planning Organization (MPO) Metropolitan Transportation Plans.

2031 MPO Plans and Programs

Strategy Description

The 2031 MPO Plans and Programs (P/P) scenario or strategy represents the implementation of the most recently adopted MPO Transportation Improvement Program and fiscally constrained long-range transportation plans (LRTP). The VMT projections for implementing the plans and programs include MPO planned projects (highway and transit) and future regional demographic projections developed by the jurisdictions in cooperation with the MDP. So, the 2031 P/P scenario includes modeled VMT and emissions outcomes from the implementation of the most recent MPO fiscally constrained long-range transportation plans and cooperative land use forecasts.

Key Assumptions

VMT growth for fiscally constrained plans and programs reflects the most recent available assumptions from MPO long-range plans (consistent with adopted LRTPs and recent amendments) and an updated VMT growth trend for counties outside MPO areas (consistent with Highway Performance Monitoring System data). In the 2020 analysis, the business-as-usual VMT growth trend (based on 1990-2017) was 1.2% annually, and the resulting 2031 P/P growth rate is 0.6% annually. In this analysis, the business as usual/reference VMT growth trend was 2.0% annually, and the resulting 2031 P/P growth rate is 1.1% annually. Using the MPO forecast, Maryland is expected to show a decrease of ***4,725 billion VMT in 2031*** relative to the reference case VMT forecast.

Emissions Reduction Estimate Change from the 2020 Greenhouse Gas Reduction Act Plan

There is a slight decrease of 0.2 million metric tons (mmt) of carbon dioxide equivalents (CO2e) when comparing the 2023 Climate Pollution Reduction Plan (CPRP) estimate to the 2020 Greenhouse Gas Reduction Act (GGRA) Plan estimate (see **Table 1**). This slight decrease can be attributed to impacts to travel activity associated with the COVID-19 pandemic which has affected VMT and transit ridership projections in subsequent years. On the other hand, these renewed investments in sustainable transportation at the federal level (e.g., Infrastructure Investment and Jobs Act (IIJA) and Inflation Reduction Act) and state level (e.g., the Climate Solutions Now ACT (CSNA)) offset this decrease partly through new and improved strategies like the transition to zero-emission school buses and an increase in electric vehicle (EV) charging infrastructure. Together, these changes resulted in lower projected emissions reductions in the transportation sector for the state of Maryland compared with the 2020 GGRA estimate.

Table 1: Comparing 2023 CPRP and 2020 GGRA Plan Emissions Reduction Estimate

Metric	2023 CPRP Estimate for 2031	2020 GGRA Plan Estimate for 2030
Annual Emission Reductions	1.53 mmt CO2e	1.71 mmt CO2e

On-Road Technology

Strategy Description

This strategy includes the continuation of the MDOT State Highway Administration's (SHA) Coordinated Highways Action Response Team (CHART) program, Smart Traffic Signals within the Traffic Relief Plan, and ongoing implementation of SHA's Transportation Systems Management and Operation (TSMO) Strategic Plan (2018) and TSMO Master Plan, which will expand the scope and coverage of advanced traffic management and information systems across Maryland roadways. These technologies help manage incidents and reduce congestion through traffic monitoring, incident management, travel information, communications, and traffic management.

Key Assumptions

Based on the existing coverage and effectiveness of CHART in the areas of incident response, and other streamlined operations the total annual emission reductions are estimated based on existing rates of coverage and effectiveness from CHART's 2021 annual report and all previous reports back to 2012. The annual delay reduction in hours was for cars and trucks and daily carbon dioxide reduction from each of these annual reports was used along with the annual VMT from MDOT's annual Attainment Reports for each year to create a trend of the percent

of delay reduction hours per VMT for each year. This percentage was used to estimate the annual delay reduction hours based on the 2031 projected VMT for the state. Annual emissions reductions of the delay reduction hours were then determined based on the emission rates of vehicles in 2031.

Furthermore, it is assumed that restricted access highways are currently covered under CHART. Thereafter, a range of increases in coverage is assumed based on a low deployment scenario relevant to SP. Under this low deployment scenario, there is a 35% expansion of CHART coverage of urban arterials and a 15% expansion of CHART of rural unrestricted access roadways.

Emissions Reduction Estimate Change from 2020 GGRA Plan

The new CPRP reduction estimate represents a decrease of 0.053 mmt CO2e due to changes in emission factors and flattening VMT from COVID-19 impacts (see Table 2). The calculation methodology for this strategy did not change; just the aforementioned inputs like VMT projections and emissions factors changed.

Table 2: Comparing On-Road Technology Emissions Reductions Estimates

Metric	2023 CPRP Estimate for 2031	2020 GGRA Plan Estimate for 2030
Annual Emission Reductions	0.089 mmt CO2e	0.14 mmt CO2e

Freight and Freight Rail Programs

Strategy Description

Implementation of the CSX National Gateway, Howard Street Tunnel, and Seagirt Marine Terminal Modernization provides new capacity and eliminates freight bottlenecks for access to the Port of Baltimore and across Maryland.

Key Assumptions

The opening of the Howard Street Tunnel to double stack rail service by 2031 will support increased rail throughput to the Port of Baltimore, helping to reduce truck VMT and reduce freight rail congestion. Assumptions for truck VMT reductions and freight rail emissions savings are consistent with assumptions in prior Commuter Connections Transportation Emission Reduction Measures of the Metropolitan Washington Council of Governments (MWCOG) analysis of the CSX National Gateway program. The Seagirt Marine Terminal Berth 3 Modernization P3 Project VMT reduction is based on the project plan's assumptions through 2031 and subtracted the out-of-state (Pittsburgh) VMT reduction.

Emissions Reduction Estimate Change from 2020 GGRA Plan

The updated GHG emission reduction estimate's increase of 0.16 mmt CO2e is due to the addition of the Seagirt Marine Terminal Modernization Project since the GGRA (see Table 3).

Table 3: Comparing Freight and Freight Rail Programs Emissions Reductions Estimates

Metric	2023 CPRP Estimate for 2031	2020 GGRA Plan Estimate for 2030
Annual Emission Reductions	0.19 mmt CO2e	0.037 mmt CO2e

Public Transportation (New Rail or Bus Capacity or Frequency & Improved Operations)

Strategy Description

This strategy includes projects designed to increase public transit capacity, improve operations and frequency, and new Bus-Rapid-Transit (BRT) corridors not included in MPO modeling in the 2031 P/P scenario. This includes North Avenue Rising, MD 355/MD586/US29 BRT in Montgomery County, Maryland Area Rail Commuter (MARC) Growth and Investment Plan Build-Out, and the Purple Line.

Key Assumptions

This strategy addresses benefits from projects not explicitly modeled in the MPO plans, based on preliminary ridership estimates from planning or alternatives analysis/environmental studies. MARC capacity/service improvements are from the Growth and Investment Plan Build-Out through 2031 based on historic ridership trends (ending in 2019 to exclude ridership anomalies during the pandemic). North Avenue Rising and the Purple Line are both assumed to have no induced ridership growth and, therefore no VMT reduction (based on published analysis). BRTs assume average trip lengths of 5.5 miles based on the American Public Transit Association's (APTA) average trip length[1] for all modes. Baltimore Link and Maryland Transit Administration (MTA) Commuter Bus service expansions are accounted for in MPO plans through the 2031 P/P strategy.

Emissions Reduction Estimate Change from GGRA Plan

There is no change in this measure. The annual emissions reductions for this strategy are due to limited new information on VMT impacts for these projects (see Table 4).

Table 4: Comparing Public Transportation Operations Emissions Reductions Estimates

Metric	2023 CPRP Estimate for 2031	2020 GGRA Plan Estimate for 2030
Annual Emission Reductions	0.011 mmt CO2e	0.011 mmt CO2e

Public Transportation (56% EV Transit Bus Fleet)

Strategy Description

This strategy includes anticipated fleet updates to both, the MTA and Washington Metropolitan Area Transit Authority (WMATA) bus fleets by 2031. The strategy makes use of the current MTA fleet turnover schedule that is anticipated to establish a 56% electric bus fleet by 2031. It also utilizes the WMATA 2021 Fleet Management Plan, which anticipates that 31% of its bus deliveries will be electric vehicles between 2021 and 2031.

