Maryland
Department of
the Environment

Appendix J

2020 MDOT GGRA Plan

2030 GGRA Plan

2020 Maryland Department of Transportation

Greenhouse Gas Reduction Act Plan

MARYLAND DEPARTMENT OF TRANSPORTATION

Executive Summary

The Greenhouse Gas Reduction Act (GGRA) Plan presents the Maryland Department of Transportation's (MDOT) approach to meet the requirements of the GGRA. The GGRA requires the Maryland Department of Environment (MDE) to submit a plan that reduces statewide greenhouse gas (GHG) emissions by 40 percent from 2006 levels by 2030 ("40 by 30"). MDOT worked in coordination with MDE, other agencies, and partners to develop and test strategies for the transportation sector to achieve the "40 by 30" goal.

The current statewide emissions inventory, developed for 2017, shows that on-road transportation is the single largest GHG emissions generator in Maryland, representing 36 percent of total GHG emissions. Off-road transportation (aviation, marine, and rail) represents another 4 percent.

Statewide VMT, which is a major indicator of transportation sector GHG emissions, has been steadily increasing in Maryland since 2014, with over 60 billion VMT in 2019. VMT growth has been consistent with population growth as VMT per capita has remained stable. While population increase is expected to create additional demand for the State's transportation systems, VMT in Maryland dropped dramatically in 2020 due to the COVID-19 pandemic. Based on MDOT's estimates of VMT trends, 2020 annual VMT is expected to drop to an estimated 51.1 billion VMT statewide. While MDOT anticipates that VMT will rebound back to 2019 levels over the next five years, there is uncertainty regarding the exact timeline and pace of the recovery.

A steady increase in transportation demand indicators including growth in population, vehicle miles traveled (VMT), and congestion combined with limited revenue relative to needs creates a major challenge. Based on MDOT analysis accounting for these challenges and by harnessing new opportunities, it is possible for Maryland's transportation sector to meet the "40 by 30" goal. The analysis considered two policy scenarios built from the Maryland Transportation Plan (MTP), the Consolidated Transportation Program (CTP), and Maryland's two major Metropolitan Planning Organizations' (MPO) plans and programs (Baltimore and Washington D.C. regions). Achieving the goal will not be easy and requires an innovative and cost-effective approach that includes:

- An aggressive investment in transportation beyond current levels of projected funding,
- Supportive policy and new and additional resources enabling MDOT to fund and advance these needed investments,
- A shared commitment and coordinated approach between MDOT and its partners to advance reliable, low-cost, and low-carbon technologies, and
- A best-case scenario for the roll-out and adoption of transportation technology, including market penetration of electric vehicles (EVs) into public and private fleets in Maryland.

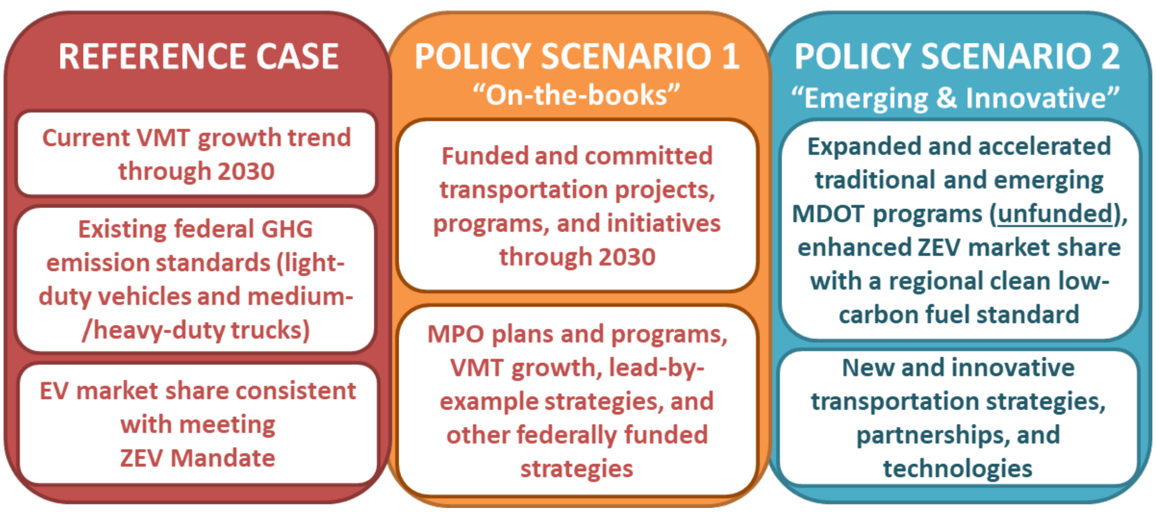
According to projections by the Maryland Department of Planning (MDP), Maryland may grow to over 6.5 million people by 2030. Coupled with economic expansion and land use change, VMT could increase to over 69 billion by 2030. Reducing emissions from this projected travel activity rests on the four pillars of emission reduction (as shown in **Figure ES 1**). These pillars rely on behavioral change and innovation among all the stakeholders of the State's transportation system, as we transition to a low-carbon emissions pathway to achieve the 2030 goal.

Figure ES 1 The Four Pillars of Emission Reductions in the Transportation Sector

Construct of Scenarios and Strategy Development

While the GGRA goal is “40 by 30” across all economic sectors in Maryland, MDOT’s analysis applies the same goal for the transportation sector as the current and projected largest contributor of GHG emissions in Maryland by 2030. The policy scenarios and results are presented in **Figure ES 2**.

Figure ES 2 MDOT GGRA Plan – Scenario Construct



The 2006 Baseline Inventory established the base conditions for the GHG reduction goals in the GGRA (25 percent by 2020 and 40 percent by 2030). The on-road portion of the emissions inventory represents a “bottom-up” approach to estimating statewide GHG emissions based on roadway congestion levels, traffic volumes, and vehicle fleet data. GHG emission estimates for on-road transportation in 2014 and 2017 baselines reflect an alignment with actual conditions based upon the process for developing the U.S. Environmental Protection Agency’s (EPA) National Emissions Inventory (NEI).

Reference Case – This scenario assumes a constant 1.2 percent annual VMT growth rate (the annual average since 1990) through 2030 combined with full implementation of current federal emission and fuel standards. With the full implementation of final federal vehicle and fuel standards through 2030, total on-road GHG emissions could decrease by 6.35 mmt CO_2e[1], bringing 2030 emissions 20 percent below 2006 emissions. Maryland meeting the Zero Emissions Vehicle Memorandum of Understanding (ZEV MOU) target of 535,000 ZEVs registered in Maryland by 2030 (9.9 percent of the light-duty vehicle fleet) will result in an additional 1.66 mmt CO_2e reductions. **This results in a reduction to 22.71 mmt CO_2e from on-road mobile sources in 2030, a 26 percent reduction from 2006.**

Policy Scenario 1 "On-the-Books" – As its name indicates, this scenario 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 MDP's goals, and GHG reducing projects included in fiscally constrained MPO metropolitan transportation plans. This scenario represents a best-case outcome for implementation of all currently funded programs through 2030. The total estimated statewide reduction as a result of implementing Policy Scenario 1 in 2030 is 2.19 mmt CO_2e. **The result is a reduction to 20.53 mmt CO_2e from on-road mobile sources in 2030, a 33 percent reduction from 2006.**

Policy Scenario 2 "Emerging and Innovative" – This scenario acknowledges that attaining the 2030 goal will require additional investments to expand or accelerate deployment of previously planned strategies. This could include expanding their scope of application, deployment of new best-practice strategies, and capitalizing on the opportunities created by new transportation technologies by enabling policies and providing incentives.

All the strategies in Policy Scenario 2 require additional funding and, in some cases, private sector commitment. The 22 strategies in this scenario (16 emerging and 6 innovative) represent a combination of approaches to reduce GHG emissions with varying levels of confidence and MDOT responsibility. The total estimated statewide reduction in 2030 under Policy Scenario 2 is estimated between 4.539 and 6.417 mmt CO_2e. **The result is a reduction to 15.70 mmt CO_2e from on-road mobile sources in 2030, a 49 percent reduction from 2006.**

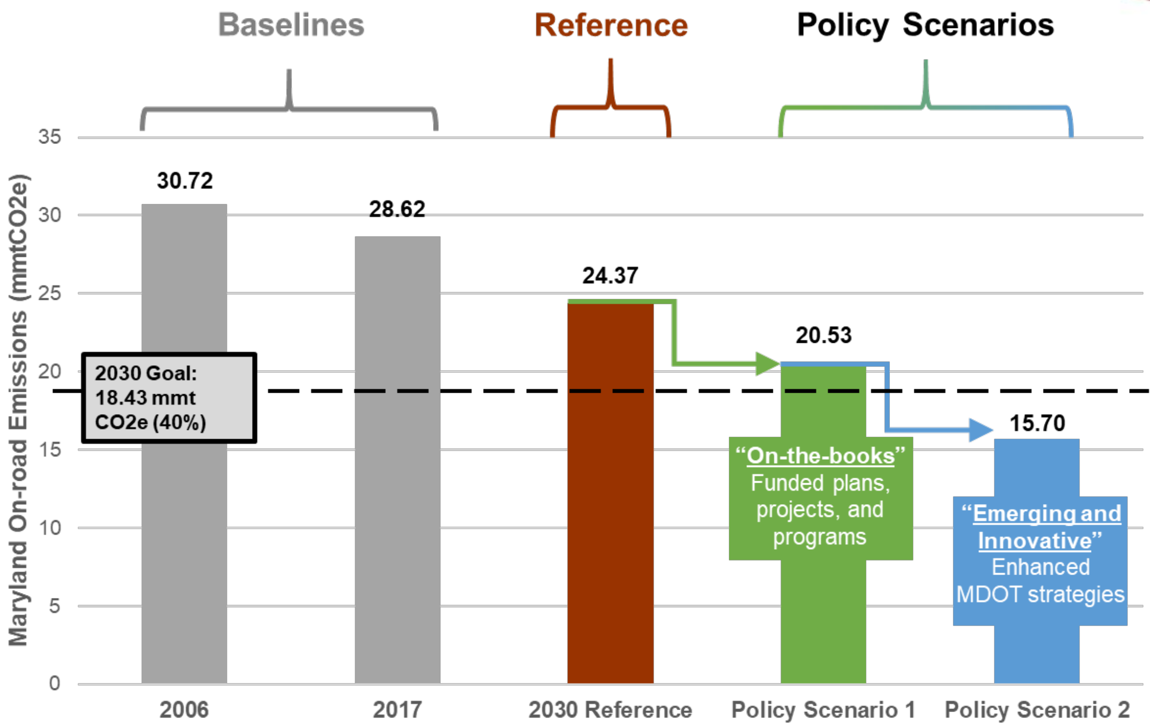
This scenario suggests that achieving the 40 percent reduction is possible; however, the transportation sector will need a new infusion of revenues and partnerships to make this a reality. The strategies in both scenarios create opportunities for significant co-benefits beyond reduced fuel consumption and GHG emissions, including improved air and water quality, public health benefits, more equitable transportation options and access to opportunity, and direct and indirect economic impacts for current and future Maryland workers and employers.

The COVID-19 pandemic resulted in a decrease in VMT and congestion on Maryland roadways as many employers switched to telework. This, coupled with advancement in transportation technology, will result in lower GHG emissions in Maryland. Nonetheless, as long-term national trends continue to show an increase in VMT and decrease in transit ridership as an externality resulting from social-distancing measures, it is important that the State continue to develop solutions that address modern preferences, such as mobile applications that offer riders real-time bus tracking, or investment in travel time reduction and facility-wide comfort.

Figure ES 3 shows how far the transportation sector in Maryland can get in terms of emission reductions by 2030 as a result of implementing the two policy scenarios.

[1] Note: CO_2e represents CO_2 equivalents, which is a measure of GHG emissions that considers the global warming potential of each GHG, including CO_2, methane, and nitrous oxides. More information is available through US EPA here.

Figure ES 3 MDOT GGRA Plan – Scenarios and Potential Emissions Reductions



Implementation Costs

A majority of the strategies require an influx of capital funding for implementation. These include facility construction costs, the cost of acquiring right-of-way, purchasing rolling stock or vehicles for transit, and technology costs for equipment and infrastructure.

Policy Scenario 1 total estimated cost is $14.091 billion. These costs are based on CTP outlays, ongoing investments in current MDOT programs from 2026 to 2030, and funded projects and programs in MPO MTPs planned for implementation by 2030. These programs are included within fiscally constrained plans based on projected revenue sources available to fund the programs for implementation.

Policy Scenario 2 total estimated cost, *not including potential investments in MAGLEV or Loop*, ranges from $11.593 billion up to $15.585 billion (total funding levels of around 80 to 110 percent above current fiscally constrained plans). A balanced investment approach is needed to identify and prioritize strategies for funding based on cost effectiveness, reduction potential, and overall feasibility including readiness of policy adoption, public acceptance, and a supportive regulatory environment for rolling out new technologies.

The path to "40 by 30" for the transportation sector is beset with implementation challenges and uncertainties, while also having the potential to capitalize on known and unknown opportunities. MDOT's approach takes a careful, fact and research-driven approach to gauge what is realistic by 2030. Given the vitality of the transportation sector for maintaining and enhancing the economic prosperity of Maryland's citizens and its contribution as the largest source of GHG emissions in Maryland, a firm commitment to fulfilling the sector's resource and implementation challenges will enable the state to meet the GGRA goals.

