Maryland Department of the Environment

Appendix J

MDOT GGRA Draft Plan

2019 GGRA Draft Plan

MARYLAND DEPARTMENT OF TRANSPORTATION

2018 Draft Greenhouse Gas Reduction Act Plan

2018 Maryland Department of Transportation Draft Greenhouse Gas Reduction Act Plan

prepared for

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Executive Summary

MDOT's 2030 Draft Greenhouse Gas Reduction Act (GGRA) Plan

This plan presents the Maryland Department of Transportation (MDOT) approach to meet the requirements of the GGRA. The GGRA requires the Maryland Department of Environment (MDE) to submit a proposed plan that reduces statewide greenhouse gas (GHG) emissions by 40 percent from 2006 levels by 2030 ("40 by 30"). In 2018, MDOT worked with MDE and other agency and stakeholder partners to develop and test strategies for the transportation sector to achieve the "40 by 30" goal.

Trends including growth in population, vehicle miles traveled, and congestion combined with less available revenue relative to needs creates a major challenge. Based on MDOT analysis accounting for these challenges and new opportunities, it is possible for Maryland's transportation sector to meet the "40 by 30" goal. The analysis considered three policy scenarios built from the Maryland Transportation Plan (MTP) and current Consolidated Transportation Program (CTP). Achieving the goal will not be easy, requiring an innovative and cost-effective approach that includes:

- An aggressive investment in transportation well beyond current projected funding,
- Supportive policy and new resources enabling MDOT to advance these needed investments,
- A commitment from MDOT partners to advance reliable, low cost, and low carbon technologies, and
- A best-case scenario for market penetration of electric vehicles into public and private fleets in Maryland.

Background

Why Are We Doing This? In response to the threat and growing concern with climate change, the Maryland Commission on Climate Change (MCCC or the Commission) was established in April 2007. The Commission released its initial plan of action for addressing climate change in August 2008 and the GGRA was passed in 2009 representing the starting point of over a decade of climate change planning in Maryland. MDOT began working with stakeholders in 2009 to develop a comprehensive approach to reduce GHG emissions from the transportation sector through 2020. In 2016, the GGRA was reauthorized, refocusing on a new goal of reducing greenhouse gas emissions by 40% from 2006 emissions by 2030.

What Is Maryland's Role in Mitigating Greenhouse Gas Emissions? Maryland's transportation system is complex, with major international ports, a high proportion of through trips, and notable challenges related to congestion and access. It is also critical that our transportation system remains a safe and sustainable resource for the movement of goods and people throughout the Northeast Megaregion.

Maryland accounts for 1.08 percent of total U.S. GHG emissions and Maryland's transportation sector accounts for 0.41 percent of total U.S. GHG emissions. The focus of this report is on-road transportation, which represented 31 percent of total Maryland GHG emissions, including emission sinks, in 2015.

How Does This Align with MDOT's Mission and the Maryland Transportation Plan? Mitigating greenhouse gas emissions from transportation and investing in a transportation system that is resilient to climate impacts is a crosscutting objective within MDOTs mission and multiple goals of the MTP.
71 percent of MDOT's planned investments in the 2018-2023 CTP (outside of system preservation projects) will facilitate GHG emission reductions from transportation. MDOT's Excellerator and the

Annual Attainment Report track multiple performance measures that are indicators of a more efficient and multimodal transportation system – all positive steps toward GHG reductions.

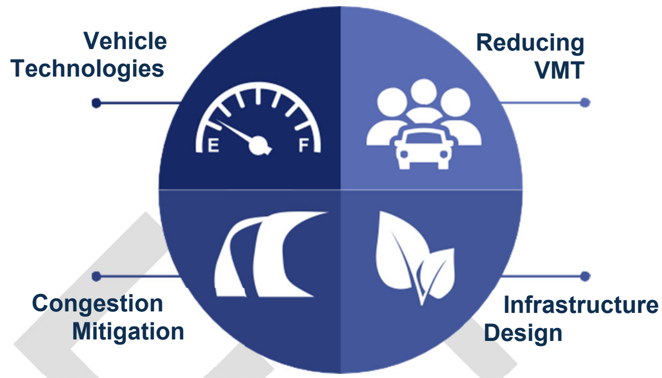
What Are Key Examples of MDOT Actions that Support the GGRA? Highlights of MDOT's ongoing actions to support GHG emission reductions through innovative delivery and operation of the transportation system and use of emerging technologies are presented below.