Key Assumptions

MTA is projected to purchase only battery electric buses (BEBs) starting in 2025 to replace aging fleet vehicles and procure clean diesel buses in the preceding years. About 70 new BEBs will be purchased each year through 2031 replacing existing hybrid and diesel buses, totaling 567 total BEBs in their fleet. According to their 2021 Fleet

[1] American Public Transit Association (APTA) 2017 Public Transportation Fact Book https://www.apta.com/wp-content/uploads/2017-APTA-Fact-Book.pdf

Management Plan, WMATA is purchasing 387 BEBs between 2023 and 2031 and 550 compressed natural gas (CNG) powered buses to replace current hybrid and CNG powered buses. To determine the impact of these BEBs and CNG powered buses, it is assumed that buses travel an average of 39,870 miles per year, which is the predicted 2031 P/P scenario transit bus VMT per vehicle using Motor Vehicle Emission Simulator (MOVES3). The fuel emissions rates in CO2e per mile for diesel, hybrid, and CNG powered buses are based on the 2031 P/P scenario as well. For both WMATA and MTA, it also assumed that for the buses that are converting from traditional diesel to new, clean diesel 3,000 gallons of diesel are saved each year per bus and that 22.38 lbs. of CO2e are emitted into the atmosphere for each gallon of diesel combusted. Finally, it is assumed that a third of the WMATA emissions reductions can be attributed to Maryland.

Emissions Reduction Estimate Change from 2020 GGRA Plan

Compared to the 2020 GGRA Plan Estimate, the 2023 CPRP estimate has decreased by about 0.018 mmt CO2e due to previously assuming a more aggressive transition to zero-emissions buses (see Table 5). This less aggressive transition to zero-emission buses, and not any calculation changes, resulted in a decrease in the emission reduction estimate.

Table 5: Comparing Public Transit Electrification Emissions Reductions Estimates

Metric	2023 CPRP Estimate for 2031	2020 GGRA Plan Estimate for 2030
Annual Emission Reductions	0.055 mmt CO2e	0.074 mmt CO2e

Intercity Transportation Initiatives

Strategy Description

This strategy assumes an increase in Amtrak Northeast Corridor ridership in Maryland that leads to VMT reductions in 2031 as automobile trips are replaced with intercity train trips.

Key Assumptions

It is assumed that Amtrak ridership will recover to 2.47 million boardings per year, above pre-COVID ridership, but less than the previous estimate from the GGRA. The baseline ridership using all years of ridership from 2013 to 2021 predicts 2.29 million boardings in 2031. The difference between these two is assumed to lead to a reduction in VMT of 12.93 million (assuming that each boarding is replacing a 70 VMT). This VMT reduction translates to 0.00326 mmt CO2e reduction based on the predicted emission rate of 252 g CO2e per mile, which is anticipated in 2031 for light-duty vehicles.

Emissions Reduction Estimate Change from 2020 GGRA Plan

There is a slight decrease of .0029 mmt CO2e due to reduced Amtrak ridership from the COVID-19 pandemic and because emissions reductions from the MARC Growth and Investment Plan were removed. (see

Table 6). The only change in methodology for estimating emissions reductions for this strategy was the removal of emissions reductions associated with the MARC Growth and Investment Plan.

Table 6: Comparing Intercity Transportation Emissions Reductions Estimates

Metric	2023 CPRP Estimate for 2031	2020 GGRA Plan Estimate for 2030
Annual Emission Reductions	0.0033 mmt CO2e	0.0061 mmt CO2e

Transportation Demand Management (TDM)

Strategy Description

This strategy includes many TDM strategies that reduce VMT. These include the MWCOG programs like Guaranteed Ride Home, Employer Outreach, Integrated Rideshare, Commuter Operations and Ridesharing Center, Telework Assistance, and Mass Marketing; MTA programs including MTA Transportation Emission Reduction Measures, MTA CharmPass FareShare; the Transit Store in Baltimore; and MDOT MTA and SHA Park and Ride.

Key Assumptions

The daily reduction in VMT for many of these programs is included in MDOT's annual Attainment Reports stretching back from 2013 to 2022. The MTA CharmPass FareShare, which began recently after the start of the COVID-19 pandemic, only has VMT reduction data for 2022. This VMT reduction was included in the 2023 analysis while the MTA College Pass and Commuter Choice Maryland Pass were removed from the analysis as they have not been reported in the Attainment Reports since 2017 and are no longer in use. VMT reduction was not reported for CharmPass, so it was assumed that it would have a similar VMT reduction to the Commuter Choice Pass. Therefore, the daily reduction in VMT was kept the same as the last report for Commuter Choice Maryland Pass. Finally, the MWCOG programs only attribute 49% of their VMT reductions to the state, so VMT reductions that could be occurring in Virginia, or the District of Columbia are not included.

For each year, from 2013 to 2022, these VMT reduction values are compared to the observed VMT for that year to determine what percentage of reduction the TDM programs represent. This percentage has increased over time from 0.70% in 2008 to 0.96% in 2021. Using this trend, it is predicted that all the TDM programs will decrease VMT by 1.05% in 2031. Then, the predicted VMT for the state based on the P/P scenario in 2031 is utilized to determine what the 1.05% reduction in VMT means in terms of 2031 VMT. This multiplication yields a projected VMT reduction due to the TDM programs.

Emissions Reduction Estimate Change from 2020 GGRA Plan

There is a slight increase in the emissions reduction estimate of .02 mmt CO2e (see Table 7). The estimate has changed due to several factors including a higher VMT reduction than the 2030 estimate, a lowered emission factor, the addition of MDOT MTA and SHA Park and Ride, and the transition from MTA College Pass and Commuter Choice Pass to MTA CharmPass. The overall methodology to calculate the emissions reductions remains unchanged, but these many inputs changed to affect the overall estimate.

Table 7: Comparing TDM Emissions Reductions Estimates

Metric	2023 CPRP Estimate for 2031	2020 GGRA Plan Estimate for 2030
Annual Emission Reductions	0.17 mmt CO2e	0.15 mmt CO2e

Pricing Initiatives (Electronic Tolling)

Strategy Description

The planned conversion of all Maryland Transportation Authority (MDTA) toll facilities to all-electronic tolling by 2030 was completed ahead of schedule in 2021 due to the COVID-19 pandemic. However, this is being kept as a strategy due to ongoing maintenance and continued GHG reduction benefits. GHG emissions reduction is associated with a reduction in idling at toll plazas.

Key Assumptions

The reduction in idling at toll plazas is estimated based on an assumed average of 1 minute per transaction. This is applied to the share of transactions in the light-duty vehicle (LDV) and heavy-duty vehicle (HDV) fleet to come up with total avoided emissions.

Emissions Reduction Estimate Change from 2020 GGRA Plan

The small decrease of .0079 mmt CO2e from the 2020 GGRA Plan Estimate of avoided emissions is due to COVID-19 impacting the predicted annual growth rate in total toll transactions (see Table 8) and does not result from any change in methodology.

Table 8: Comparing Pricing Initiatives Emissions Reductions Estimates

Metric	2023 CPRP Estimate for 2031	2020 GGRA Plan Estimate for 2030
Annual Emission Reductions	0.015 mmt CO2e	0.022 mmt CO2e

Bicycle and Pedestrian Strategies

Strategy Description

This strategy assumes VMT reductions due to the availability of bicycle facility lane miles and improved bicycle level of traffic stress (LTS) consistent with existing and planned infrastructure improvements, repaving, and new facilities highlighted in the CTP and projected based on historical efforts to improve the number of directional miles.

Key Assumptions

This strategy assumes that roads with a bicycle LTS of 1, 2, or 3 support trips on bicycles instead of motor vehicles. LTS ranges from 1 to 4 with 1 applying to bicycle infrastructure that is comfortable for all ages and abilities, 2 being comfortable for most adults, and 3 being comfortable for confident cyclists. LTS 4 bicycle infrastructure is uncomfortable for most, so it is not assumed to yield any mode shift from motor vehicles to bicycles.

The Maryland network of roads that are given a bicycle LTS of 1, 2, or 3 was taken from the Maryland Bicycle LTS map[2] from the ArcGIS Hub for Maryland. All of these segments were added up to determine the total number of

[2] Maryland Bicycle Level of Traffic Stress (LTS), ArcGIS Online for Maryland https://hub.arcgis.com/datasets/maryland::maryland-bicycle-level-of-traffic-stress-lts/explore

segments of bicycle infrastructure that could support bicycle trips that would place cars. As of the start of 2023, this was a total of 4,088 miles in the state of Maryland.

To predict the number of miles of LTS 1, 2, or 3 bicycle infrastructure there should be in 2031, a trend of the number of miles of improvements was collected and projected forward to 2031. Maryland will likely improve more than 600 miles of bicycle infrastructure in 2023 to one of these levels and continue to make additional investments each year through 2031. By this year, there is expected to be about 12,000 miles of LTS 1, 2, or 3 bicycle infrastructure in Maryland.