1. Background and Approach

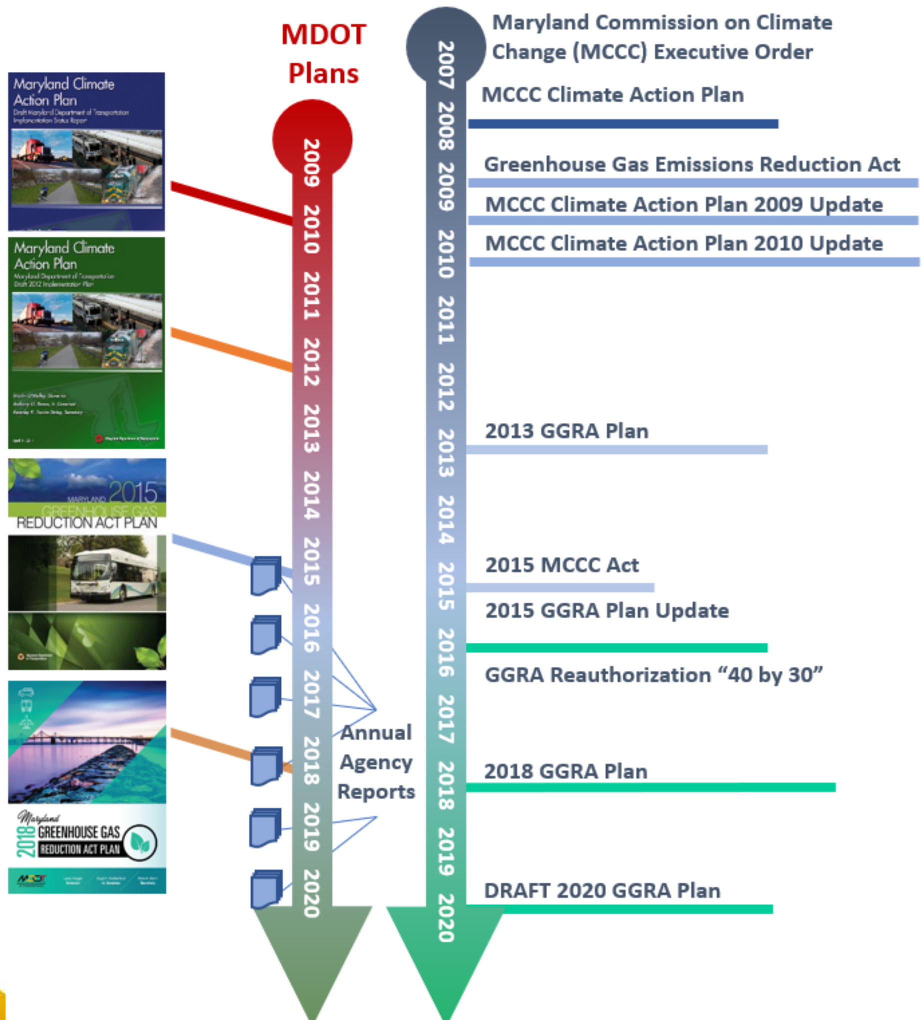
The Greenhouse Gas Reduction Act (GGRA) Plan presents the Maryland Department of Transportation's (MDOT) blueprint for reducing greenhouse gas (GHG) emissions from the transportation sector through 2030. The Plan includes information on emission reductions, co-benefits, implementation considerations, and costs of a diverse set of strategies and scenarios developed in coordination with the Maryland Department of Environment (MDE), other State agencies, and regional and local partners.

Greenhouse Gas Reduction Act and Maryland Commission on Climate Change

Maryland adopted the 2009 GGRA in June 2009. MDOT began working with stakeholders to develop a comprehensive approach to reduce GHG emissions from the transportation sector through 2020 and beyond.

In 2016, Maryland reauthorized the 2009 GGRA, refocusing efforts on a new goal of reducing GHG by 40 percent of 2006 emissions by 2030 ("40 by 30"). This plan represents MDOT's draft approach toward achieving the 2030 goal, which will be finalized through development of the required 2020 GGRA Plan. An overview of the history, showing MDOT's role relative to the activities of the Maryland Commission on Climate Change (MCCC), is highlighted in **Figure 1.1**.

Figure 1.1 MDOT's Contribution to Climate Change Planning in Maryland



Purpose of the Plan

The Plan presents the progress made by the transportation sector in reducing GHG emissions, the trends affecting GHG emissions through 2030, and the anticipated benefits of planned MDOT strategies to support achieving the "40 by 30" goal. The Plan's purpose is to:

- Present transportation sector accomplishments since 2009;
- Discuss broad trends impacting vehicle miles traveled (VMT), vehicle technology, and fuel use, as well as the associated emission outcomes of these trends;
- Identify specific actions, including costs and benefits, for implementation through 2030; and
- Assess the transportation sector's contribution to the overall 2030 emission reduction goal.

Recent and Ongoing MDOT Actions

MDOT, through annual status reports to the Governor's Office and General Assembly, provides a review of recent, ongoing, and planned activities aimed toward meeting the GGRA goals across three different implementation tiers: policy, programs, and data. These plans are available for review here.

Transportation Technology

As a leader in implementing emerging transportation technologies, MDOT is leading various initiatives including the Maryland Zero Emission Electric Vehicle Infrastructure Council (ZEEVIC), connected and automated vehicle (CAV) technology, and renewable energy.

- Total registered Electric Vehicles (EVs) in Maryland stands at 29,268 as of December 31, 2020.
- MDOT is completing its Fleet Innovation Plan which will support the conversion of MDOT's light-duty and bus fleet to Zero Emission Vehicles (ZEVs).

Congestion Mitigation

MDOT continues its comprehensive and innovative approach to mitigating congestion and improving travel and freight reliability through various initiatives, including those within Transportation Systems Management and Operations (TSMO).

- In 2019, the Coordinated Highways Action Response Team (CHART) Program cleared 31,750 traffic incidents and assisted 39,500 motorists on Maryland highways. The program saved drivers $1.4 billion in delay and fuel costs through effective traffic incident management, traveler information, and emergency services.

VMT Reduction

MDOT invests in low-emissions travel modes (transit, bicycle, and pedestrian) and provides commuting incentives and information under the Commuter Choice Maryland Travel Demand Management Program.

- MDOT Maryland Transit Administration (MTA) continues its railcar replacement program, replacing 78 railcars to improve passenger comfort and travel time reliability, and enhancing safety components on the Metro SubwayLink system.
- MDOT MTA launched real-time tracking for MARC Train service in August 2020 to improve traveler information and system management.

Infrastructure Design

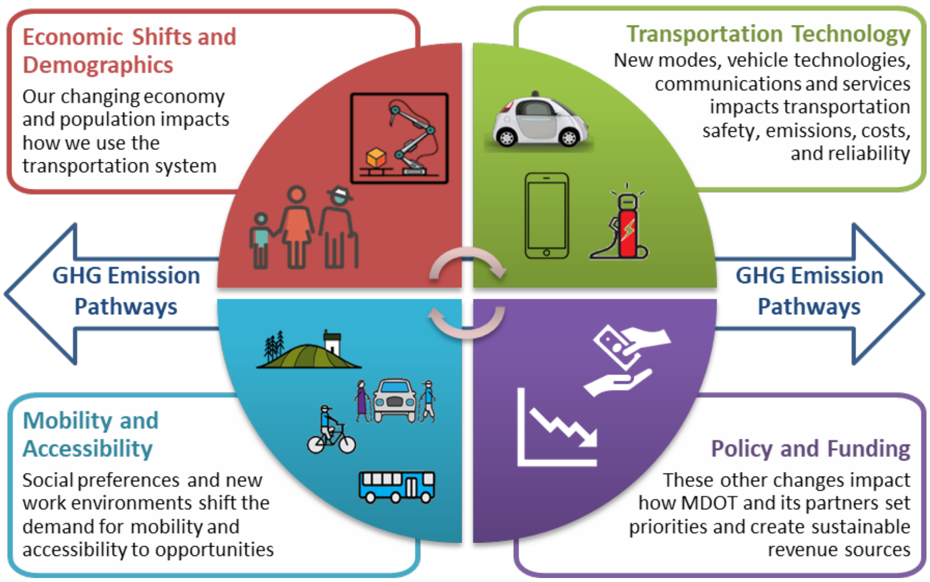
MDOT continues to emphasize the importance of reducing emissions through design principles including practical and innovative project implementation.

- MDOT Transportation Secretary's Office (TSO) published design guidance for projects applying for MDOT Kim Lamphier Bicycle Program funding.
- Maryland Transportation Authority (MDTA) implemented permanent full-time all-electronic (cashless) tolling at all of its facilities across Maryland.

Setting the Context for 2030: Drivers and Trends

Maryland continues to witness significant shifts in the factors impacting transportation demand. The Maryland Transportation Plan (MTP) establishes a 20-year vision for multimodal transportation and outlines the State's transportation policies and priorities to proactively address these shifts. The MTP outlines strategies that support a new framework for transportation investments. **Figure 1.2** shows the four broad drivers which shape the State's transportation emissions pathways through 2030 and beyond.

Figure 1.2 Drivers and Trends

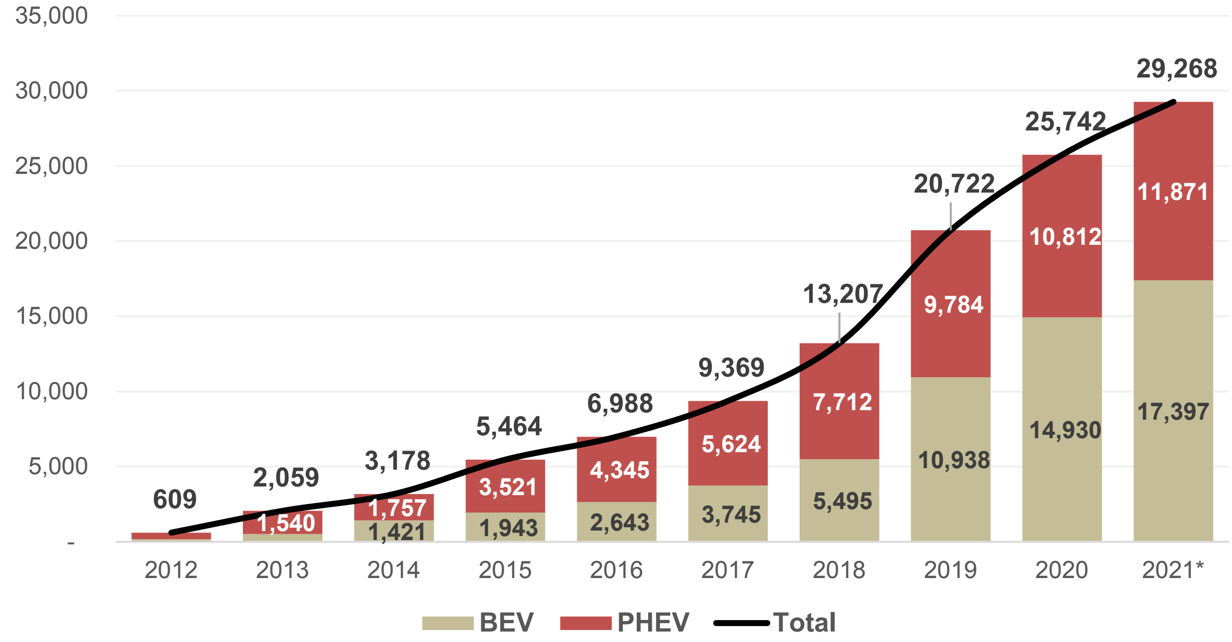


Economic shifts and changing demographics are the key drivers of demand for travel in Maryland. MDOT's balanced transportation system connects system users and customers to life's opportunities. In areas of the state with high population density, residents tend to rely more on mass transit and non-motorized transportation modes, while those living in rural, ex-urban, and less populated areas rely on motor vehicles for connectivity and access.

Emerging **mobility and accessibility** trends toward a "sharing economy" in transportation and changing logistics and supply chain patterns will influence the use of the transportation system. Given the expansive scope of the origins and drivers of these trends, MDOT has very limited control in how they will play out. Through the MTP and other long-range planning activities, MDOT and its partners will balance demand and available resources to accommodate current needs and create the 2030 and beyond transportation network.

Maryland is a leader in adopting **transportation technologies**. Through the Clean Cars Program, Maryland adopted more stringent standards for vehicles purchased in the State. **Figure 1.3** shows the number of EVs registered by fiscal year since the start of the Clean Cars Program in 2011. MDOT also leads a workgroup dedicated to ensuring that CAV technology is deployed safely and thoughtfully on Maryland's roads. Through facilitation of enabling policies for innovative and low-emissions transportation technologies, MDOT is positioning Maryland to achieve the full potential GHG emission benefits afforded by new vehicle technologies.

Figure 1.3 Registered Electric Vehicles in Maryland by Fiscal Year



* FY 2021 registrations as of Dec 31, 2020

MDOT supports strategies across every mode of transportation – improving the customer experience on the transportation network by improving safety, reducing congestion, providing more convenient travel options, increasing connections between modes, and improving the flow of goods. MDOT's multimodal transportation investment **policy and funding** priorities demonstrate commitment to reducing emissions in the transportation sector.

MDOT tracks the total share of Consolidated Transportation Program (CTP) funding dedicated to projects that will help Maryland meet its climate change goals. In the FY 2020–2025 CTP, 65 percent (approximately $7.05 billion) of Maryland's $10.85 billion six-year major capital program are investments that will reduce GHG emissions. These investments range from connecting Maryland with expanded transit options to addressing highway congestion to optimizing waterways and intermodal facilities for trade.

The economic challenges and uncertainty surrounding the COVID-19 global pandemic have impacted virtually all MDOT operations and revenues. In response, MDOT has reduced its revenue projections. Estimated State revenues for the Draft FY2021 – FY2026 CTP are $2.6 billion less than the estimates for the FY2020 – FY2025 CTP (reducing total projected capital spending by almost 18 percent).