MDOT Highlight	Implementation Details Supporting the GGRA
Electric Vehicle Infrastructure Council (EVIC) MDOTs leadership of EVIC builds opportunities, financial incentives, and promotion of EVs, and the installation of electric vehicle supply equipment (EVSE) to support the State's EV goals.	▪ EVIC produces annual reports on the progress of developing, evaluating and recommending strategies to facilitate the successful integration of EVs and EV infrastructure into Maryland's existing transportation infrastructure. ▪ EVIC supported the passage of the Clean Cars Act of 2017, which increased and extended funding that support rebates and incentives for electric vehicle purchases. ▪ MDOT is also working to complete an EV Signage Plan, focusing first on the acquisition, installation, and maintenance of EV signage on Maryland's ten FHWA designated alternative fuel corridors.
Renewable Energy MDOT issued six Master Services Agreements (MSA) for qualified contractors to design, construct, commission, finance, operate, and maintain renewable energy facilities at MDOT locations throughout Maryland.	▪ The program, one of the first of its kind by a state transportation agency, provides MDOT with the flexibility of developing renewable energy systems quickly and efficiently. The MSA is also available to any Maryland local government or non-profit organization. ▪ Phase 1 of the program deployed renewable energy sources at 35 sites across Maryland, including seven EV charging stations. In total, these sites will help reduce over 15,000 metric tons of CO_2 emissions. ▪ MDOT owns or controls more than 874 facilities, including buildings and parking lots that are eligible for renewable energy system development.
Transit and Transportation Demand Management (TDM) MDOT continues to expand and diversify its commitment to improving transit service throughout Maryland while continuing to work to improve transportation demand management (TDM) programs available to Maryland commuters and students.	▪ Construction on the Purple Line began in August 2017 through securing of \$900 million from the Federal Transit Administration to match State, local, and private funding. The project will be delivered through a design/build/operate public-private partnership. ▪ Supported by two grants from US DOT, MDOT Maryland Transit Administration (MDOT MTA) is working with Baltimore City to deliver the North Avenue Rising project and Montgomery County to deliver the US 29 Bus Rapid Transit project. ▪ MDOT and MDOT MTA continue to work with Maryland's metropolitan planning organizations (MPOs), major employers, and universities, to expand TDM programs, aimed at providing commuters incentives and information to support ridesharing and transit use through Commuter Connections and Commuter Choice Maryland. ▪ The Maryland Metro/Transit Funding Act commits \$167 million per year in additional, dedicated, funding for Metro from Maryland for the next 3 years. The bill also includes an additional \$60 million annually for capital and operating funding to MDOT MTA.
Connected and Automated Vehicles (CAV) and Integrated Corridor Management MDOT is developing Maryland's vision for a connected and automated vehicle future and deploying technologies to manage congestion.	▪ MDOT is developing CAV strategic plans that document opportunities, challenges, priorities, strategies, and recommendations to help guide the State in planning and implementing CAV technology. ▪ MDOT State Highway Administration (MDOT SHA) is implementing Integrated Corridor Management (ICM), which uses real-time traffic conditions and artificial intelligence to adjust traffic signal timing. ▪ MDOT SHAs investment into a "progressive" design-build approach to improve reliability and reduce congestion in the I-270 corridor is an example of a project that will utilize technology to manage congestion.

Continuing Progress

Where Are We Headed Through 2030? According to projections by the Maryland Department of Planning, Maryland may grow to over 6.5 million people by 2030. Coupled with economic expansion and land use change, vehicle miles traveled could increase to over 71 billion by 2030, compared to 59 billion in 2017.