To determine just how many trips away from automobiles and on bicycles, these projected 12,000 miles of bicycle infrastructure will support in 2031, a methodology created by the California Air Resources Board (CARB) was utilized. This methodology[3] calculates VMT reductions from automobiles as a function of the days per use per year (the default is 200 days), annual average two-way daily vehicular traffic on parallel roads, an adjustment factor, an activity center credit, and bike trip length (1.8 per miles per direction is the default).

For 2031, the default 200 days was utilized, an adjustment factor of 0.0027318, which is the average for all segments with the 2023 segment data based on their annual average daily traffic (AADT) and project length, and an average activity center credit of 0.001 (the activity center that applies if 3 activity centers are within a quarter mile of the segment or if 3 to 7 activity centers are within a half mile of the segment). Then, it is assumed that the 12,000 miles of bicycle infrastructure projects for 2031 consist of 12,000 one-mile segments and that the annual average two-way daily vehicular traffic on the parallel road (AADT) for these segments is 6,830. Finally, the average bike trip length is assumed to be 1.8 miles (which is what was assumed in the CARB study).

Emissions Reduction Estimate Change from 2020 GGRA Plan

There is a slight increase of .010 mmt CO2e from the 2020 estimate due to changes in calculations due to the switch from bicycle level of comfort (LOC) to LTS (see Table 9). The changes from LOC to LTS forced a complete overhaul of the methodology, which greatly impacted the calculations.

Table 9: Comparing Bicycle and Pedestrian Strategies Emissions Reductions Estimates

Metric	2023 CPRP Estimate for 2031	2020 GGRA Plan Estimate for 2030
Annual Emission Reductions	0.033 mmt CO2e	0.024 mmt CO2e

Port of Baltimore Drayage Truck Replacements

Strategy Description

This strategy estimates the emissions benefit of replacing 525 total dray trucks resulting from the Maryland Department of Energy (MDE), MDOT, and Federal grants through 2031, which is based on the current replacement rate.

[3] Equation 1 in Quantifying Reductions in Vehicle Miles Traveled from New Bike Paths, Lanes, and Cycle Tracks, California Air Resources Board, 2019 https://ww2.arb.ca.gov/sites/default/files/auction-proceeds/bicycle_facilities_technical_041519.pdf

Key Assumptions

Consistent with the current program status and recent EPA grant award, the Port of Baltimore is on track to turn over 525 heavy-duty diesel dray trucks by 2031.

Emissions Reduction Estimate Change from 2020 GGRA Plan

There is a slight change in estimated emissions reductions because the few dray trucks are expected to turn over by 2031. For the 2020 GGRA, it was assumed that 600 trucks would turn over, and now 525 trucks are expected to turn over (see Table 10).

Table 10: Comparing Drayage Truck Emissions Reductions Estimates

Metric	2023 CPRP Estimate for 2031	2020 GGRA Plan Estimate for 2030
Annual Emission Reductions	0.0046 mmt CO2e	0.0053 mmt CO2e

BWI Airport Parking Shuttle Replacements

Strategy Description

This strategy involves the replacement of Baltimore/Washington International (BWI) airport parking shuttles either with clean diesel buses or with electric buses. It is assumed that 40 diesel buses will be replaced with clean diesel and that 8 diesel buses will be replaced with 8 electric vehicle (EV) buses by 2031.

Key Assumptions

It is assumed that 40 buses will be converted to clean diesel and therefore save 3,000 gallons of diesel per bus per year compared to the existing diesel buses. It is also assumed that eight diesel buses will be replaced with electric buses, which will eliminate tailpipe emissions from these buses. About 6,000 gallons of diesel per bus per year will be eliminated due to the introduction of electric buses assuming buses travel about 40,000 miles per year and have a current fuel economy of just over six miles per gallon. So, overall, the 40 diesel buses will save 120,000 gallons of diesel per year and the eight electric buses will save about 50,000 gallons per year. Assuming that each gallon of diesel emits 22.38 pounds of CO2e, the fleet transition will save about 0.0017 mmt CO2e in 2031.

Emissions Reduction Estimate Change from 2020 GGRA Plan

There was a slight increase of .0014 mmt CO2e in the estimated emissions reduction due to the changes associated with the updated program; previously BWI was only replacing shuttles with clean diesel and not electric buses (see Table 11).

Table 11: Comparing BWI Parking Shuttle Emissions Reductions Estimates

Metric	2023 CPRP Estimate for 2031	2020 GGRA Plan Estimate for 2030
Annual Emission Reductions	0.0017 mmt CO2e	0.0003 mmt CO2e

MDOT Fleet Electrification

Strategy Description

MDOT is in the process of converting its non-revenue passenger vehicles fleet to ZEVs. SP focuses on the passenger vehicle fleet only, while Potential New Initiatives (PNI) focuses on the heavy-duty vehicle fleet.

Key Assumptions

This strategy assumes ZEV conversion of the 1,771 MDOT non-revenue passenger vehicles that are currently in service by 2031, each averaging a traveling distance of 12,500 miles per year.

Emissions Reduction Estimate Change from 2020 GGRA Plan

There has been no significant change in the estimation since 2020. The small reduction of .0004 mmt CO2e is due to an updated number of MDOT passenger vehicles with potential for conversion since 2020.

Table 12: Comparing MDOT Vehicle Fleet Emissions Reductions Estimates

Metric	2023 CPRP Estimate for 2031	2020 GGRA Plan Estimate for 2030
Annual Emission Reductions	0.0056 mmt CO2e	0.006 mmt CO2e

EV Programs & Policies (NEVI Formula Funding)

Strategy Description

The National Electric Vehicle Infrastructure (NEVI) Formula Program[4] is a recent federal program to deploy direct-current fast chargers (DCFC) along Alternative Fuel Corridors (AFC). The program was established by the Bipartisan Infrastructure Law, enacted as the IIJA in 2021. The state of Maryland will receive approximately $60M for the program in FY 2023 through 2027 to add DCFC along with AFC.

Key Assumptions

The emissions reduction benefits of NEVI were included in the EV adoption scenario. To avoid double counting emission benefits for this strategy, the estimated emissions benefits have been documented here, but should not be considered additive to the EV adoption scenario. This earmarked emissions estimate assumes a 50-site AFC build-out, with the required 4 chargers per site, resulting in the installation of 200 DCFCs. The estimate was calculated using the Argonne, LLC AFLEET Charging and Fueling Infrastructure Emissions Tool, v1.1, which was released on April 3, 2023. The tool does account for emissions resulting from the use of electricity and assumes the source of electricity (electricity mix) falls within the Reliability First (RF) region, identified in the tool as Region 7. The calculations were performed under the tool's high utilization scenario, which assumes 867 ZEVs will use each station per year.

[4] NEVI Program, Alternative Fuels Data Center https://afdc.energy.gov/laws/12744

Emissions Reduction Estimate Change from 2020 GGRA Plan

There was no estimate in 2020 since this is a new strategy; however, the current emissions reduction estimate is 0.007 mmt CO2e.

Zero-Emission School Buses

Strategy Description

The CSNA requires county boards of education to only purchase zero-emission school buses after October 1, 2024. County boards of education must comply with this requirement unless MDE determines there are no zero-emission vehicles (ZEV) that meet their performance requirements, or the board cannot acquire sufficient funding to cover the incremental cost of purchasing a ZEV. Given this requirement, it is projected that the percentage of school buses that are ZEVs will increase greatly in the state by 2031.

Key Assumptions

This strategy assumes that starting in 2025, 75% of new school bus purchases will be electric, replacing the current diesel, gasoline, gasoline flex, and propane fleet. The strategy also includes the 326 additional electric school bus purchases by 2025 that Montgomery County[5] is planning to purchase. With these two assumptions included, 37 percent of school buses are expected to be electric by 2031 since school buses are assumed to have a useful life of 15 years[6]. Finally, it is assumed that the average annual VMT of school buses is 12,000 for each bus[7].

Emissions Reduction Estimate Change from 2020 GGRA Plan

There was no estimate in 2020 since this is a new strategy; however, the current emissions reduction estimate is 0.046 mmt CO2e.

Carbon Reduction Program

Strategy Description

IIJA established the Carbon Reduction Program (CRP), which provides funds for projects designed to reduce transportation emissions, defined as CO2e emissions from on-road highway sources. Maryland will receive approximately $94M between FY 2022 – 2026. It has not been determined how this money will be invested in the SP strategies.