2. 2030 Modeling Approach and Considerations

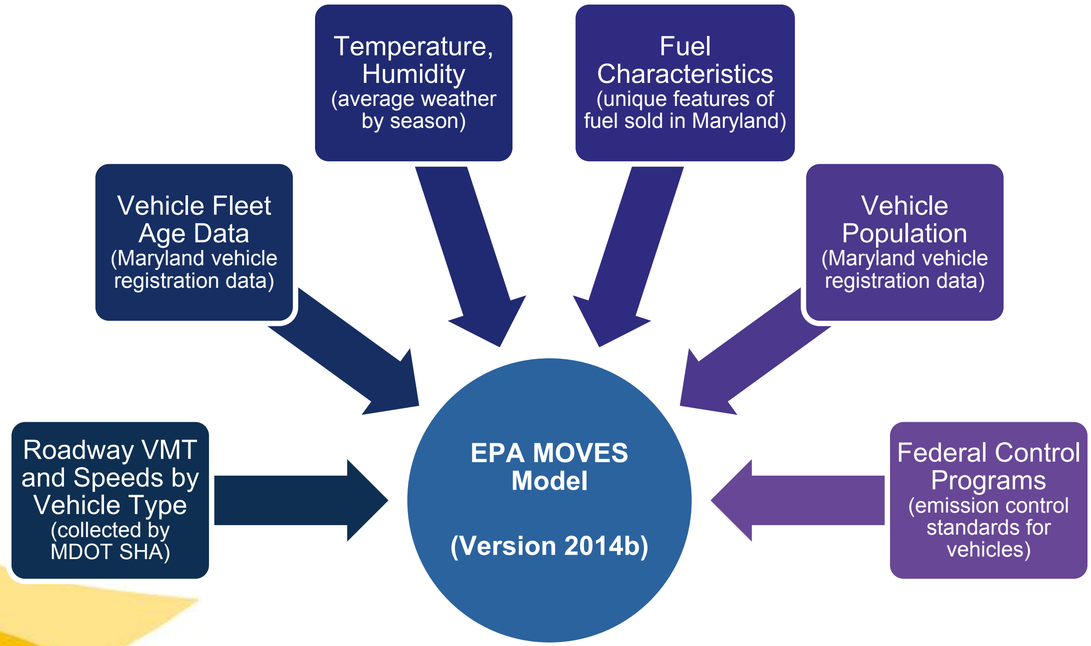
Emission reduction strategies and scenarios in this Plan pivot from the 2006 Base Year GHG emissions inventory. MDOT refers to 2006, 2014, and 2017 inventories as “Baseline Scenarios.”

- The 2006 Baseline Inventory established the base conditions for the GHG reduction goals in the GGRA (25 percent by 2020 and 40 percent by 2030). The on-road portion of the emissions inventory represents a “bottom-up” approach to estimating statewide GHG emissions based on travel speeds and traffic volumes. This approach utilizes emission rates from the U.S. Environmental Protection Agency’s (EPA) MOVES (Motor Vehicle Emissions Simulator) model and Maryland reported VMT.
- GHG emission estimates for on-road transportation in 2014 and 2017 baselines reflect an update to actual conditions based on the process for developing EPA’s National Emissions Inventory (NEI). The statewide inventories represent traffic conditions based on roadway segment counts, reported speed data from MDOT State Highway Administration (SHA), and the vehicle technology standards in place for each inventory.

Technical Approach

MDOT’s technical approach to analyzing GHG emission outcomes and co-benefits continues to evolve with new and updated tools. In addition, there are new assumptions for consideration with each iteration of inventory development, including economic growth, socioeconomics, vehicle and fuel technology, and transportation funding trends. As in prior analysis, the EPA’s MOVES model remains the primary tool for estimating on-road GHG emissions. This model has improved from previous MDOT analyses, as have the inputs from MPO metropolitan transportation plans and statewide planning forecasts. **Figure 2.1** highlights the primary inputs into the MOVES model for each emissions inventory.

Figure 2.1 Emissions Inventory Modeling and Inputs



2030 Reference Case

The 2030 Reference Scenario includes the Maryland Clean Cars Program and federal vehicle technology and fuel economy standards, and federal renewable fuels standards in place in 2020 (at the time of emissions modeling). Implementation of these state and federal vehicle and fuel standards yields a substantial GHG emissions reduction for on-road emissions from cars and trucks through 2030. The technology advances are designed to improve vehicle fuel economy and reduce average GHG emissions per mile. The benefits will increase over time as older vehicles are replaced with newer vehicles. A summary of these standards is presented in **Table 2.1**.

Table 2.1 2030 Approach Overview – Standards and Programs

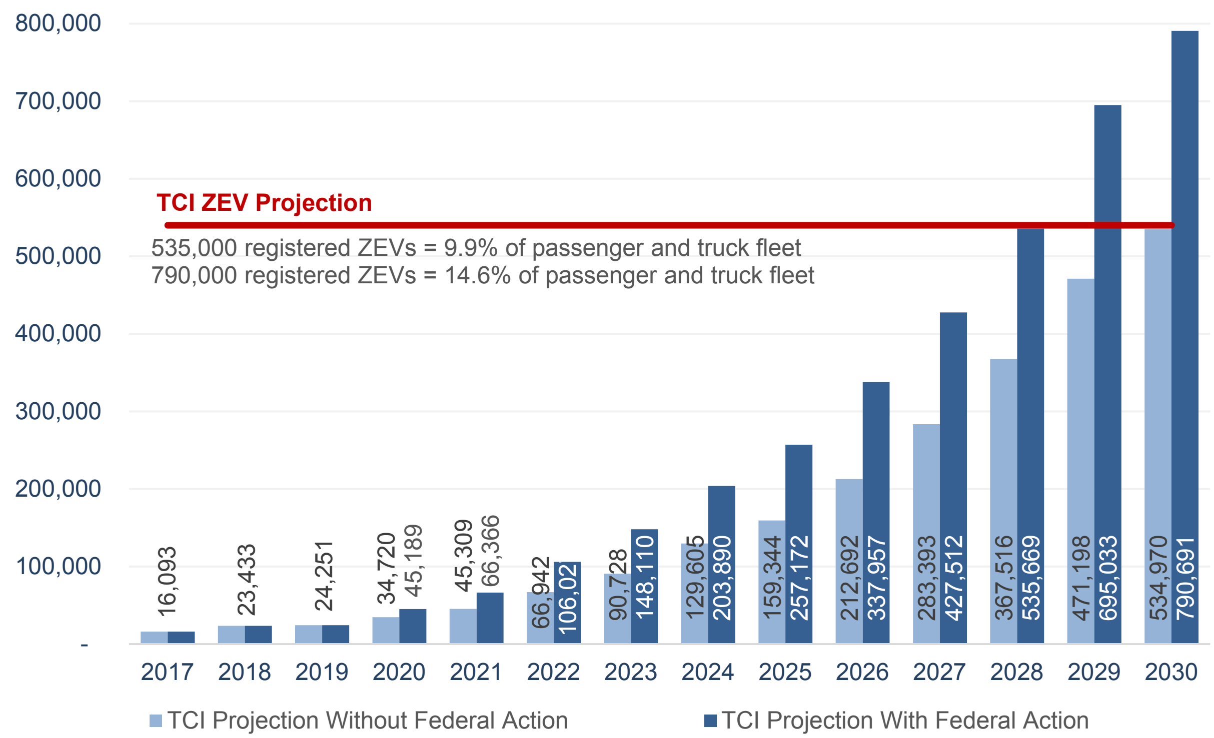
Light-Duty Vehicle (passenger cars and trucks) Standards
• ***The Maryland Clean Car Program (Model Year 2011)*** – Implements California's Low-Emission Vehicle (LEV) standards to vehicles purchased in Maryland. The California LEV program also includes goals for the sale of EVs (adopted 2007). • ***Corporate Average Fuel Economy (CAFE) Standards (Model Years 2008-2011)*** – Vehicle model years through 2011 are covered under CAFE standards. These remain intact under the National Program. • ***National Program (Model Years 2012-2016)*** – The light-duty vehicle fuel economy standards for model years between 2012 and 2016. The fuel economy improvements increase over time until an average 250 gram/mile CO_2 standard is met in 2016. This equates to an average fuel economy near 35 mpg (published May 2010). • ***National Program Phase 2 (Model Years 2017-2020)*** – The light-duty vehicle fuel economy standards for model years between 2017 and 2020. These standards were projected through model year 2025 but were replaced by the SAFE Vehicle Rule. (The National Program Phase 2 was originally published October 2012.) • ***Safer Affordable Fuel-Efficient (SAFE) Vehicle Rule (Model Years (2021-2026)*** – The light-duty fuel economy standards for model years 2021-2026. SAFE replaces the Phase 2 National Fuel Economy Program. Under SAFE, the rollback to standards equate to an estimated miles per gallon efficiency of 40.4 mpg compared to the previous rule that would have achieved 54.5 mpg (published April 2020). Note, this rule is currently under review per Executive Order by the Biden Administration on January 20, 2021.
Medium-/Heavy-Duty Vehicle (trucks and buses) Standards
• ***Phase 1 National Medium and Heavy Vehicle Standards (Model Years 2014-2018)*** – Fuel efficiency and GHG standards for model years 2014 to 2018 medium- and heavy-duty vehicles. The new rulemaking adopted standards for three main regulatory categories: combination tractors, heavy-duty pickups and vans, and vocational vehicles (published September 2011). • ***Phase 2 National Medium and Heavy Vehicle Standards (2018 and Beyond)*** – The Phase 2 fuel efficiency and GHG standards for medium- and heavy-duty vehicles for model year 2018 and beyond. The standards apply to four categories of medium- and heavy-duty vehicles: combination tractors, heavy-duty pickups and vans, vocational vehicles and trailers to reduce GHG emissions and improve fuel efficiency. The standards phase in between model years 2021 and 2027 for engines and vehicles, and between model years 2018 and 2027 for trailers (published October 2016).
Fuel Standards
• ***Tier 3 vehicle and fuel standards*** – The rule establishes more stringent vehicle emissions standards and will reduce the sulfur content of gasoline from current average level of 30 ppm to 10 ppm beginning in 2017. The gasoline sulfur standard will make emission control systems more effective for both existing and new vehicles and will enable more stringent vehicle emission standards. The vehicle standards will reduce both tailpipe and evaporative emissions from gasoline powered vehicles (published April 28, 2014). • ***The Federal Renewable Fuel Standard Program (RFS2)*** – Mandates the use of 36 billion gallons of renewable fuel annually by 2022 (published March 2010). Based on an approach utilized by the Metropolitan Washington Council of Governments (MWCOG), the use of renewable fuels will represent a 2 percent reduction in total on-road gasoline CO_2 emissions in 2030.

Electric Vehicles

Initiatives to encourage the purchase and use of electric and other low and ZEVs are part of Maryland's efforts to reduce emissions from mobile sources by providing alternatives to conventional internal combustion engine vehicles. EVs include battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs). Achieving the goals as part of Maryland's participation within the [ZEV Memorandum of Understanding] (ZEV MOU) reflects a commitment to a low-emissions fleet that goes beyond what the federal standards require. The path from nearly 30,000 PHEVs and BEVs registered in Maryland in December 2020 to between 535,000 vehicles (without Federal action) and 790,000 vehicles (with Federal action) by 2030—as estimated by the Transportation and Climate Initiative (TCI)—will require a combination of opportunities to come together. Maryland is striving to meet this goal through aggressive deployment of EVs and the charging stations necessary to support their adoption.

Figure 2.2 presents the projected ZEV deployment curve through 2030 starting from 2017. Costs to Maryland to facilitate this level of deployment includes up to $1.2 million annually through 2030 for the Electric Vehicle Recharging Equipment Rebate Program and other capital costs associated with matching federal grants to expand public EV charging infrastructure throughout Maryland.

Figure 2.2 ZEV Deployment Projections Through 2030



Multi-State Medium- and Heavy-Duty Zero Emission Vehicle MOU

In July 2020, Maryland signed the Multi-State Medium-and Heavy-Duty Zero Emission Vehicle (MHDV) MOU, joining 14 other states and the District of Columbia, to address GHG pollution from medium-and heavy-duty vehicles through the electrification of large pick-up trucks and vans, delivery trucks, box trucks, school and transit buses, and long-haul delivery trucks.

The Multi-State MHDV MOU will identify barriers to the electrification of medium- and heavy-duty vehicles and will develop solutions to support the deployment of zero emission medium-and heavy-duty vehicles. The MHDV MOU identifies a target of 30 percent of all medium- and heavy-duty vehicle sales will by ZEVs by 2030. Maryland has outlined a Maryland Clean Truck Planning Framework that engages stakeholders and communities to collaboratively develop an action plan to reduce air pollution and GHG emissions from the trucking industry, while preserving existing jobs and creating new jobs.

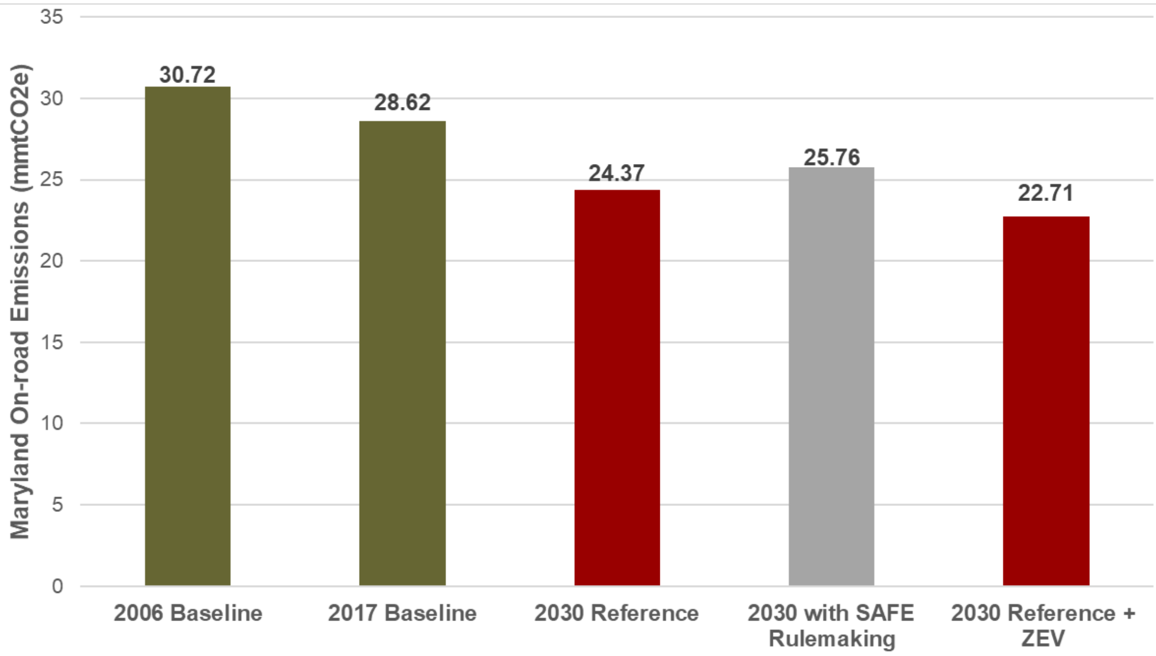
2030 Reference Scenarios Emission Outcomes

With the full implementation of federal standards through 2030, total on-road GHG emissions could decrease by 6.35 mmt CO_2e compared to 2006, bringing 2030 emissions to 20 percent below 2006 emissions.