What Drives Greenhouse Gas Emission Reductions from Transportation?

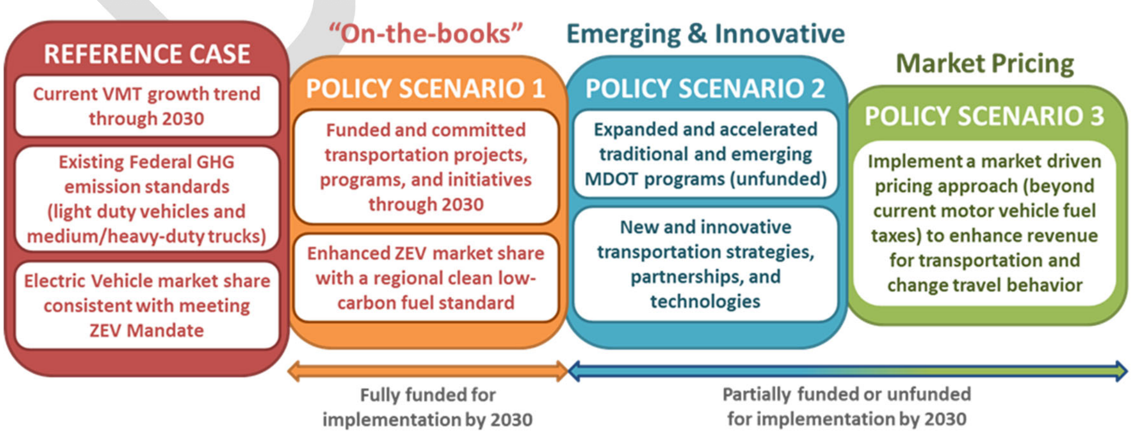


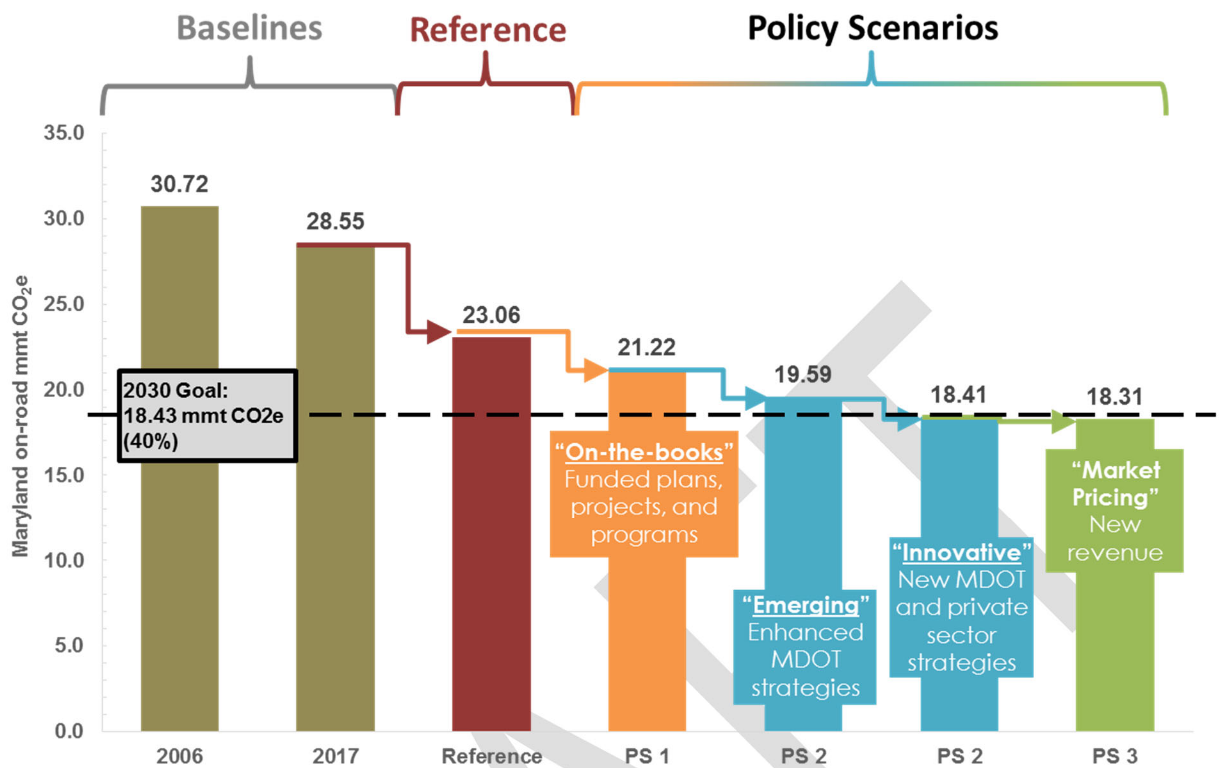
- **Vehicle Technologies** – New vehicle technologies could reduce average annual CO_2 emissions from each vehicle by 34 percent through 2030.
- **Congestion Mitigation** – Reducing congestion is a critical component of mitigating GHG emissions. A vehicle operating at 25 mph emits 25 percent more CO_2 per mile than one operating at 50 mph.
- **Reducing Vehicle Miles Traveled (VMT)** – Mitigating the growth in VMT relative to population growth is critical to GHG emission reductions. The strategies to change traveler behavior are complex, with success contingent on other decisions like land use. As the fleet becomes more efficient, VMT strategies are also less effective at reducing GHGs.
- **Infrastructure Design** – MDOT is developing vulnerability assessments and resiliency plans to address the current and future impacts of climate change. Contractors also are competing to install, operate, and maintain solar systems on MDOT properties, resulting in reductions in energy use.