Key Assumptions

MDOT created an illustrative "Preferred Strategies Investment Portfolio" after reviewing strategies and their cost-effectiveness. The following percentages for each strategy were chosen as an early assumption for the CRP investment:

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[5] Montgomery County School District https://ww2.montgomeryschoolsmd.org/press/index.aspx?pagetype=showrelease&id=10547

[6] Rousch Cleantech https://www.roushcleantech.com/fuel-fact-check-do-propane-school-buses-actually-have-a-shorter-lifespan/#:~:text=There%20are%20different%20factors%20to,is%2012%20to%2015%20years.

[7] Average Annual Vehicle Miles Traveled by Major Vehicle Category, AFDC https://afdc.energy.gov/data/widgets/10309

- On-Road Technology (CHART) (20%)
- Freight and Freight Rail Programs (10%)
- Public Transportation (10%)
- Electrified Transit (20%)
- Transportation Demand Management (10%)
- Bicycle and Pedestrian Strategies (10%)
- Drayage Truck Replacements (20%)

Emissions Reduction Estimate Change from 2020 GGRA Plan

There was no estimate in 2020 since this is a new strategy; however, the current emissions reduction estimate is 0.038 mmt CO2e based on the Preferred Strategies Investment Portfolio.

Strategy, Emissions and Cost Summary for SP Strategies

Table 13: Summary of Emissions and Cost for Each SP Strategy

Strategies	2031 Estimate (mmt CO2e)	2031 Total Estimated Costs ($M)	2031 Total Estimated Costs per Reduction ($M per mmt CO2e)
EV Projections***	3.055	0	*N/A*
2031 P/P Yield Lower Annual VMT Growth	1.53	12,380	8,091
Freight and Freight Rail Programs	0.19	783	4,122
Transportation Demand Management	0.17	80	470
On-Road Technology	0.089	265	2,973
Public Transportation (56% EV Transit Bus Fleet)	0.055	1,170	21,278
Zero-Emission School Buses	0.046	*50**	*N/A*
Carbon Reduction Program	0.038	94	2,483
Bicycle and Pedestrian Strategies	0.033	575	17,409
Pricing Initiatives (Electronic Tolling)	0.015	288	19,227
Public Transportation (New Rail or Bus Capacity or Frequency & Improved Operations)	0.011	3,896	354,191
EV Programs & Policies (NEVI Formula Funding)	0.007**	*63*	*N/A*
MDOT Fleet Electrification	0.0056	0	*N/A*
Port of Baltimore Drayage Truck Replacements	0.0046	13	2,891
Intercity Transportation Initiatives	0.0033	0	*N/A*
BWI Airport Parking Shuttle Bus Replacements	0.0017	38	22,176
Total	5.25	19,645	3,744

*Costs not included in the total, **GHG reduction estimate not included in the total

Potential New Initiatives

The PNI scenario acknowledges that attaining the 2031 goal will require additional investments to expand or accelerate the deployment of previously planned strategies, deployment of new best-practice strategies, and capitalizing on the opportunities created by new transportation technologies. All of the strategies in this scenario require additional funding and, in some cases, private sector commitment. The 25 strategies in this scenario (20 emerging and 5 innovative) represent a combination of approaches to reduce GHG emissions with varying levels of confidence and MDOT authority.

EMERGING STRATEGIES

TSMO/Integrated Corridor Management (Limited Access System)

Strategy Description

This strategy includes the continuation of MDOT SHA's CHART program, Smart Traffic Signals within the Traffic Relief Plan, and ongoing implementation of SHA's TSMO Strategic Plan (2018) and TSMO Master Plan, which will expand the scope and coverage of advanced traffic management and information systems across Maryland roadways. These technologies help manage incidents and reduce congestion through traffic monitoring, incident management, travel information, communications, and traffic management.

Key Assumptions

Based on the existing coverage and effectiveness of CHART in the areas of incident response, and other streamlined operations, the total annual emission reductions are estimated based on existing rates of coverage and effectiveness from CHART's 2021 annual report and all previous reports back to 2012. The annual delay reduction in hours and daily CO2e reduction from cars and trucks listed in the annual reports was used along with the annual VMT from the Attainment Report for each year to create a trend of the percent of delay reduction hours per VMT for each year. This percentage was used to estimate the annual delay reduction hours based on the 2031 projected VMT for the state. Annual emissions reduction of the delay reduction hours was then determined based on the emission rates of vehicles in 2031.

For this strategy, it is assumed that restricted access highways in urban areas are currently covered under CHART (in the absence of a detailed breakdown of VMT and deployment data by roadway facility types). In SP, the on-road technology strategy assumes an increase in CHART coverage of 15% for rural limited-access roadways. This strategy increased the assumption to a 100% increase in rural limited access roadways under this high deployment scenario.

Partners for Implementation

CHART is operated under the Office of Transportation Mobility and Operations (OTMO), which is a subdivision of SHA. So, in order to expand CHART coverage and other initiatives of the TSMO Strategic Plan, cooperation with SHA is critical, especially with OTMO.

Emissions Reduction Estimate Change from 2020 GGRA Plan

There is a small increase in emission reduction numbers due to a change in the horizon year from 2030 to 2031.

Table 14: Comparing 2023 CPRP and 2020 GGRA Plan Emissions Reduction Estimate

Metric	2023 CPRP Estimate for 2031	2020 GGRA Plan Estimate for 2030
Annual Emission Reductions	0.08 mmt CO2e	0.077 mmt CO2e

TSMO/Integrated Corridor Management (Arterial System)

Strategy Description

This strategy assumes corridor management, intelligent transportation systems, or advanced traffic management systems are in place on all urban arterials. This strategy also estimates the impact of expanded CHART coverage on urban and rural arterials.

Key Assumptions

Only urban arterials are being assumed to be covered as part of the strategy through 2031. CHART is expanded such that urban arterials have 75% CHART coverage (beyond the 35% coverage assumed in SP) and rural arterials have 25% CHART coverage. The Federal Highway Administration's "Travel and Emissions Impacts of Highway Operations Strategies" final report, under final completion by Cambridge Systematics, and the work of MWCOGs multisector working group (as documented in the January 2016 report) are used to support this analysis. The most similar program in the 2023-2028 CTP is CHART, which is funded by 60% Federal, and 40% State. The same share is assumed for this comparable/extended strategy. 2020 costs are indexed to inflation.

Partners for Implementation

CHART is operated under the OTMO, which is a subdivision of SHA. So, to expand CHART coverage and other initiatives of the TSMO Strategic Plan, cooperation with SHA is critical, especially OTMO.

Emissions Reduction Estimate Change from 2020 GGRA Plan

There is an increase in emission reduction numbers due to a change in the horizon year from 2030 to 2031 and from additional emissions reductions from the expansion of CHART coverage to urban and rural arterials.

Table 15: Comparing 2023 CPRP and 2020 GGRA Plan Emissions Reduction Estimate

Metric	2023 CPRP Estimate for 2031	2020 GGRA Plan Estimate for 2030
Annual Emission Reductions	0.15 mmt CO2e	0.100 mmt CO2e

Variable Speeds / Speed Management

Strategy Description

Corridor management (including ramp metering), intelligent transportation systems, or advanced traffic management systems are in place on all urban restricted access facilities and all urban principal and minor arterials. All urban limited-access facilities are assumed to be covered.

Key Assumptions

For ramp metering, a two-minute wait time on average was considered during peak hours at the ramp entrance for a high estimate and a one-minute wait time was considered for the low estimate. The ramp fraction was estimated at 8% from MOVES3 defaults.

Partners for Implementation

Execution of this strategy falls under the responsibility of SHA and their ability to implement ramp metering at an expanded scale across Maryland's limited access roads given the funding necessary to make these improvements.

Emissions Reduction Estimate Change from 2020 GGRA Plan

There is a slight increase in emission reduction numbers mainly due to changes in the horizon year from 2030 to 2031.

Table 16: Comparing 2023 CPRP and 2020 GGRA Plan Emissions Reduction Estimate

Metric	2023 CPRP Estimate for 2031	2020 GGRA Plan Estimate for 2030
Annual Emission Reductions	0.012 mmt CO2e	0.011 mmt CO2e

Intermodal Freight Centers Access Improvements

Strategy Description

As noted in the Strategic Goods Movement Plan, reliability improvements and congestion mitigation that positively impact supply chain costs associated with driver and truck delay and fuel consumption is a desired outcome. The strategy to achieve this includes SHA and MDTA continuing to advance appropriate measures to reduce or mitigate the effects of congestion on industry supply chains.