The impact of the SAFE Vehicles Rule through 2026 model year is forecast to increase GHG emissions by 1.39 mmt CO_2e. This result represents a potential worst-case scenario associated with implementation of the SAFE Vehicles Rule. Ultimately, the emissions impact of this standard change is uncertain given the executive action noted in **Table 2.1** and that auto manufacturers may choose to exceed federal standards, particularly in state's like Maryland that are committed to the California standards. **Figure 2.3** presents each component of the Baseline Scenarios and the Reference Scenario.

If fuel economy standards continue to increase by five percent per year from 2026 through 2030, an additional decrease of 0.80 mmt CO_2e would result from the vehicle technology standards. This assumption has been included under Policy Scenario 2 given the uncertain standards beyond 2025.

Figure 2.3 Baseline and Reference Scenarios



Presuming the current federal vehicle standards are fully implemented, and Maryland meets the 535,000 EV goal by 2030, **total on-road GHG emissions could decrease by another 1.66 mmt CO_2e, bringing 2030 emissions to 26 percent below 2006 emissions.**

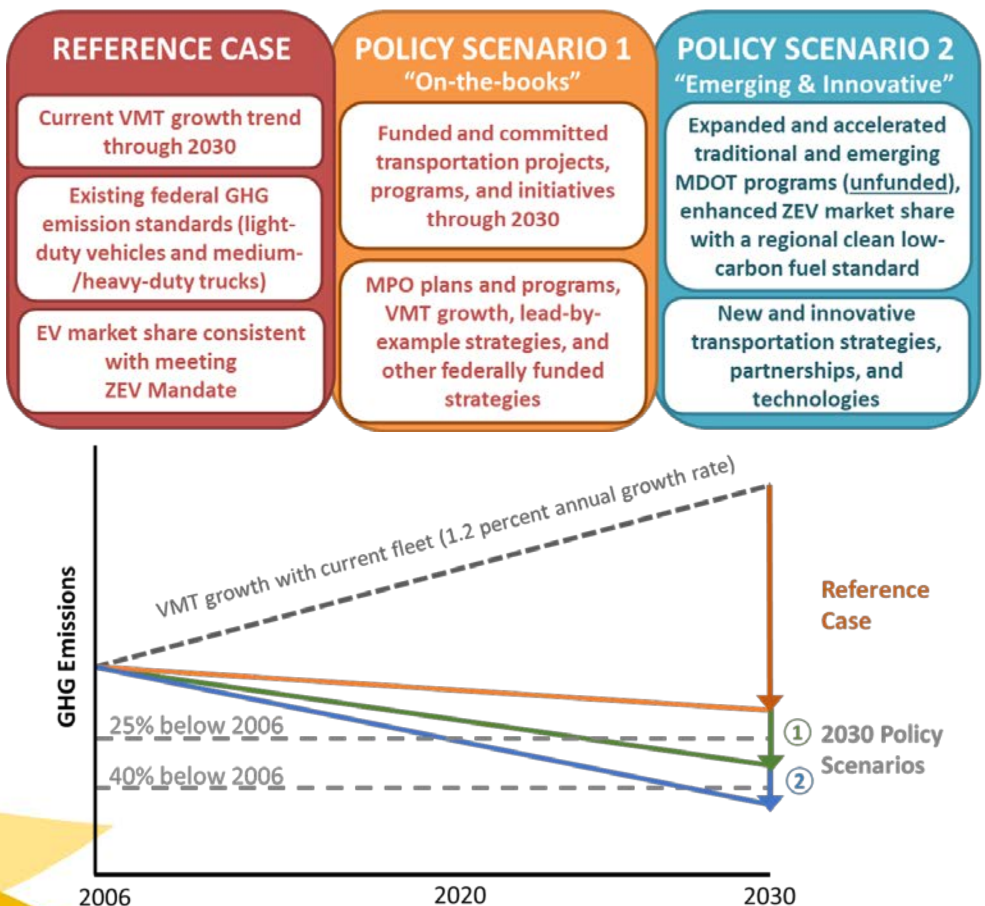
2030 Strategies and Scenarios Development

MDOT has developed scenarios and associated strategies, consistent with the goals, objectives, and strategies in the 2040 MTP, to put Maryland's transportation sector on a path toward the "40 by 30" goal. While there is some certainty established with transportation funding over the next six years (2020 – 2025) through the CTP, there are significant projects and programs in early planning stages, plus other technological changes such as the shift to an electric fleet, automated and connected vehicles, and the rise of mobility-on-demand services that could greatly change the landscape through 2030. **Appendix B** lists each GHG mitigation strategy evaluated under the two policy scenarios, with strategy descriptions and underlying contextual and cost assumptions. MDOT coordinated its scenario organization and strategy assumptions with MDE for maintaining consistency with the Mitigation Work Group (MWG):

- **Policy Scenario 1:** Extension of the current policy and program framework within the Reference Case including funded plans, projects, and programs; and
- **Policy Scenario 2:** New programs and policies beyond Policy Scenario 1 that are not currently funded.

Figure 2.4 depicts the overall strategy and high-level definitions for this scenario approach focused on the on-road transportation sector. Off-road transportation strategies and scenarios (aviation, marine, and rail) are developed and analyzed through a partnership approach between MDOT and MDE and presented separately.

Figure 2.4 2030 Scenarios and Strategies Approach



3. Policy Scenario 1 – On-the-Books

Policy Scenario 1 includes projects and programs funded within MDOT's 2020-2025 CTP, expected investments in continuing MDOT GHG emission reduction strategies included in current (2021-2026) and future CTPs through 2030, as well as projects in fiscally constrained MPO metropolitan transportation plans for implementation by 2030.

2030 Plans and Programs

MDOT continually takes steps to plan, invest in, and evaluate the transportation system to ensure it connects customers to key destinations–enabling a growing economy. MDOT sets a vision for the transportation system through the MTP, which is then implemented through the six-year budget for transportation, projects produced annually as the CTP. In coordination with MDOT, Maryland's MPOs develop federally required metropolitan transportation plans. These plans carefully combine locally driven projections of future land use with stakeholder input on transportation needs to develop fiscally constrained list of long-term transportation investments over the next 25 years. The 2030 Plans and Programs use information from the CTP, each MPO plan, and land use, population, and employment projections from the Maryland Department of Planning (MDP) to estimate the emission trendline through 2030. The plans and programs are also referenced in this report as "on-the-books" (or Policy Scenario 1) to reflect that these actions are programmed for implementation by MDOT.

The primary benefit of the plans and programs relative to the Reference Scenario is the reduction in VMT and improved operational efficiency of the multimodal transportation system. **Figure 3.1** presents Maryland's VMT trend since 2006 and the alternative VMT projections (Reference Case compared to Policy Scenario 1) for 2030.

Other "On-the-Books" Strategies

Along with the traditionally funded transportation programs and investments assumed within the 2030 Plans and Programs, Policy Scenario 1 also assumes other "on-the-books" strategies that have been implemented with funding from Federal agencies (like the Department of Energy, EPA, and others) for improving air quality and reducing GHG emissions. Examples include Diesel Emissions Reduction Act (DERA) funding to replace or repower diesel engines, marine vessels, and cargo handling equipment. One such strategy includes MDOT MPA's support to replace dray trucks, which results in air quality benefits within the Port of Baltimore area where they operate. Policy Scenario 1 also estimates the emissions impacts of current diesel transit bus replacement policies toward clean diesel and compressed natural gas for MDOT MTA, locally operated transit systems (LOTS), Washington Metropolitan Area Transit Authority (WMATA), and Baltimore/Washington International Thurgood Marshall (BWI) Airport shuttle buses.

Strategy, Emissions, and Cost Summary

Table 3.1 lists the Policy Scenario 1 strategies, GHG reduction potential, and estimated costs for implementation. For example, investments in MPO plans and programs yield the highest emission reduction, but also have the highest cost ($10.1 billion).

Figure 3.1 VMT and VMT per Capita Trends, including Policy Scenario 1

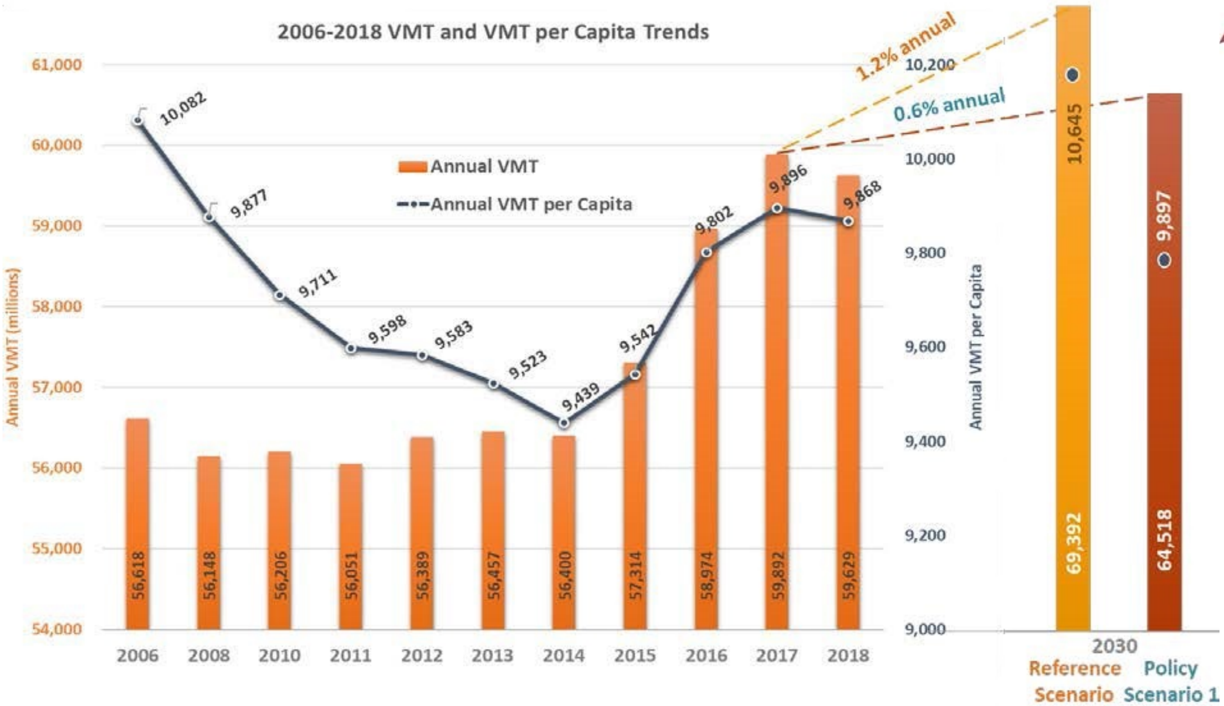


Table 3.1 Policy Scenario 1 Strategies Summary Table

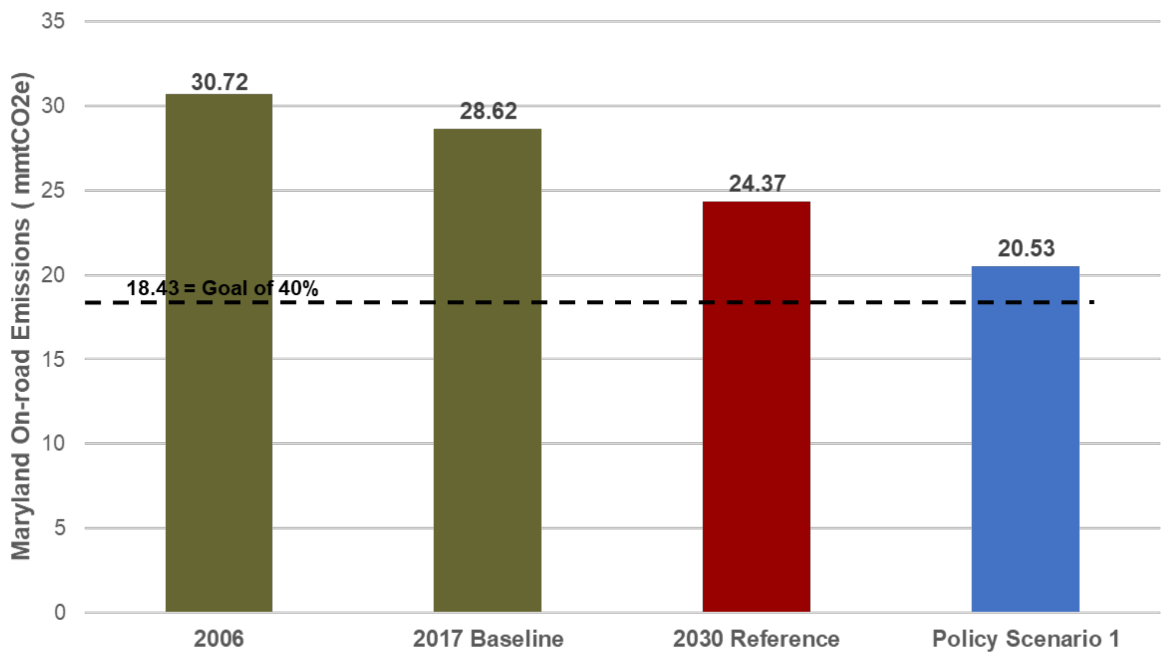
Strategies (Funded)	GHG Emission Reduction (mmt CO_2e)	Estimated Costs ($M)
2018/2019 MPO Plans & Programs yield lower annual VMT growth (estimated at 0.6% per year growth)	1.712	$10,146.5
On-Road Technology (CHART, Traveler Information)	0.142	$247.0
Freight and Freight Rail Programs (National Gateway, Howard Street Tunnel, MTA rail projects)	0.037	$503.2
Public Transportation (New rail or bus capacity or frequency, improved operations)	0.011	$2,009.8
Public Transportation (50% EV transit bus fleet)	0.074	$625.1
Intercity Transportation Initiatives (Amtrak NE Corridor, Intercity bus)	0.006	$0.0
Transportation Demand Management	0.146	$63.9
Pricing Initiatives (Electronic Tolling)	0.022	$188.5
Bicycle and Pedestrian Strategies (current program continuation and expansion through 2030)	0.024	$263.8
Port of Baltimore Drayage Track Replacements	0.005	$18.0
BWI Airport parking shuttle bus replacements	<0.001	$26.1
MDOT Vehicle Fleet (Fleet Innovation Plan)	0.006	n/a
Total Policy Scenario #1	**2.19**	**$14,091.9**

Emissions Outcomes

Figure 3.2 presents the emission outcomes from Policy Scenario 1, compared to the 2030 Reference and the 2006 and 2017 Baselines.