Key Assumptions

The strategy has been applied to intermodal sections in Maryland and the mileage is assumed to be similar to the national share of 1.4% (as data on intermodal facilities mileage in MD was not able to be estimated based on available data). Improvement in free-flow speed from 25 mph to 55mph on urban restricted and unrestricted road types is assumed.

Partners for Implementation

In addition to continued coordination with SHA and MDTA, other partners include the trucking industry, commercial developers, warehousing entities, Maryland Port Administration (MPA), Maryland Aviation

Administration (MAA), Maryland Vehicle Administration (MVA), businesses at the Port of Baltimore, and other public and private freight stakeholders.

Emissions Reduction Estimate Change from 2020 GGRA Plan

There is a slight decrease resulting from a combination of less projected VMT in 2031 and an improvement of overall emission factors resulting in less overall emissions benefit – half of what was assumed in the previous plan.

Table 17: Comparing 2023 CPRP and 2020 GGRA Plan Emissions Reduction Estimate

Metric	2023 CPRP Estimate for 2031	2020 GGRA Plan Estimate for 2030
Annual Emission Reductions	0.010 mmt CO2e	0.017 mmt CO2e

Commercial Vehicle Technologies (Idle Reduction, Low-Carbon Fleet, Dynamic Routing)

Strategy Description

Auxiliary power units (APU) will be used by vehicles abiding by anti-idling regulations for long-term idling. This strategy considers extended idling only and not short-term idling (e.g., at a delivery/pick-up point). Data requirements for short-term idling are more extensive and might not be substantial compared to the extended idling emissions. It is assumed that APUs will be used to power the trucks during the time spent idling.

Key Assumptions

It is assumed that trucks would have spent time idling in the absence of new laws/requirements. A high case and a low case for emission reductions are estimated considering all or just 50% of extended idling is handled by APUs. This does not double count truck stop electrification and ZEVs; public rest stops can be included.

Partners for Implementation

Partners may include vehicles and equipment manufacturers in addition to the trucking industry, commercial developers, warehousing entities, MPA, MAA, MVA, businesses at the Port of Baltimore, and other public and private freight stakeholders.

Emissions Reduction Estimate Change from 2020 GGRA Plan

A combination of multiple improvements to medium- and heavy-duty vehicle (M/HDV) technologies will result in fewer emission reductions for this strategy. Public incentives will result in costs for the state.

Table 18: Comparing 2023 CPRP and 2020 GGRA Plan Emissions Reduction Estimate

Metric	2023 CPRP Estimate for 2031	2020 GGRA Plan Estimate for 2030
Annual Emission Reductions	0.0122 mmt CO2e	0.025 mmt CO2e

Eco-Driving

Strategy Description

Statewide commitment to a marketing and education program and voluntary adoptions by Maryland drivers, including private passenger vehicles and commercial vehicles (light, medium, and heavy-duty trucks).

Key Assumptions

Assumptions are based on the extent of government-led programs. Private sector programs are not included. For example, fleet operators of trucks, and logistical operation enterprises conduct eco-driving for their fleet separately and typically have a higher degree of focus and return on results from the programs. It is assumed that 2% of the statewide population is reached using these general marketing programs. Out of these people, only 50% (1% of the total population) have onboard display tools that have onboard display tools that provide feedback from eco-driving. The benefit of eco-driving is two-pronged - one by training and the other due to attention being paid to the on-board display tools. Heavy-duty trucks included in this analysis are only assumed to be a part of the general marketing campaign and no specific training is provided elsewhere.

Partners for Implementation

Partners for this strategy may include the Maryland Insurance Agency, the MPOs that have implemented consumer education and similar programs, and the MDE. Coordination with commercial fleet operators and MVA could be beneficial.

Emissions Reduction Estimate Change from 2020 GGRA Plan

A decrease in emission factors and VMT led to a slight reduction in the estimate.

Table 19: Comparing 2023 CPRP and 2020 GGRA Plan Emissions Reduction Estimate

Metric	2023 CPRP Estimate for 2031	2020 GGRA Plan Estimate for 2030
Annual Emission Reductions	0.036 mmt CO2e	0.042 mmt CO2e

Transit Capacity/Service Expansion (Fiscally Unconstrained)

Strategy Description

Potential transit network improvements and expansions are noted in BMC and MWCOG long-range plans, in addition to other projects with recent/ongoing planning. This includes the Southern Maryland Rapid Transit Study, Corridor Cities Transitway, additional BRT corridors in Montgomery County, and priority “Early Opportunity” corridors noted in the Central Maryland Regional Transit Plan.

Key Assumptions

The compilation of transit network improvements and expansions in the BMC Maximize 2045 plan results in a 0.3% VMT reduction by 2045. This reduction is assumed to be accelerated to 2031, with full implementation of the Mazimize2045 plan (including corridors recommended in the Central Maryland Regional Transit Plan. Other potential transit corridors by 2031 include three additional BRT corridors (MD 650, Randolph Rd., North Bethesda) plus the Corridor Cities Transitway in Montgomery County and future BRT service in Southern Maryland, consistent

with recommendations in the Southern Maryland Rapid Transit Study. The low-range assumption assumes that 50% of this system will be implemented by 2031, while the high-range assumes the entire system will be implemented by 2031. Cost assumptions are based on transit expansion splits consistent with recent projects and projects in the CTP. This also acknowledges what would be considered a "competitive" funding arrangement for the Federal Capital Investment Grants program (the umbrella program for "New Starts" and "Small Starts").

Partners for Implementation

In addition to the various transit agencies, other partners include the Federal Transit Administration (FTA), MDP local town and city authorities, and any other public and private transit stakeholders.

Emissions Reduction Estimate Change from 2020 GGRA Plan

There is a small increase in emission reduction numbers due to changes in the horizon year from 2030 to 2031. Cost estimates have increased due to individual revised project cost estimates and adjusting for inflations between 2020 and 2023.

Table 20: Comparing 2023 CPRP and 2020 GGRA Plan Emissions Reduction Estimate

Metric	2023 CPRP Estimate for 2031	2020 GGRA Plan Estimate for 2030
Annual Emission Reductions	0.021 mmt CO2e	0.019 mmt CO2e

Expanded Rail Regional Transit (e.g. MARC Growth and Investment Plan, Other Cross-regional Transit)

Strategy Description

Improvements to MARC service include the completion of the fourth track on the Penn Line to facilitate service expansion (which requires new Susquehanna and Bush River crossings and replacement of the B&P Tunnel); reduced peak headways, new midday service, and weekend service on the Camden Line (including expansion to three main tracks between Baltimore and Washington); increased service, longer trains, and expanded parking on the Brunswick Line; and, implementation of Virginia Railway Express (VRE)-MARC Run-Through Service.

Key Assumptions

The estimated 2031 ridership, consistent with the full build-out of the MARC Growth and Investment Cornerstone Plan, totals over 16 million passengers. Compared to a low and average annual ridership growth rate through 2031, this could yield a statewide VMT reduction between 107 and 165 million miles in 2031. The VRE-MARC Run-Through Service estimated the potential for over 16,000 trips per day, resulting in a VMT reduction of 30.5 million by 2031. The funding sources are similar to transit expansion, although typically with more access to Federal funds through Federal Railroad Authority funding /grant programs, which justifies a higher Federal split.

Partners for Implementation

In addition to MARC, other partners include the FTA, MDP, Amtrak Alstom, CSX transportation local town and city authorities, and any other public and private transit stakeholders.

Emissions Reduction Estimate Change from 2020 GGRA Plan

There is a small increase in emission reduction numbers due to the change in the horizon year from 2030 to 2031. Costs have been revised based on capital cost estimates from the MARC Cornerstone plan.

Table 21: Comparing 2023 CPRP and 2020 GGRA Plan Emissions Reduction Estimate

Metric	2023 CPRP Estimate for 2031	2020 GGRA Plan Estimate for 2030
Annual Emission Reductions	0.045 mmt CO2e	0.038 mmt CO2e

Transit Oriented Development Build-Out

Strategy Description

Estimated transit oriented development (TOD) build-out across multiple locations in different lines, resulting in additional new housing developments within 1/2 mile of the station. Each house within the TOD zone averages a VMT reduction of 20% to 40% based on the MDP website. Additional TOD projects may be forthcoming, including along the red line route, but they are not included in the calculations.

Key Assumptions

Based on the MDP's website, average VMT reductions in transit-oriented zones compared to traditional urban/suburban development range from 20% to 40%. Using this range, applied to the potential number of new households at buildout, and average VMT per capita, a range of VMT reductions is determined. There is no federal aid assumed, just 100 percent state and local funding. We assume an additional funding equivalent based on past years' CTP allocation to continue until 2031.

Partners for Implementation

Potential partners required to implement this strategy are MDP, MARC, WMATA, the Department of Housing And Community Development, county planning offices, and local developers.

Emissions Reduction Estimate Change from 2020 GGRA Plan

The increase in emission reduction is due to a change in VMT reduction assumptions based on different sources and methodology changes in affected household estimates. Cost estimates are based on an extrapolation from the updated CTP.

Table 22: Comparing 2023 CPRP and 2020 GGRA Plan Emissions Reduction Estimate

Metric	2023 CPRP Estimate for 2031	2020 GGRA Plan Estimate for 2030
Annual Emission Reductions	0.05 mmt CO2e	0.033 mmt CO2e

56% to 75% EV Transit Bus Fleet

Strategy Description

This strategy assumed fleet updates to MTA and WMATA fleets in order to reach a 75 percent electric fleet by 2031.

Key Assumptions

Using an updated MTA fleet turnover document and the 2021 Fleet transition plan for WMATA, we project that 56 percent of the fleet will be electric by 2031 under their current funded policies. So, this strategy is what is needed to reach a 75% EV fleet (or 85% for the high case). We assume an average VMT of 43,000 miles per year for transit vehicles. We estimate that an additional 261 buses will be converted to electric/zero-emissions by 2031 for the low estimate and 398 for the high estimate. Purchasing an additional 261 buses at a cost of $250,000 each will cost over $65 million. An additional 398 buses will cost over $99 million.

Partners for Implementation

MTA and WMATA are the key partners for the implementation of this strategy since they cover their transit asset management and electrification schedule.

Emissions Reduction Estimate Change from 2020 GGRA Plan

There is a decrease in the estimated emissions reduction associated with this strategy since previously this strategy covered a jump from 50 percent to 75 percent, but now the differential is just 56 percent to 75 percent, so the number of buses that electrify under this strategy has decreased.

Table 23: Comparing 2023 CPRP and 2020 GGRA Plan Emissions Reduction Estimate

Metric	2023 CPRP Estimate for 2031	2020 GGRA Plan Estimate for 2030
Annual Emission Reductions	0.121 mmt CO2e	0.081 mmt CO2e

Expanded TDM Strategies (Car-Sharing)

Strategy Description

Many types of expanded TDM strategies were considered related to the sharing economy. Only the reductions from car-sharing were utilized because other strategies like ride-sharing/ride-hailing have much uncertainty around their potential VMT impacts (and may in fact be increasing VMT by attracting riders who would have otherwise taken transit). Car-sharing availability is associated with reduced vehicle ownership and therefore reduced VMT.

Key Assumptions

7.5% of Maryland's population is affected by car-sharing availability in the low estimate (10% in the high estimate). VMT is reduced by 19% and 34% in low and high estimate cases, respectively due to the availability of car-sharing. This considers any induced demand from car-sharing availability. 2020 costs are indexed to inflation.

Partners for Implementation

To increase the amount of car-sharing in the state, local municipalities will likely be needed to permit car-sharing companies to park their vehicles in designated spots in densely populated urban areas like Baltimore. The Baltimore Parking Authority already has designated parking spots for Zipcar throughout the city. The city may want to consider adding designated on-street parking spots for car-sharing as other cities like New York City have done. Partnerships with private car-sharing companies are also required to increase the availability of car-sharing.

Emissions Reduction Estimate Change from 2020 GGRA Plan

There is a slight decrease in the 2023 estimate compared to 2020 because VMT impacts of car-sharing were slightly reduced and the percentage of the Maryland population that it would impact for the low estimate.

Table 24: Comparing 2023 CPRP and 2020 GGRA Plan Emissions Reduction Estimate

Metric	2023 CPRP Estimate for 2031	2020 GGRA Plan Estimate for 2030
Annual Emission Reductions	0.25 mmt CO2e	0.27 mmt CO2e

Expanded Telework

Strategy Description

Telework expanded greatly during the pandemic but has begun to decrease as more employees work in-person again. This strategy assumes that telework increases year over year above the current post-onset of the COVID-19 pandemic "status quo".

Key Assumptions

This strategy assumed that 30% of annual VMT is associated with work-related VMT. It also assumes a 25% telework rebound effect (i.e., that in spite of reducing VMT by not driving to work, many workers still drive many of their commuting miles due to running errands and other trips). A low estimate of 30% of workers working remotely in 2031 is used, based on the 2022 percentage plus a 5% growth rate each year. A high estimate of 45% work remotely in 2031 in the high case is used by assuming the 2022 percentage plus 10% growth rate each year. 2020 costs are indexed to inflation.

Partners for Implementation

MDOT will need to work with employers to ensure that workers who operate jobs that can be done remotely have the flexibility to be able to do so. MDOT should also ensure that their employees who can work remotely also possess this option.

Emissions Reduction Estimate Change from 2020 GGRA Plan

There is a decrease in 2023 estimates due to the model assuming a smaller number will work remotely in 2031 for low and high estimates and the Maryland workforce will grow at a smaller rate than previously assumed.

Table 25: Comparing 2023 CPRP and 2020 GGRA Plan Emissions Reduction Estimate

Metric	2023 CPRP Estimate for 2031	2020 GGRA Plan Estimate for 2030
Annual Emission Reductions	0.490 mmt CO2e	0.57 mmt CO2e

Expanded Bike/Pedestrian System Development

Strategy Description

This strategy assumes VMT reductions due to the availability of bicycle facility lane miles and improved bicycle LTS consistent with existing and planned infrastructure improvements, repaving, and new facilities highlighted in the CTP and projected based on historical efforts to improve the number of directional miles.

Key Assumptions

This strategy assumes that roads with a bicycle LTS of 1, 2, or 3 support trips on bicycles instead of motor vehicles. VMT reduction is a function of AADT of the road, average bike trip length, and other factors according to research done for CARB. The average bike trip length is assumed to be 1.8 miles. The miles of bike facilities in Maryland with LTS 1, 2, or 3 will increase to ~12,000 miles by 2031, up from just ~4,000 today based on a 100% increase above the current trend for this low estimate, or a 200% increase for the high estimate. Bike lanes cost an estimated $133,000 to $537,000 per mile. Assuming a value that is the average of these two for the increased mileage, then costs are $3.5 billion for the low case and $7 billion for the high case.

Partners for Implementation

The cooperation of MDOT's Office of Planning and Capital Programming and counties and municipalities is required to implement this strategy.

Emissions Reduction Estimate Change from 2020 GGRA Plan

There is a decrease in 2023 estimates because of a change in methodology due to a switch from Bicycle LOC to LTS.

Table 26: Comparing 2023 CPRP and 2020 GGRA Plan Emissions Reduction Estimate

Metric	2023 CPRP Estimate for 2031	2020 GGRA Plan Estimate for 2030
Annual Emission Reductions	0.02 mmt CO2e	0.040 mmt CO2e

Red Line Transit

Strategy Description

The Red Line corridor extends 14 miles from Woodlawn (Baltimore County) to the Johns Hopkins Bayview Medical Center campus on the east (Baltimore City). The actual mode of transit is yet to be determined.

Key Assumptions

VMT reductions as a result of the line are sourced from the Red Line Environmental Impact Assessment in 2012. However, emissions per VMT are based on 2031 updated estimates. Since being revived there has not been a revised cost estimate. Hence, the original 2012 cost estimates are used.

Partners for Implementation

As is the case with any transit project, multiple agencies, are involved. In addition to MTA, others include the Baltimore City Department of Transportation, the MDP, and county planning offices.

Table 27: Emissions Reduction Estimate

Metric	2023 CPRP Estimate for 2031
Annual Emission Reductions	0.005 mmt CO2e

Intercity Bus Service Expansion

Strategy Description

MDOT is expected to increase its intercity bus service (replacing some routes currently operated by Greyhound) based on its Intercity bus study. New services proposed in the Maryland Intercity bus study are expected to reduce VMTs. Privately operated unsubsidized routes are not included (e.g., Greyhound, Flixbus, etc.). The intercity bus study did not estimate demand.

Key Assumptions

Average passenger bus miles per revenue service mile are taken from APTA's commuter bus details[8] for Maryland to estimate patronage. Since these are new services 100% of passenger miles contribute to VMT reductions in the high estimate, and 50% of passenger miles in the low estimate. Costs are based on estimates from the 2023 Maryland intercity bus study.