- **The total estimated statewide reduction in 2030 is 2.19 mmt CO_2e. This brings the emissions levels to 20.53, resulting in 2030 emissions at 33.2 percent below 2006 emissions (*2.10 mmt CO_2e short of the 18.43 mmt CO_2e goal*).**
- Strategies that reduce VMT, including the plans and programs and other on-the-books strategies, result in a total reduction of **5.585 billion VMT in Maryland by 2030, equivalent to an 8 percent VMT reduction** relative to business-as-usual VMT growth.

Figure 3.2 Policy Scenario 1 Emission Outcomes



Implementation

Strategies listed as part of Policy Scenario 1 are funded in the six-year MDOT CTP (FY 2020-FY 2025), MPO metropolitan transportation plans, or through federal grants and funding sources. The total cost of Policy Scenario 1 is $14.092 billion in capital investment through 2030. This does not include additional operating costs for expanded transit or other services implemented by 2030. The objective of constructing Policy Scenario 1 is to group programs and strategies that are completely funded or expected to be funded based on current funding levels and assumptions, and thereby have a high certainty of successful implementation by 2030.

The challenges for Policy Scenario 1 strategies include widely acknowledged concerns such as diminishing fuel tax revenue relative to infrastructure costs, which is a primary funding mechanism for the Maryland Transportation Trust Fund (TTF). Another related challenge is continued diminishing returns relative to needs from federal sources, particularly formula funds provided through Federal Highway Administration (FHWA) and Federal Transit Administration (FTA). MDOT and its partners also have to deliver this program, while at the same time prioritizing funds to support maintaining and operating Maryland's multimodal transportation system.

4. Policy Scenario 2: Emerging and Innovative

This scenario envisions implementing two distinct categories of GHG mitigating strategies—emerging and innovative strategies. The key distinction between the Policy Scenario 1 strategies and these strategies is the potential funding available for implementation. Funding sources for emerging and innovative strategies have not been finalized in any planning documents by federal, State, local or private agencies. For a number of these strategies, MDOT has limited control in their execution. Some of these strategies are driven by market forces that require MDOT to play the role of a facilitator enabling supportive policy and regulatory framework for their implementation.

Emerging Strategies

Emerging strategies can be defined as logical next steps for strategies that are currently funded in Policy Scenario 1, whose implementation requires one or more of the following:

- Full implementation of a strategy where current fiscally constrained plans have not identified the complete funding approach.
- Expanded application of the strategy by enhancing its geographic scope, accelerated implementation of a strategy that would otherwise not be implemented before 2030, and implementation ramp-up of a strategy involving its intensity of application.
- Strategies that have been implemented in peer states that could work in Maryland.
- Expanded policy impetus and partnerships for a regional scale strategy application.

Emerging strategies have a demonstrable record of mitigating emissions based on practice. However, there is still some uncertainty, especially as it relates to the rate of adoption of new technologies by policymakers and the general public. Examples of such strategies include adoption of EVs by the public and transition to an electric bus fleet by transit agencies.

Innovative Strategies

Among the strategies grouped under innovative strategies in Policy Scenario 2 are those that are “disruptive” or undergoing breakthroughs in innovation, having impact on a significant user base and broad market reach, and having the potential to alter status quo in the way people make and execute their travel choices. These strategies are also characterized by uncertainty in the technological and policy maturity that is required for widespread adoption. Examples of strategies that require policy and technological maturity are CAV technologies, zero emission truck corridors, and SCMAGLEV or Loop. Some strategies have been implemented on a controlled or limited scale by pioneering jurisdictions—for example, freight consolidation centers and variable speed management corridors. MDOT’s role in implementing some of these strategies is by playing the role of a facilitator and a policy regulator. MDOT can facilitate by providing a safe and conducive environment for Maryland residents and businesses to adopt these new technologies. Challenges to implementing some of these strategies include public funding availability, technological maturity, MDOT’s limited role in strategy facilitation or rolling out an enabling regulatory framework, partnerships with the private sector, transportation safety and data security and privacy, and concerns surrounding public acceptance (for example, speed management on freeways).

Strategy, Emissions, and Cost Summary

Table 4.1 shows a breakdown of estimated GHG reductions between emerging and innovative solutions as well as the estimated cost presented as ranges. The reason for presenting this information in ranges has to do with uncertainty due to scope and intensity of implementation and other externalities that determine their effectiveness by the year 2030.

Table 4.1 Policy Scenario 2 Strategies Summary Table

Strategies (Unfunded)	GHG Emission Reduction (mmt CO_2e)	Estimated Costs ($M)
Emerging Strategies		
TSMO/Integrated Corridor Management (Limited Access System)	0.08 to 0.14	$108 to $152
TSMO//Integrated Corridor Management (Arterial System)	0.10 to 0.18	$453 to $680
Variable Speeds/Speed Management	0.01 to 0.02	$108 to $152
Intermodal Freight Centers Access Improvement	0.02	$2,240 to $3,136
Commercial Vehicle Technologies (Idle Reduction, Low-Carbon Fleet, Dynamic Routing)	0.03 to 0.05	Uncertain §
Regional Clean Fuel Standard	0.895	$148
Eco-Driving (informal implementation underway)	0.042	$3 to $5
EV Market Share Ramp-up of an additional 255,000 vehicles	0.88	$140
Extended CAFE Standards (Model Years 2026-2030)	0.80	$0
Transit capacity/service expansion (fiscally unconstrained)	0.019 to 0.039	$2,307 to $2,659
MARC Growth and Investment Plan / Cornerstone Plan	0.038 to 0.054	$1,078
Transit-Oriented Development (TOD) Build-Out (20 zones)	0.033	$4 to $8
50% to 75% EV Transit Bus Fleet	0.081 to 0.103	$93
Expanded TDM strategies (dynamic)	0.274 to 0.972	$15 to $30
Expanded Telework	0.300 to 0.793	$100 to $200
Expanded bike/pedestrian system development	0.040 to 0.051	$103
Innovative Strategies		
Autonomous/Connected Vehicle Technologies	0.68 to 0.73	$43 to $63
Zero-Emission Truck Corridors	0.03 to 0.06	$34 to $128
Freight Villages/Urban Freight Consolidation Centers	0.03 to 0.04	$4,705 to 6,893
Speed Management on Freeways (increased enforcement)	0.04 to 0.20	$7 to $14
High-Speed Rail/SCMAGLEV	0.011 to 0.021	$45,300 to $47,300
Pay-As-You-Drive Insurance	0.123 to 0.292	n/a §§
Total Policy Scenario #2 “Emerging and Innovative”	**4.539 to 6.417**	**$56,893 to $62,886**

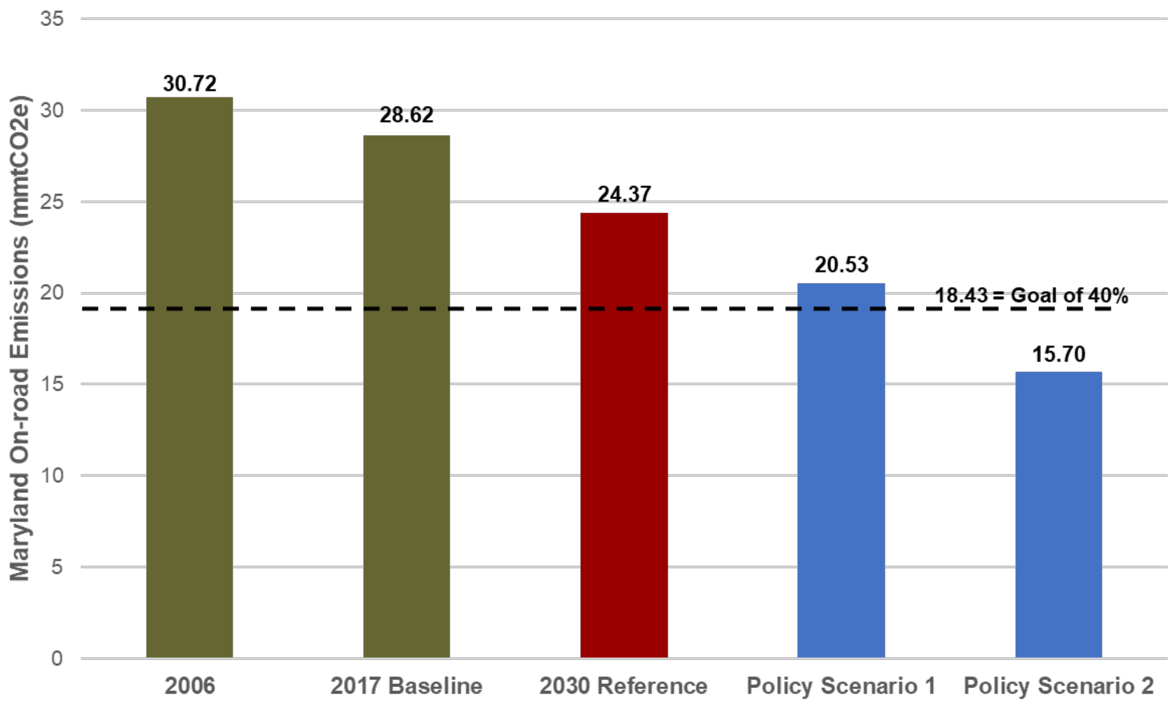
§ Policy change with potential incentive program. Uncertain costs.
§§ Policy action with supportive technology/programs offered by private sector.

Emissions Outcome

Figure 4.2 presents the emission outcomes from Policy Scenario 2, compared to the 2030 Reference and the 2006 and 2017 Baselines.

- The total estimated statewide reduction in 2030 under Policy Scenario 2 is estimated between 4.539 and 6.417 mmt CO_2e. This brings emissions levels to 15.70 mmt CO_2e (low range) to 13.99 mmt CO_2e (high range), demonstrating reduction well beyond the 2030 goal.
- Policy Scenario 2 strategies that reduce VMT result in a total reduction of 4.034 billion VMT (low range) in Maryland by 2030, which is lower compared to the reduction from the Policy Scenario 1. This is due to the majority of Policy Scenario 2 strategies being focused on new technologies and system efficiencies rather than additional transportation capital investments, which are uncertain to be implemented by 2030 given resource realities.

Figure 4.2 Policy Scenario 2 Emissions Outcomes



Implementation

Policy Scenario 2 strategies are currently not funded within MDOT's CTP or the MPO's metropolitan transportation plans for implementation by 2030. Policy Scenario 2 total estimated costs, not including potential investments in SCMAGLEV or Loop, ranges from $11.593 billion up to $15.585 billion.

These strategies require dedicated funding sources outside the current traditional investment sources. It should be noted that some these strategies require significant funding (comparable to the level of the State's entire CTP), which is indicative of challenges to their implementation. MDOT's role in implementation of these strategies is lower than that of the emerging strategies as the driving factors for the successful implementation of many of these strategies involve market forces and require significant share of private funding for execution.

5. Implementation Challenges, Opportunities, and Next Steps

As highlighted by the results presented in this Plan, the on-road transportation sector in Maryland could achieve the “40 by 30” goal. There are a multitude of approaches MDOT and its partners could take to facilitate achievement of the goal. These include substantial investments in multimodal options and financial and policy support of new technologies to push more people and goods toward cleaner and more efficient modes, and to improve the efficiency of transportation system operations. However, many of the most significant GHG reduction strategies are mostly outside the control of MDOT, including notable examples like EV market penetration, CAV technology, and expanded telework.

Maryland’s multimodal transportation network faces a number of challenges including continued need to maintain and modernize infrastructure and ensure the safe and efficient movement of people and goods. MDOT continues to monitor changing transportation needs associated with technological, societal, demographic, land use, climate, and other environmental changes. Opportunities and challenges come hand-in-hand as increasing number of residents and employers in the State will generate additional revenue, but they will also demand services, including transportation services, which could require increased spending. The impact of transportation-related technological changes such as CAVs, EVs, and the shared mobility economy is uncertain, given that the technology maturity and market penetration are yet to play out in the marketplace. MDOT maintains and delivers a transportation system that addresses these challenges to ensure that Maryland remains a great place to live, work, and do business.

Across all of these challenges, Maryland faces the overarching uncertainty associated with the transportation-funding picture through 2030:

- Needs continue to far outweigh available resources and revenues;
- The federal funding picture continues to trend toward a competitive grant program, with less reliance on traditional formula-based funding; and
- Traditional revenue sources are producing less relative to growing demand, particularly as trends continue toward more efficient vehicle and lower ownership rates.

Maryland’s transportation needs are comprised of the costs required to operate and maintain the current transportation system, and to expand services and infrastructure as needed. These costs include operation and maintenance (O&M) expenses, capital needs as provided by MDOT’s six transportation business units (TBUs), and Maryland’s share of financial support form the WMATA system. O&M expenses include the costs of service for more than 100 million annual transit trips, maintenance of highways, bridges and tunnels, dredging for the Port of Baltimore, and operations for the BWI and MTN airports.