Partners for Implementation

Beyond the MTA, other potential partners are the major private bus lines such as Greyhound, Peter Pan, Megabus, and BayRunner Shuttle.

Table 28: Emissions Reduction Estimate

Metric	2023 CPRP Estimate for 2031
Annual Emission Reductions	0.004 mmt CO2e

Hydrogen Fuel Cell Vehicles (Medium- and Heavy-duty Vehicles, Non-state Fleet)

Strategy Description

This strategy includes incentives and programs to accelerate M/HDV Hydrogen Fuel Cell Vehicle Adoption beyond existing Advanced Clean Truck (ACT) adoption rates, which were the standards assumed for the SP scenario. Infrastructure investment and technology development are required for these scenarios to be realized.

Key Assumptions

High assumptions are based on the Roadmap to a US Hydrogen Economy. (Build to 14% HDV from 2027-2031 and 10% MDV). Low assumes building to 5% MDV and 7% HDV, based on Fuel Cell & Hydrogen Energy Association data. We assume the costs for these strategies would be linked to incentives rather than the overall cost of the vehicle.

[8] Public Transportation Fact Book - American Public Transportation Association (apta.com)

Partners for Implementation

Coordination with the Maryland Zero Emission Electric Vehicle Infrastructure Council, as well as their partners, will be beneficial in reaching out to hydrogen fuel cell vehicle and refueling infrastructure representatives. Other partners include the trucking industry, commercial developers, warehousing entities, MPA, MAA, MVA, businesses at the Port of Baltimore, and other public and private freight stakeholders.

Table 29: Emissions Reduction Estimate

Metric	2023 CPRP Estimate for 2031
Annual Emission Reductions	0.08 mmt CO2e

Truck Stop Electrification

Strategy Description

Truck idling emissions are reduced due to the electrification of parking bays at truck stops. Trucks use diesel power to idle engines to provide electricity for heating/cooling the cabs. This strategy assumes all trucks will switch to shore power whenever available over idling. It's applied to 50% -90% of all private truck stops and two public rest areas that allow commercial activity.

Key Assumptions

Trucks typically Idle 8 out of 10 hours of daily break. Between 2023 and 2031 truck stop locations are assumed to increase linearly with truck VMT increase. 15% of trucks on the road are assumed to be Zero Emission Vehicles by 2031 and will not be applicable to this strategy. An average truck parking spot is assumed to be occupied for 75% of the time. Electrification costs are assumed to be $20,000 per space-based 2019 ICCT report.

Partners for Implementation

In addition to continued coordination with SHA and MDTA, other partners include the trucking industry, commercial developers, major truck stop operators, MPA, and MDE.

Table 30: Emissions Reduction Estimate

Metric	2023 CPRP Estimate for 2031
Annual Emission Reductions	0.02 mmt CO2e

Medium-/Heavy-Duty Vehicle Low-Carbon Fleet/Fueling Incentives and Programs (Non-state Fleet)

Strategy Description

This strategy encompasses incentives and programs to accelerate M/HDV ZEV adoption beyond existing ACT (what was assumed in the SP scenario) adoption rates.

Key Assumptions

The strategy assumes a 5% per year addition from 2027-2031 under a low estimate and 10% per year under a high estimate. Cost assumptions only include incentives and not the total vehicle cost.

Partners for Implementation

In addition to continued coordination with MDE, other partners include the trucking industry, commercial developers, warehousing entities, MPA, MAA, MVA, businesses at the Port of Baltimore, and other public and private freight stakeholders.

Table 31: Emissions Reduction Estimate

Metric	2023 CPRP Estimate for 2031
Annual Emission Reductions	0.10 mmt CO2e

Lead by Example - Alternative Fuel Usage in State/Local Government Fleet in Medium- and Heavy-Duty Vehicles

Strategy Description

This strategy explores the benefits of turnover of state and local government M/HDVs to ZEVs.

Key Assumptions

This strategy prescribes the reductions according to CARB's Advanced Clean Fleet rule. A list of MDOT vehicles over 10,000 lbs. was used and segmented into the categories of Advanced Clean Fleet. Costs are estimated using the International Council on Clean Transportation's March 2023 working paper[9] on the cost to electrify different M/HDV trucks.

Partners for Implementation

This strategy is internal to MDOT, but they will need to partner with original equipment manufacturers to find the most appropriate vehicles to allow them to transition their fleet to more alternative fuel vehicles.

Table 32: Emissions Reduction Estimate

Metric	2023 CPRP Estimate for 2031
Annual Emission Reductions	0.030 mmt CO2e

Parking Incentives, Pricing, Mins/Maxs

Strategy Description

Minimum parking requirements for new developments tend to induce more driving. Studies show that removing parking requirements from commercial developments leads to less parking being built, which results in reduced VMT. Unbundling parking costs from housing costs separates parking from property costs, requiring those who

[9] International Council on Clean Transportation (ICCT) "Purchase costs of zero-emission trucks in the United States to meet future Phase 3 GHG standards" March 2023 https://theicct.org/wp-content/uploads/2023/03/cost-zero-emission-trucks-us-phase-3-mar23.pdf

wish to purchase parking spaces to do so at an additional cost from the property cost. This removes the burden from those who do not wish to utilize a parking space. Parking will be priced separately from home rents /purchase prices or office leases.

Key Assumptions

Since this strategy is only effective in dense urban neighborhoods, it is assumed to be effective only in the top 5% of highest highest-density zip codes in Maryland. Current construction market trends are assumed to continue at the same rate in order to estimate applicable new development. An assumption is made that the parking costs are passed through to the vehicle owners/drivers utilizing the parking spaces in residential buildings. Residential parking costs range from $25 - $125 per month. As it is a policy change strategy, there is no direct cost associated with implementation.

Partners for Implementation

Potential partners required to implement this strategy are MDP, the Department of Housing and Community Development, county planning offices, and local developers.

Table 33: Emissions Reduction Estimate

Metric	2023 CPRP Estimate for 2031
Annual Emission Reductions	0.02 mmt CO2e

INNOVATIVE STRATEGIES

Connected and Automated Vehicle (*CAV*) Technologies

Strategy Description

Core assumptions regarding market penetration of CAVs, change in VMT, and fuel savings have been adopted from an Eno Center for Transportation study which lays out three scenarios of AV deployment, of which the low-end penetration of 10% by 2031 is considered in this analysis.

Key Assumptions

Emissions associated with VMT increase resulting from mobility benefits (CAVs added to the fleet – these increase emissions and thereby a negative impact, estimated at 20 percent increase); Fuel savings due to CAVs (savings of CAVs only, estimated at 13 percent reduction); Congestion reduction benefits on freeways and arterials (assumed level of service E to C on restricted access roadways and unrestricted access roadways). These are due to vehicles following automated vehicles, etc. level of service criteria for restricted and unrestricted roadway types obtained from the Highway Capacity Manual (HCM) and emission rates are applied at the different operating speeds (bins) and assigned to VMT by that roadway type (estimated at 15 percent reduction for limited access facilities and 5 percent reduction for arterials). Ranges for high cases have been varied to include a higher market penetration (15%) and thereby an increased freeway congestion reduction benefit (20%). Infrastructure costs to the state are considered. 100% of costs are to be borne by the state.

Partners for Implementation

In addition to internal coordination with MVA and SHA, partners could include representatives of the Maryland CAV working group, which represents, law enforcement, traffic safety, planning, engineering, economic development, regional, state, and local government, policymakers, trucking industry, private industry, and education.

Emissions Reduction Estimate Change from 2020 GGRA Plan

There is a small change in emission reductions due to changes in emission estimates per VMT. 2023 estimates cleaner vehicles than 2020. Thus, the effectiveness of the strategy decreases. Costs have been adjusted for inflation from 2014.

Table 34: Comparing 2023 CPRP and 2020 GGRA Plan Emissions Reduction Estimate

Metric	2023 CPRP Estimate for 2031	2020 GGRA Plan Estimate for 2030
Annual Emission Reductions	0.521 mmt CO2e	0.679 mmt CO2e

Zero-Emission Truck Corridors

Strategy Description

This strategy considers corridors in MD (port connections, etc.) in line with the I-710 Calstart Corridor.

Key Assumptions

More research is required to establish potential deployment scenarios within Maryland, primarily at the Port of Baltimore. Options include a zero-emissions dray truck program similar to the proposed program in the Los Angeles region, or deployment in specific corridors (e.g., where trucks connect to an overhead electric power system. The current approach assumes that from 300 (low) to 700 (high) dray trucks are electrified in Maryland (approx. 20% to 40% of the total dray truck fleet operating at the Port of Baltimore). California examples primarily are currently using Volkswagen Mitigation resources to fund truck replacements up to $200k value. The presumption is that a private share is contributed, but that is unknown. Once VW mitigation trust funding is spent, sources for these programs are uncertain (a fair assumption is a mix of Federal grants, state match or incentives, and private leverage. The cost estimate represents the public share only.

Partners for Implementation

Potential partners required to implement this strategy are the Port of Baltimore, vehicles, and equipment manufacturers, MPA, and businesses at the Port of Baltimore.

Emissions Reduction Estimate Change from 2020 GGRA Plan

Both costs and emission reductions have decreased due to a revision in the extent of applicability of the strategy. Instead of assuming 100% application to dray trucks, the strategy assumed 20 – 40% application by 2031.

Table 35: Comparing 2023 CPRP and 2020 GGRA Plan Emissions Reduction Estimate

Metric	2023 CPRP Estimate for 2031	2020 GGRA Plan Estimate for 2030
Annual Emission Reductions	0.007 mmt CO2e	0.027 mmt CO2e

Freight Villages/Urban Freight Consolidation Centers

Strategy Description

Consolidated freight distribution centers to utilize cleaner last-mile delivery trucks for urban areas (fleet or urban area approach).

Key Assumptions

The benefits are localized to individual intersections/interchanges and ramps, as well as local streets/intermodal connectors providing access to the Port of Baltimore and other intermodal facilities. This is assumed to be implemented on a public-private partnership basis. Hence the split was assumed to be fifty-fifty.

Partners for Implementation

Partners may include vehicles and equipment manufacturers in addition to warehousing entities, the MDP, and local law enforcement.

Emissions Reduction Estimate Change from 2020 GGRA Plan

Small decrease in emission reduction due to a decrease in the revised emission per VMT estimates. Costs are adjusted for inflation between 2020 to 2023.

Table 36: Comparing 2023 CPRP and 2020 GGRA Plan Emissions Reduction Estimate

Metric	2023 CPRP Estimate for 2031	2020 GGRA Plan Estimate for 2030
Annual Emission Reductions	0.022 mmt CO2e	0.025 mmt CO2e

Speed Management on Freeways (Increased Enforcement)

Strategy Description

Speed Management is assumed to cover urban and rural restricted access roadways in the state. Emission reduction from light- and heavy-duty vehicles traveling at speed limit instead of above speed limit, which yields a lower emission rate per mile for the vehicles. Applies to rural and urban limited access VMT.

Key Assumptions

This strategy assumes that 40% of urban VMT occurs during peak periods. Of that 40%, just 60% (with the directional split factored in) experience congestion and do not benefit from these measures. Then these potential reductions are applied to 100% of urban restricted access roadways and only 50% of rural restricted access roadways for a high-range implementation and 50% of urban restricted roadway coverage and 25% of rural restricted access coverage for low-range implementation. It is assumed that HDVs maintain speeds closer to the

posted limits compared with LDVs and most shipping companies have requirements or have already implemented strategies for optimizing fuel consumption. Emission factor at average speed used corresponding to 65 mph for HDV.

Partners for Implementation

Increased speed enforcement can be utilized with speed cameras that can be implemented by SHA.

Emissions Reduction Estimate Change from 2020 GGRA Plan

There is a small decrease in emission reduction numbers that can be attributed to changes in emission factors at different speeds for vehicles on average.

Table 37: Comparing 2023 CPRP and 2020 GGRA Plan Emissions Reduction Estimate

Metric	2023 CPRP Estimate for 2031	2020 GGRA Plan Estimate for 2030
Annual Emission Reductions	0.044 mmt CO2e	0.040 mmt CO2e

Pay-As-You-Drive Insurance

Strategy Description

Pay-as-you-drive (PAYD) insurance is a usage-based insurance program where charges are based on usage and driver behavior, which is offered by several auto insurance companies in the US. This strategy involves the adoption of PAYD insurance, which has been observed in multiple studies to reduce VMT.

Key Assumptions

A range of 10 to 20% of licensed Maryland drivers use a pay-as-you-drive auto insurance premium by 2031. The range of VMT reduction for PAYD insurance is from 4 to 12% based on Victoria Transport Policy Institute (VTPI) research[10]. This reduction is applied to the average VMT per capita for the 10 to 20% of Maryland licensed drivers with PAYD insurance premiums. The strategy is administered by private insurance providers and is 100% privately funded.

Partners for Implementation

As an industry-driven strategy, the main partners are the insurance companies, the MVA, and local law enforcement agencies.

Emissions Reduction Estimate Change from 2020 GGRA

Emission estimates increase in range between low and high, due to the revised VMT reduction estimated for PAYD drivers based on new studies by the VTPI.

[10] Victoria Transportation Policy Institute, March 2023, Distance-Based Vehicle Insurance (vtpi.org)

Table 38: Comparing 2023 CPRP and 2020 GGRA Plan Emissions Reduction Estimate

Metric	2023 CPRP Estimate for 2031	2020 GGRA Plan Estimate for 2030
Annual Emission Reductions	0.06 mmt CO2e	0.12 mmt CO2e

Strategy, Emissions and Cost Summary for PNI Strategies

Table 39: Summary of Emissions and Cost for Each PNI Strategy

Strategy	2031 Estimate (mmt CO2e)	2031 Total Estimated Costs ($M)	2031 Total Estimated Costs per Reduction ($M per mmt CO2e)
Emerging Strategies			
Expanded Telework	0.49 to 0.74	981 to 6,077	2,019 to 8,226
Expanded TDM strategies (Car-Sharing)	0.25 to 0.6	18 to 35	60 to 71
TSMO/Integrated Corridor Management (Arterial System)	0.15 to 0.23	536 to 804	3,454 to 3,3661
56% to 75% EV Transit Bus Fleet	0.12 to 0.18	65 to 99	539 to 539
Medium- and Heavy-duty Vehicle Low-Carbon Fleet/Fueling Incentives and Programs (Non-state Fleet)	0.1 to 0.21	20 to 39	188 to 189
TSMO/Integrated Corridor Management (Limited Access System)	0.08 to 0.15	128 to 180	1,234 to 1,553
Hydrogen Fuel Cell Vehicles (Medium- and Heavy-duty Vehicles, Non-state Fleet)	0.08 to 0.16	45 to 89	546 to 556
TOD Build-Out	0.05 to 0.1	2 to 2	25 to 49
Expanded Rail Regional Transit (e.g. MARC Growth and Investment Plan, Other Cross-regional Transit)	0.04 to 0.06	2,580 to 2,580	40,528 to 57,892
Eco-Driving	0.04	4 to 6	99 to 164
Lead by Example - Alternative Fuel Usage in State/Local Government Fleet in Medium- and Heavy-duty Vehicles	0.03 to 0.05	629 to 1,015	19,788 to 20,874
Expanded Bike/Pedestrian System Development	0.02 to 0.04	1,750 to 3,500	79,077 to 79,077
Transit Capacity/Service Expansion (Fiscally Unconstrained)	0.02 to 0.04	3,979 to 4,646	109,475 to 187,539
Truck Stop Electrification	0.02 to 0.03	31 to 53	1,666 to 1,666
Parking Incentives, Pricing, Mins/Maxs	0.02 to 0.08	*	*
Commercial Vehicle Technologies (Idle Reduction, Low-Carbon Fleet, Dynamic Routing)	0.01 to 0.02	2 to 4	175 to 247
Variable Speeds/Speed Management	0.01 to 0.02	128 to 180	9,700 to 10,683
Intermodal Freight Centers Access Improvement	0.01	2,649 to 3,708	264,880 to 370,832
Red Line Transit	0.01	2,332 to 2,332	494,824 to 494,824
Intercity Bus Service Expansion	0.004 to 0.007	6 to 7	1,126 to 1,486
Innovative Strategies			
CAV Technologies	0.52 to 0.65	94 to 128	179 to 197
Pay-As-You-Drive Insurance	0.06 to 0.37	**	**
Speed Management on Freeways (Increased Enforcement)	0.04 to 0.09	8 to 17	190 to 190
Freight Villages/Urban Freight Consolidation Centers	0.02 to 0.03	5,737 to 8,405	251,298 to 257,293
Zero-Emission Truck Corridors	0.01 to 0.02	8 to 23	980 to 1,002
Total	**2.20 to 3.93**	**$21,729 to $33,928**	**$8,624 to $9,874**

* Policy change with uncertain costs, ** Technology/programs offered by the private sector