Transportation Revenue Sources

Transportation programs and projects in Maryland are primarily funded from an integrated account called the TTF from sources including motor fuel tax, rental car sales tax, titling tax, corporate income tax, operating revenues, federal aid, motor vehicle taxes and fees, and bond sales. The distribution of revenue is subject to a number of federal and state laws that constrain how and for what system revenues can be assigned. More detail on this process is available within documentation in the CTP.

Environmental Co-Benefits

Ensuring environmental protection and sensitivity is a goal of the 2040 MTP. The goal focuses on strategies to deliver sustainable transportation infrastructure improvements that protect and reduce impacts to Maryland’s natural, historic, and cultural resources.

The strategies, policies and programs implemented as part of the two policy scenarios, also achieve substantial reductions of the National Ambient Air Quality Standards (NAAQS) criteria pollutants, including ozone producing volatile organic compounds (VOC) and nitrogen oxides (NOx), and fine particulates (PM2.5). Transportation related control measures and improvements to vehicle technologies that reduce ozone and PM2.5 have been included in State Implementation Plans (SIP) and transportation conformity determinations. These measures are major contributors to meeting the State's air quality goals and have proven to be effective in attaining the NAAQS for ozone and fine particulates.

Advanced vehicle and fuel technologies and the draft GGRA Plan scenarios not only reduce criteria pollutant and GHG emissions, but also indirectly will reduce on-road transportation sources impact on Maryland's water quality and diverse and sensitive ecosystems.

Other Benefits

Public Health. Reductions in emissions could help prevent premature deaths and asthma cases in Maryland, translating to reductions in public health costs. Continued investment in bicycle and pedestrian systems can foster healthier lifestyles for Maryland residents.

Equity. The MTP goals recognize the importance of Maryland's transportation system in facilitating access for the aging population and supporting growth and diversification of economic activity in disadvantaged communities. The increase in older and non-working transportation users could change travel patterns and travel times and affect public transportation agencies, non-profit transportation providers, and/or private providers. While Maryland's largest employment centers are in the Baltimore and Washington regions, other parts of the State require transportation investments to ensure the continued growth of their economies. Striking a balance between congested and growing areas and slower growth areas in need of investment continues to be a key consideration within short- and long-range multimodal planning in Maryland. Many of these communities also lack access to reliable and cost-effective travel choices, which limits access to services, health care, education, and jobs. A number of strategies within this Plan can help address these barriers, especially when they are implemented in a context-sensitive and community supported manner.

Consumer Cost Savings. Adoption and implementation of the two policy scenarios would likely lead to cost increases initially in the form of upfront costs as consumers purchase more advanced clean vehicles. These increases would be more than offset in a short term by cost savings from reduced fuel use (because consumers are driving more fuel-efficient vehicles and driving less as a result of more and improved multimodal options), reduced vehicle maintenance costs (also because they are driving less), and incentives and discounts (to promote clean vehicles).

Business Cost Savings. Adoption and implementation of the two policy scenarios would likely lead to businesses experiencing initial cost increases due to higher vehicle prices and other policies that may be implemented to increase transportation revenue. Over time, savings from reduced fuel use and vehicle maintenance costs, as well as reductions in labor costs due to relieved congestion and the availability of more cost-effective freight options would quickly offset these increases.

Looking Toward 2050

The transportation sector faces unique challenges when considering potential pathways to an 80 percent reduction in 2006 GHG emissions by 2050. These challenges are associated with current and emerging disruptors in multimodal passenger and freight transportation, including CAVs, EVs, smart and shared mobility, evolving manufacturing and logistics patterns, and emerging modes and ownership models. These disruptors are playing out at the same time as an uncertain transportation revenue future is layered over a system facing increasing system preservation and resilience needs. MDOT's MTP, MPO metropolitan transportation plans, and other state and regional plans have identified these needs and uncertainties through 2040 and beyond, however, to date, few, if any have attempted to quantify the potential range of impacts, they may create to Maryland's transportation system, including GHG emissions.

While the current 2030 scenario analysis has been able to project the scope and anticipated levels of implementation for current and planned transportation emission reduction strategies and their anticipated benefits over the next decade, MDOT is considering an approach to 2050 scenario analysis, which would allow for a more comprehensive view of the degree of uncertainty that a 30-year period of forecasting entails, with 2050 scenarios built on macro-indicators (such as technology, VMT growth, freight patterns, socioeconomics, location choices, mode choice). **Figure 5.1** presents some perspectives on the opportunities, challenges, and uncertainty facing the transportation sector through 2050. As further analysis in 2021 begins to look at 2050, these areas will represent a starting point for evaluating GHG emission reduction opportunities.

Figure 5.1 2050 Perspective on Opportunities, Challenges, and Uncertainty

GHG Emissions Opportunity

Trends and drivers that present inherent opportunities to decrease GHG emissions from the transportation sector

- **Federal GHG Emission Standards**
- **ZEV market share growth**
- **Transition to an electric transit fleet**

GHG Emissions Challenge

Trends and drivers that present inherent challenges to mitigating GHG emissions in the transportation sector

- **Population and VMT growth**
- **System delay and reliability**
- **Transportation costs**

Uncertain

Trends and drivers where there are too many uncertainties in transportation sector impacts or extent of relevance through 2030

- **Autonomous and connected vehicles**
- **Mobility as a service**
- **Change in freight logistics patterns**
- **Climate impacts and system resiliency**

Appendix A. 2017 Baseline and 2030 Technology Scenario Emissions Inventory Documentation

This technical analysis report documents the methodology and assumptions used to produce the greenhouse gas (GHG) inventory for Maryland's on-road portion of the transportation sector. Statewide emissions have been estimated for the 2017 baseline and 2030 forecast technology scenario based on the most recent traffic trends. The inventory was calculated by estimating emissions for carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Those emissions were then converted to carbon dioxide equivalents that are measured in the units of million metric tons (mmt CO_2e). Carbon dioxide represents about 97 percent of the transportation sector's GHG emissions.

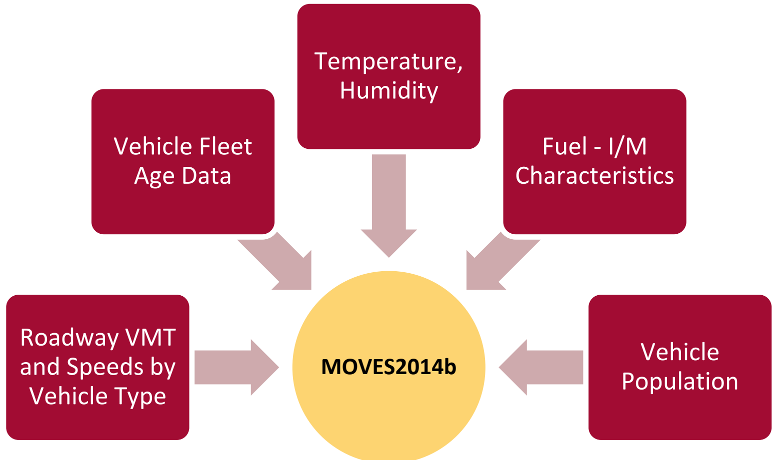
The on-road portion of the inventory was developed using EPA's emissions model MOVES2014b (Motor Vehicle Emissions Simulator) released in August 2018. The MOVES2014b model improves estimates of emissions from nonroad mobile sources and does not change the on-road emissions results of MOVES2014a. With MOVES, greenhouse gases are calculated from vehicle energy consumption rates and vary by vehicle operating characteristics including speed, engine size, and vehicle age.

On-Road Analysis Process

The data, tools and methodologies employed to conduct the on-road vehicle GHG emissions inventory were developed in close consultation with MDE and are consistent with the *MOVES2014, MOVES2014a, and MOVES2014b Technical Guidance: Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity, EPA-420-B-18-039, August 2018*. MOVES2014b incorporates all existing CAFE standards in place in 2017 plus: a) medium/heavy duty greenhouse gas standards for model years 2014-2018, b) light duty greenhouse gas standards for model years 2017-2025, and c) Tier 3 fuel and vehicle standards for model years 2017-2025.

As illustrated in Figure A.1, the MOVES2014b model has been integrated with local traffic, vehicle fleet, environmental, fuel, and control strategy data to estimate statewide emissions.

Figure A.1 Emission Calculation Data Process



The modeling assumptions and data sources were developed in coordination with MDE and are consistent with other SIP-related inventory efforts. The process represents a "bottom-up" approach to estimating statewide GHG emissions based on available roadway and traffic data. A "bottom-up" approach provides several advantages over simplified "top-down" calculations using statewide fuel consumption. These include:

- Addresses potential issues related to the location of purchased fuel. Vehicle trips with trip ends outside of the state (e.g. including "thru" traffic) create complications in estimating GHG emissions. For example, commuters living in Maryland may purchase fuel there but may spend much of their traveling in Washington D.C. The opposite case may include commuters from Pennsylvania working in Maryland. With a "bottom-up" approach, emissions are calculated for all vehicles using the transportation system.
- Allows for a more robust forecasting process based on historic trends of VMT or regional population and employment forecasts and their relationship to future travel. For example, traffic data can be forecasted using growth assumptions determined by the MPO through their analytic (travel model) and interagency consultation processes.

GHG emission values are reported as annual numbers for the 2017 baseline and 2030 technology scenarios. The annual values were calculated based on annual MOVES runs as summarized in Figure A.2. Each annual run used traffic volumes, and speeds that represent an annual average daily traffic (AADT) condition, and temperatures and fuel input parameters representing an average day in each month.

Figure A.2 Calculation of Annual Emissions

For the 2017 and 2030 technology scenario emissions inventories, the traffic data was based on roadway segment data obtained from the Maryland State Highway Administration (SHA). This data does not contain information on congested speeds and the hourly detail needed by MOVES. As a result, post-processing software (PPSUITE) was used to calculate hourly-congested speeds for each roadway link, apply vehicle type fractions, aggregate VMT and VHT, and prepare MOVES traffic-related input files. The PPSUITE software and process methodologies are consistent with that used for state inventories and transportation conformity analyses throughout Maryland.

Other key inputs including vehicle population, temperatures, fuel characteristics and vehicle age were obtained from and/or prepared in close coordination with MDE staff. The following sections summarize the key input data assumptions used for the inventory runs.

Summary of Data Sources

A summary of key input data sources and assumptions were developed in consultation with MDE and are consistent with the *MOVES2014, MOVES2014a, and Technical Guidance: Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity, EPA-420-B-18-039, August 2018* and are provided in Table A.1. Many of these data inputs are consistent to those used for SIP inventories and conformity analyses. Several data items require additional notes:

- Traffic volumes and VMT are forecasted for the 2030 technology scenario analysis. A discussion of forecasted traffic volumes and vehicle miles of travel (VMT) is discussed in more detail in the following section.
- Vehicle population is a key input that has an important impact on start and evaporative emissions. The MOVES Model requires the population of vehicles by the thirteen source type categories. For light duty vehicles, vehicle population inputs were prepared and provided by MDE for base year (2017). For the analysis year 2030, the vehicle population was forecasted based on projected household and population growth obtained from state and MPO sources. For heavy-duty trucks, vehicle population was calculated from VMT using MOVES default estimates for the typical miles per vehicle by source type (e.g. vehicle type). The PPSUITE post processor automatically prepares the vehicle population file under this method.
- The vehicle mixes are another important file that is used to disaggregate total vehicle volumes and VMT to the 13 MOVES source types. The vehicle mix was calculated based on 2017 SHA vehicle type pattern percentages by functional class, which disaggregates volumes to four vehicle types: light-duty vehicles, heavy-duty vehicles, buses, and motorcycles. As illustrated in Figure A.3, from these four vehicle groups, MOVES default Maryland county VMT distributions by source type was used to divide the four groups into each of the MOVES 13 source types.

Figure A.3 Defining Vehicle Types

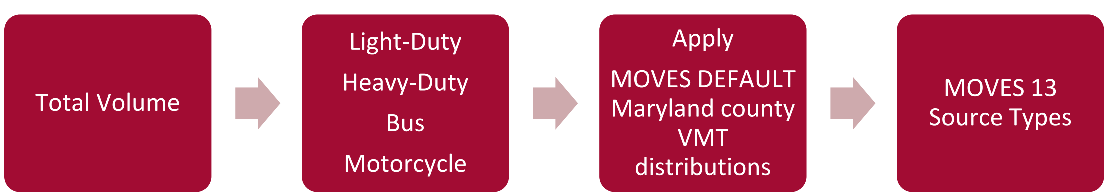


Table A.1 Summary of Key Data Sources

Data Item	Source	Description	Difference between 2017 and 2030Technology
Roadway Characteristics	2017 MDOT SHA Universal Database	Includes lanes, segment distance, facility type, speed limit	*Same Data Source*
Traffic Volumes	2017 MDOT SHA Universal Database	Average Annual Daily Traffic Volumes (AADT)	Volumes forecasted for 2030 technology scenario
Seasonal Adjustments	SHA 2017 *ATR Station Reports in the Traffic Trends System Report Module* from the MDOT SHA website	Used to develop day and month VMT fractions as inputs to MOVES to disaggregate annual VMT to daily and monthly VMT	*Same Data Source*
VMT	Highway Performance Monitoring System 2017	Used to adjust VMT to the reported 2017 HPMS totals by county and functional Class	VMT forecasted for 2030 technology scenario
Hourly Patterns	MDOT SHA 2016 *Traffic Trends System Report Module* from the SHA website	Used to disaggregated volumes and VMT to each hour of the day	*Same Data Source*
Vehicle Type Mix	2017 MDOT SHA vehicle pattern and hourly distribution data; MOVES default Maryland county VMT distributions	Used to split traffic volumes to the 13 MOVES vehicle source types	*Same Data Source*
Ramp Fractions	MOVES Defaults	MOVES Defaults	*Same Data Source*
Vehicle Ages	2017 Maryland Registration data; MOVES national default age distribution data	Provides the percentage of vehicles by each model year age	*Used 2017 registration data for light duty vehicles and MOVES2014 national default data for source types 61 & 62.*
Hourly Speeds	Calculated by PPSUITE Post Processor	Hourly speed distribution file used by MOVES to estimate emission factors	Higher volumes produce lower speeds in 2030
I/M Data	Provided by MDE	Based on current I/M program	Different I/M Program Characteristics
Fuel Characteristics	Provided by MDE	Fuel characteristics vary by year	Different Fuel Characteristics
Temperatures	Provided by MDE	Average Monthly Temperature sets	*Same Data Source*
Vehicle Population	Light duty vehicles: used vehicle population data provided by MDE for 2017 baseline and applied growth rates to forecast population to 2030	Number of vehicles by MOVES source type which impact forecasted start and evaporative emissions	2030 based on projected demographic and VMT growth

	Heavy duty trucks: Calculated by PPSUITE Post Processor; MOVES Default Miles/Vehicle Population Data

Traffic Volume and VMT Forecasts

The traffic volumes and VMT within the MDOT SHA traffic database were forecast to estimate future year emissions. Several alternatives are available to determine forecast growth rates, ranging from historical VMT trends to the use of MPO-based travel models that include forecast demographics for distinct areas in each county. For the 2030 technology scenario, the forecasts were determined based on historic trends of 1990-2017 highway performance monitoring system (HPMS) VMT growth. The average statewide annualized growth rate through 2030 for this scenario is 1.2 percent. Table A.2 summarizes the growth rates by county.

Table A.2 VMT Annual Growth Rates (Per Maryland CAP) for 2030 Technology Scenario

County	2030 Technology (Based on 1990-2017 HPMS)
Allegany	0.6%
Anne Arundel	1.2%
Baltimore	1.0%
Calvert	2.3%
Caroline	1.3%
Carroll	1.3%
Cecil	1.8%
Charles	1.6%
Dorchester	0.9%
Frederick	1.8%
Garrett	1.5%
Harford	1.1%
Howard	2.2%
Kent	0.0%
Montgomery	0.9%
Prince George's	1.1%
Queen Anne's	2.0%
Saint Mary's	1.5%
Somerset	0.8%
Talbot	1.4%
Washington	1.6%
Wicomico	1.7%
Worcester	0.5%
Baltimore City	0.2%
Statewide	**1.2%**

Table A.3 summarizes total 2017 baseline and 2030 forecast VMT by vehicle type.

Table A.3 2017 Baseline and 2030 Technology Scenario - VMT by Vehicle Type

Annual VMT (millions)	2017 Baseline	2030 Technology
Light-Duty	55,799	64,633
Medium/Heavy-Duty Truck & Bus	4,093	4,759
TOTAL VMT (in millions)	**59,892**	**69,392**

The analysis process (e.g. using PPSUITE post processor) re-calculates roadway speeds based on the forecast volumes. As a result, future year emissions are sensitive to the impact of increasing traffic growth on regional congestion.

Vehicle Technology Adjustments

The MOVES2014b emission model includes the effects of the following post-2017 vehicle programs on future vehicle emission factors:

- **National Program Phase 2 (Model Years 2017-2025)** – The light-duty vehicle fuel economy for model years between 2017 and 2025 are based on the October 15, 2012 Rule "2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards" (EPA-HQ-OAR-2010-0799 and No. NHTSA-2010-0131). The new fuel economy improvements apply to model years 2017 to 2025. The standards are projected to result in an average 163 gram/mile of CO_2 in model year 2025. This equates to an average fuel economy of 54.5 mpg.
- **Maryland Clean Car Program** – The Maryland Clean Car Program implements California's low emissions vehicle (LEV) standards to vehicles purchased in Maryland starting with model year 2011. By creating a consistent national fuel economy standard, the 2012-2016 National Program and the Phase 2 2017-2025 National Program, which closely resemble the California program, replaces Maryland's Clean Car Program for those model years. As a result, the GHG reduction credits for the Maryland Clean Car Program, apply only to 2011 model year vehicles and post-2011 electric vehicles that meet the California's zero emission program (ZEV) requirement.
- **National 2014-2018 Medium and Heavy Vehicle Standards** – The medium- and heavy- duty vehicle fuel economy for model years between 2014-2018 are based on the September 15, 2011 Rule "Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles". The rulemaking has adopted standards for three main regulatory categories: combination tractors, heavy-duty pickups and vans, and vocational vehicles. For combination tractors, the final standard will achieve 9 to 23 percent of reduction in carbon dioxide (CO2) emissions and fuel consumption by the 2017 model year compared to the 2010 baseline. For heavy-duty pickup trucks and vans, separate standards have been established for gasoline and diesel trucks, which will achieve up to a 10 percent reduction for gasoline vehicles and a 15 percent reduction for diesel vehicles by the 2018 model year (12 and 17 percent respectively if accounting for air conditioning leakage). Lastly, for vocational vehicles, the final standards would achieve CO2 emission reductions from six to nine percent by the 2018 model year.

Emission Results

The 2017, and 2030 technology scenarios emission results for the Maryland statewide GHG inventories are provided in Table A.4 for 2017 Baseline, and A.5 for the 2030 technology scenario. Within each table, emissions are also provided by fuel type and vehicle type.

Table A.4 2017 Annual On-Road GHG Emissions (mmt)

	VMT (Millions)	CO_2	CH_4	N_2O	CO_2e
TOTAL	**59,892**	**28.41**	**0.00102**	**0.00062**	**28.62**
By Fuel Type					
Gasoline	55,028	22.105	0.000620	0.000609	22.302
Diesel	4,544	6.164	0.000343	0.000010	6.176
CNG	12.3	0.015	0.000049	0.000001	0.016
E-85	307	0.122	0.000006	0.000002	0.122
By MOVES Vehicle Type					
Motorcycle	266	0.098	0.000008	0.000001	0.099
Passenger Car	25,592	8.788	0.000198	0.000211	8.855
Passenger Truck	26,209	11.859	0.000403	0.000349	11.973
Light Commercial Truck	3,731	1.561	0.000054	0.000034	1.572
Intercity Bus	124	0.220	0.000005	0.000000	0.220
Transit Bus	82	0.107	0.000052	0.000001	0.108
School Bus	195	0.183	0.000011	0.000001	0.183
Refuse Truck	35	0.062	0.000002	0.000000	0.062
Single Unit Short-haul Truck	1,367	1.384	0.000067	0.000019	1.391
Single Unit Long-haul Truck	81	0.076	0.000004	0.000000	0.077
Motor Home	19	0.019	0.000001	0.000000	0.020
Combination Short-haul Truck	531	0.934	0.000022	0.000001	0.935
Combination Long-haul Truck	1,659	3.114	0.000191	0.000003	3.120

Table A.5 2030 Technology Scenario Annual On-Road GHG Emissions (mmt)

	VMT (Millions)	CO_2	CH_4	N_2O	CO_2e
TOTAL	**69,392**	**24.23**	**0.00090**	**0.00040**	**24.37**
By Fuel Type					
Gasoline	61,698	16.980	0.000291	0.000373	17.098
Diesel	5,390	6.592	0.000547	0.000012	6.609
CNG	14.7	0.017	0.000041	0.000001	0.018
E-85	2,290	0.643	0.000024	0.000014	0.648
By MOVES Vehicle Type					
Motorcycle	310	0.115	0.000009	0.000001	0.115
Passenger Car	29,559	6.821	0.000130	0.000148	6.868
Passenger Truck	30,464	9.432	0.000212	0.000205	9.498
Light Commercial Truck	4,300	1.270	0.000035	0.000027	1.279
Intercity Bus	143	0.242	0.000007	0.000000	0.242
Transit Bus	93	0.115	0.000045	0.000001	0.116
School Bus	229	0.201	0.000013	0.000001	0.202
Refuse Truck	41	0.070	0.000002	0.000000	0.070
Single Unit Short-haul Truck	1,594	1.501	0.000092	0.000010	1.507
Single Unit Long-haul Truck	89	0.078	0.000005	0.000000	0.078
Motor Home	22	0.022	0.000001	0.000000	0.022
Combination Short-haul Truck	489	0.810	0.000027	0.000001	0.811
Combination Long-haul Truck	2,059	3.556	0.000322	0.000004	3.565

Appendix B: Strategy Definitions and Assumptions

1.0 Policy Scenario 1 (On-the-Books)

As its name implies, this scenario evaluates the emission reductions from funded projects and programs. This includes projects and programs in the Consolidated Transportation Program (CTP), land development assumptions consistent with local plans and Maryland Department of Planning goals, and GHG reducing projects included in fiscally constrained MPO metropolitan transportation plans.

1.1 2018/2019 MPO Plans and Programs yield lower annual VMT growth (0.6%/year)

Strategy Description: Modeled vehicle miles traveled (VMT) and emissions outcomes from implementation of most recent MPO fiscally constrained long-range transportation plans and cooperative land use forecasts.

Key Assumptions: VMT growth for fiscally constrained plans and programs reflect the most recent available assumptions from MPO long-range plans (consistent with adopted LRTPs and recent amendments) and an updated VMT growth trend from 1990-2017 for counties outside MPO areas (consistent with HPMS data). In the 2018 analysis, the business as usual VMT growth trend (based on 1990-2014) was 1.7% annual and the resulting plans and programs growth rate was 1.4% annual. For this analysis, the business as usual VMT growth trend (based on 1990-2017) is 1.2% annual, and the resulting plans and programs growth rate is 0.6% annual.

1.2 On-Road Technology (Transportation System Management and Operations - CHART and other traffic management technologies)

Strategy Description: Continuation of MDOT SHA's CHART program, Smart Traffic Signals within the Traffic Relief Plan, and ongoing implementation of SHAs TSMO Strategic Plan (2018) and TSMO Master Plan 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 anagement, travel infromation, communications, and traffic management.

Key Assumptions: MDOT SHAs 2019 Mobility Report documents recent and planned activities to mitigate congestion and improve reliability on Maryland's highway system. This includes TSMO - CHART, signal operations, and smart/adaptive signal systems. Benefits from each of these programs include reduced delay and fuel consumption. Through 2030, these programs are assumed to expand in scope and coverage, consistent with current funding and implementation assumptions, increasing the overall benefit to the system in terms of reduced delay and fuel consumption. In Policy Scenario 1, this translates to increased effectiveness across the CHART coverage area and a 35% expansion of systems on urban arterials and a 15% expansion of systems on rural limited-access facilities.

1.3 Freight and Freight Rail Programs (National Gateway, Howard Street Tunnel, and MTA rail projects)

Strategy Description: Implementation of the CSX National Gateway provides new capacity and eliminates bottlenecks for access to the Port of Baltimore and across MD for rail access westward toward PA and OH and south toward VA and NC, including rail double-stack service through the expanded Howard Street Tunnel.

Key Assumptions: Opening of the Howard Street Tunnel to doublestack rail service by 2030 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 MWCOG analysis of the CSX National Gateway program. To the extent that information is available within the Howard Street Tunnel INFRA Grant application, updated estimates could reflect details within the grant benefit-cost analysis.

1.4 Public Transportation (new capacity, improved operations/frequency, bus rapid transit (BRT))

Strategy Description: This strategy includes projects designed to increase public transit capacity, improve operations and frequency, and new BRT corridors not included in MPO modeling in the plans and programs. This includes North Avenue Rising, MD 355/MD586/US29 BRT in Montgomery County, and MARC reliability/park-and-ride/station improvements.

Key Assumptions: MPO plans account for implementation of the Purple Line, MARC capacity/service improvements, and BaltimoreLink and MTA Commuter Bus service expansions through 2030. 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.

1.5 Public Transportation (50% Electric Vehicle (EV) transit bus fleet)

Strategy Description: Applies to replacing MTA and WMATA bus fleets in Maryland (approximately 1,500 buses) to a 50% EV fleet by 2030 (consistent with MDOTs Fleet Innovation Plan).

Key Assumptions: Based on current replacement cycles, MTA could achieve a 50% EV transit bus fleet if all replacement and new vehicles starting in 2025 are EV (assuming appx. 400 buses are replaced over the 5-6 year period, mostly from buses that entered the fleet from 2012 to 2018). This strategy also presumes that WMATA moves toward a 50% EV fleet within Maryland by 2030. For LOTS buses, procurement is expected to generally follow existing MTA direction toward clean diesel, with some limited expansion of electric buses as part of recent and ongoing grant awards.

1.6 Intercity Transportation Initiatives (Amtrak Northeast Corridor, Intercity bus)

Strategy Description: Northeast corridor analysis assumes growth in annual ridership by 2030 for Amtrak consistent with addressing growing demand and benefits created through SOGR investments only through 2030.

Key Assumptions: Annual ridership growth on the AMTRAK Northeast Corridor consistent with high growth 2015 - 2019 will continue through 2030, compared to a lower baseline growth since 2010. Continuing this rate of growth assumes that ongoing planned state of good repair investments and limited capacity expansion enables Amtrak to accomodate growth with new and improved service, and enhanced reliability. Ridership is converted to reduced vehicle miles traveled based on an average Maryland trip length for intercity trips.

1.7 Transportation Demand Management (TDM)

Strategy Description: The following programs are included for consideration towards reduction in VMT: Commuter Connections Transportation Emission Reduction Measures (MWCOG), Guaranteed Ride Home, Employer Outreach , Integrated Rideshare, Commuter Operations and Ridesharing Center, Telework Assistance, Mass Marketing, MTA Transportation Emission Reduction Measures, MTA College Pass, MTA Commuter Choice Maryland Pass, Transit Store in Baltimore.

Key Assumptions: VMT reductions are based on current trends as documented in MDOTs Annual Attainment Report, and results of ongoing and emerging programs within MWCOGs Commuter Connections Program and Commuter Choice Maryland. This analysis assumes implementation of TDM programs consistent with pre COVID-19 conditions related to telework and other TDM incentives.

1.8 Pricing Initiatives (Electronic Tolling)

Strategy Description: Ongoing Conversion to All-Electronic Tolling.

Key Assumptions: Consistent with the 2020-2025 CTP, tolling on MDTA facilities is planned for complete coversion to a cashless system by 2030. This includes programmed investments in video toll collection technologies and implementation of cashless tolling on the Francis Scott Key Bridge (I-695) and Hatem Bridge (US 40) by 2025. MDTA is also implementing an extension of the I-95 Express Lanes to the MD24 interchange, with completion planned before 2030. GHG emissions reduction is associated with a reduction in idling at toll plazas, assumed to average 1 minute per transaction.

1.9 Bicycle and Pedestrian Strategies (Provision of non-motorized infrastructure including sidewalks and bike lanes)

Strategy Description: Assumes VMT reductions due to availability of bicycle facility lane miles and improved bicycle level of comfort consistent with existing and planned infrastructure improvements, repaving, and new facilities highlighted in the 2020 - 2025 CTP and current SHA plans.

Key Assumptions: This strategy assumes that improved directional miles of bicycle facilities and bicycle level of comfort will increase through 2030 consistent with the trend reported in the Annual Attainment Report from 2015 through 2019. This is compared to a do-nothing scenario, resulting in increased bicycle and pedestrian activity and reduced VMT.

1.10 Drayage Track Replacements

Strategy Description: This strategy estimates the benefit of replacing 600 total dray trucks resulting from MDE, MDOT and Federal grants through 2030, which is based on the current replacement rate.

Key Assumptions: Consistent with current program status and recent EPA grant award, the Port of Baltimore is still on-track to turnover 600 heavy-duty diesel dray trucks by 2030.

1.11 BWI Airport Parking Shuttle Bus Replacements

Strategy Description: This strategy involves replacement of BWI airport parking shuttles - 50 diesel buses with clean diesel buses and CNG buses.

Key Assumptions: Acquisition information based on what is publicly available from MDOT and news sources including the types of vehicles replacing the existing vehicles.

1.12 MDOT Vehicle Fleet (Fleet Innovation Plan)

Strategy Description: Conversion of MDOT fleet (non-revenue vehicles) to EVs (initial focus on MDOT agency passenger vehicle fleet only, heavy duty vehicles included in Policy Scenario 2).

Key Assumptions: Assume 95% EV conversion of 2,114 passenger vehicles by 2030 averaging 12.5k miles per year.

2.0 Policy Scenario 2 (Emerging and Innovative)

This scenario acknowledges that attaining the 2030 goal will require additional investments to expand or accelerate 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 22 strategies in this scenario (16 emerging and 6 innovative) represent a combination of approaches to reduce GHG emissions with varying levels of confidence and MDOT responsibility.

Emerging Strategies

2.1 TSMO/Integrated Corridor Management (Limited Access System)

Strategy Description: Integrated corridor management, intelligent transportation systems, or advanced traffic management systems for urban restricted access roadways in the state.

Key Assumptions: The most similar program in the 2020-2025 CTP is CHART, which is funded 60% Federal, 40% State. The same share is assumed for this comparable/extended strategy.

2.2 TSMO/Integrated Corridor Management (Arterial System)

Strategy Description: This strategy estimates the benefits of implementing corridor management, intelligent transportation systems, or advanced traffic management systems are in place on all urban arterials.

Key Assumptions: Only urban arterials are being assumed to be covered as part of this strategy through 2030. The most similar program in the 2020-2025 CTP is CHART, which is funded 60% Federal, 40% State. The same share is assumed for this comparable/extended strategy.

2.3 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 ramp entrance. Ramp fraction was estimated at 8% from MOVES defaults. The most similar program in the 2020-2025 CTP is CHART, which is funded 60% Federal, 40% State. The same share is assumed for this comparable/extended strategy.

2.4 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). Assumed splits according to Freight and Freight Rail programs in PS 1. 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.

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

Strategy Description: Considers extended idling only and not short term idling (eg. 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 absence of new laws/requirements. A high case and a low case for emission reductions is estimated considering all or just 50% of extended idling is handled by Auxillary Power Units (APUs). Negligible costs to the state for enforcement. Truck drivers purchase APUs.

2.6 Regional Clean Fuel Standard

Strategy Description: Consistent with TCI approach assuming a 15% clean fuel standard (applied to fuel consumption from remaining ICE fleet above and beyond RFS). Ultimately this strategy should be deployed as a regional approach for gasoline and diesel fuel.

Key Assumptions: Administration and program management costs to be totally borne by the state.

2.7 Eco-Driving

Strategy Description: Statewide commitment to a marketing and eduction program and volunatary adoptions by Maryland drivers, including private passenger vehicles and commercial vehicles (light, medium, and heavy-duty trucks).

Key Assumptions: Assumptions based on the extent of government-led programs. Private sector programs not included. For example, fleet operators of trucks, 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 are reached using these general marketing programs. Out of these people, only 50% (1% of total population) have on-board display tools that have on-board display tools that provide feedback from ecodriving. The benefits 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 for this analysis are only assumed to be a part of the general marketing campaign and no specific training provided elsewhere. Modest marketing, education and outreach program costs to be borne by the state.

2.8 Transit capacity/service expansion (fiscally unconstrained, including MTA, WMATA, LOTS, and other intercity providers)

Strategy Description: Potential transit network improvements and expansions 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 Maximize2045 plan result in a 0.3% VMT reduction by 2045. This reduction is assumed to be accelerated to 2030, with full implementation of the Mazimize2045 plan (including corridors recommend in the Central Maryland Regional Transit Plan. Other potential transit corridors by 2030 include three additional BRT corridors (MD 650, Randolph Rd., North Bethesda) plus the CCT 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 is implemented by 2030, while the high range assumes the entire system is implemented by 2030. 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 CIG program (essentially the blanket now for New Starts / Small Starts).

2.9 Expanded Transportation Demand Management (TDM) strategies - Dynamic ridesharing/mobility and non-work demand management

Strategy Description: The TDM programs included in PS1 are broadly expanded consistent with a market-wide implementation of dynamic TDM programs including on-demand ride sharing/shared mobility/microtransit services plus greater market penetration of on-demand deliveries/services through autonomous/drone technologies.

Key Assumptions: There is significant uncertainty in this strategy, given the range of different technologies and services, including many that are led by the private sector. Generally, the assumption is that regular ridesourcing/ridesharing users in Maryland (mobility as a service, micromobility, smart mobility options) range from 10% to 20%, which leads to a reduction in vehicle ownership and overall reduction in travel (ranging from 30% to 60%). These estimates are drawn from academic/industry studies in 2018 and 2019. This includes the potential impact of less non-work trips associated with more at-home deliveries/services. Same as 2018. However, 2018 costs assume that a 100% of the costs are borne by the state, unlike the typical 70%-30% split as assumed in funded PS 1 strategies. The rationale for this is that Federal funds typiucally supporting TDM (e.g. CMAQ) are highly competitive and segmented. A broader TDM program will either require new Federal programs or (more likely) a much higher State commitment.

2.10 Expanded bike/pedestrian system development

Strategy Description: Assumes VMT reductions due to availability of bicycle facility lane miles and improved bicycle level of comfort consistent with a 50% increase in existing and planned infrastructure improvements, repaving, and new facilities highlighted in the 2020 - 2025 CTP and current SHA plans.

Key Assumptions: Total improved directional miles would increase from 367 miles in 2019 (per the Attainment Report) to a low range over 1,300 in 2030 (which is a 25% increase over the current growth trend) to a high range over 1,600 in 2030 (which is a 50% increase over the current growth trend). Splits assumed to be similar to the funded bicycle and pedestrian improvements.

2.11 Expanded Telework

Strategy Description: In light of COVID19 the share of people who are teleworking has seen a multi-fold increase compared to the levels a year ago. It has been a near unanimous opinion in the research literature reviewed for this strategy analysis that the increase in telework trends is going to be a long term phenomenon.There are different views about the share of people now teleworking under the COVID19 constraints who will remain to telework long after the impacts of the pandemic.

Key Assumptions: The share of the regular teleworking workforce (>3 days per week) ranges from 32% to 44% in 2030. These shares are applied to 2030 VMT per capita and an assumption that approximately 30% of total VMT per capita is attributed to commuting. Costs of program management assumed—after considering other states and metro area telework programs, a $10-20 million annual funding was determined to be adequate for a MD-Telework program. If costs to the employers are not assumed, it will lead to underestimation of total costs that are eligible for tax credits, etc. Also, in the case of government employees, the installation and capital costs of equipment, etc., are typically reimbursed.

2.12 MARC Growth and Investment Plan (MGIP) / Cornerstone Plan Completion

Strategy Description: Improvements to MARC service include completion of the fourth track on the Penn Line to facilitiate service exapansion (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 VRE-MARC Run-Through Service.

Key Assumptions: Estimated 2030 ridership, consistent with full build-out of the MGIP/Cornerstone Plan, totals over 16 million passengers. Compared to a low and an average annual ridership growth rate through 2030, this could yield a statewide VMT reduction between 107 and 165 million miles in 2030. The VRE-MARC Run-Through Servce estimated the potential for over 16,000 trips per day, resulting in a VMT reduction of 30.5 million by 2030. Similar to transit expansion, although typically more access to Federal funds through Federal Railroad Authority fundind/grant programs—justifies a higher Federal split.

2.13 Transit-Oriented Development (TOD) Build-Out (20 incentive zones)

Strategy Description: Estimated TOD build-out across 20 locations totals an additional 36,000 households, each with an average VMT reduction of 33% to 56% based on average VMT savings by transit zone density.

Key Assumptions: Based on Center for Neighborhood Technology (CNTs) nationwide 2010 study, average VMT reductions in transit oriented zones compared to traditional urban/suburban development range from 33% to 56%. 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. CTP Special Funding Source. No Federal Aid. 100% State & Local Funding. Assumes additional funding equivalent to what is in the CTP now to be required for 20 zones build out.

2.14 EV Market Share Ramp-up of an additional 255,000 vehicles

Strategy Description: Additional 255,000 EVs by 2030, compared to the TCI projection to reach 790k ZEVs (with Federal action).

Key Assumptions: Same assumptions are applied as in the reference case for the share of BEV vs. PHEVs and proportion of PHEV travel operating as electric. The cost assumption is based on maxing out the current annual EVSE rebates and EV credits under PS 1 and factored for the additional 255,000 EVs.

2.15 Extended CAFE Standards (Model Years 2026-2030)

Strategy Description: Federal fuel economy standards continue to increase from 2026 through 2030.

Key Assumptions: With support of the auto manufacturers and new Administration for the National Program Standards, if the fuel economy standards would continue to increase by five percent per year through 2030, an additional emissions decrease of 0.80 mmt CO_2e would result from the vehicle technology standards.

2.16 50 percent to 75 percent EV Transit Bus Fleet

Strategy Description: Applies to MTA and WMATA bus fleets in Maryland (approximately 1,500 buses).

Key Assumptions: Based on current replacement cycles, MTA could achieve a 50% EV transit bus fleet if all replacement and new vehicles starting in 2025 are EV (assuming appx. 400 buses are replaced over the 5-6 year period, mostly from buses that entered the fleet from 2012 to 2018). To reach a 75% EV fleet, MTA would need to replace an additional 200 buses, which would include new clean diesel buses entering the fleet in 2019-2021 (or would need to change its current replacement cycle and move toward EVs earlier than 2025). Federal/state splits are consistent with current fundign assumption for bus purchases/replacement in the 2020-2025 CTP. However, higher purchase cost of EV transit buses compared to existing clean diesel procurement could ultimately require larger state share.

Innovative Strategies

2.17 Autonomous/Connected Vehicle Technologies

Strategy Description: Core assumptions regarding market penetration of AVs, change in VMT, and fuel savings have been adopted from an ENO study which lays out three scenarios of AV deployment, of which the low-end penetration of 10% by 2030 is considered in this analysis.

Key Assumptions: Emissions associated with VMT increase resulting from mobility benefits (AVs added to the fleet—this increases emissions and thereby a negative impact, estimated at 20 percent increase); fuel savings due to AVs (savings of AVs only, estimated at 13 percent reduction); congestion reduction benefits on freeways and arterials (assumed LOS 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 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 case have been varied to include a higher market penetration (15%) and thereby an increased freeway congestion reduction benefit (20%). Infrastructure costs to the state considered. 100% to be borne by the state.

2.18 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 required to establish potential deployment scenario 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 (eg. where trucks connect into an overhead electric power system. 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 VW 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.

2.19 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 (PPP) basis. Hence the split was assumed to be 50-50.

2.20 Pay-As-You-Drive (PAYD) Insurance

Strategy Description: PAYD 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 adoption of PAYD insurance, which has been observed in multiple studies to reduce VMT.

Key Assumptions: Range of 10 to 20% of licensed Maryland drivers use a pay-as-you-drive auto insurance premium by 2030. The range of VMT reduction for PAYD insurance is from 8 to 10% based on national research. This reduction is applied to average VMT per capita for the 10 to 20% of Maryland licensed drivers with PAYD insurance premiums. Private insurance providers (administration and marketing) (100%)

2.21 Speed Management on Freeways (increased enforcement)

Strategy Description: Speed Management covering urban and rural restricted access roadways in the state.

Key Assumptions: Assumes coverage of 100% urban restricted access roadways and only 50% of rural restricted access roadways for a high range implementation and 50% urban restricted roadway coverage and 25% rural restricted access coverage for low range implementation. Discounted for peak-period congested travel VMT.

2.22 High-Speed Passenger Rail/SCMAGLEV

Strategy Description: Assumes build-out of the NEC Vision Plan (low range) by 2030 and build-out of NEC Next-Gen Plan (high range) by 2030.

Key Assumptions: Build-out of both of these systems would require a significant influx of Federal and private funding in addition to extensive engineering, environmental, and construction resources to implement. It is highly unlikely given the current Federal funding situation and post-pandemic economic recovery and travel patterns that implementation of such a broad scale expansion of service on the NEC is possible. SCMaglev is assumed to be 100% privately funded. Implementation of the NEC Vision Plan would be primarily Federal, however, there is no funding source existing to support.