The 2030 Approach and Outcomes

What Is the 2030 Approach? – While there is some certainty established with transportation funding over the next six years, there are projects in early planning stages, plus other technological changes that will affect the 2030 landscape. Working closely with MDE, MDOT developed a list of strategies, organized across three Policy Scenarios, to put Maryland's transportation sector on a path toward the "40 by 30" goal.

How Far Could We Get by 2030? – While the GGRA goal is "40 by 30" across all economic sectors in Maryland, MDOT analysis applies the same goal for the transportation sector as the projected largest contributor of GHG emissions in Maryland by 2030. The policy scenarios and results are presented below.





Reference – This scenario assumes a constant 1.7 percent annual VMT growth rate (the annual average since 1990) through 2030 combined with full implementation of current Federal emission and fuel standards and Maryland meeting the Zero Emissions Vehicle (ZEV) mandate target of over 600k ZEVs registered in Maryland by 2030 (11 percent of the light-duty vehicle fleet). **The result – 23.06 mmt CO_2e from on-road mobile sources in 2030, a 25 percent reduction from 2006.**

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 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. **The result – 21.22 mmt CO_2e from on-road mobile sources in 2030, a 31 percent reduction from 2006.** In other words, this scenario represents a best-case outcome for implementation of all strategies on the books through 2030.

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 25 strategies in this scenario (17 emerging and 8 innovative) represent a combination of approaches to reduce GHG emissions with varying levels of confidence and MDOT responsibility. **The result – 18.41 mmt CO_2e from on-road mobile sources in 2030, exactly a 40 percent reduction from 2006.** In other words, this scenario suggests that achieving the 40 percent reduction is possible; however, the transportation sector will need new revenues and partnerships to make this a reality.

Policy Scenario 3 "Market Pricing" – This scenario takes a look at possibilities for addressing the primary challenge associated with implementing Policy Scenario 2 – funding. A market pricing approach could include current revenue sources, or augment or replace some of these sources with a VMT or carbon pricing approach. Among these options, MDOT estimated the outcomes of a carbon pricing strategy based on potential as a more sustainable and equitable revenue source. **This analysis was conducted for the scenario planning purposes of this report and is in no way indicative of MDOT's policy position.**

The result – 18.31 mmt CO_2e from on-road mobile sources in 2030, just past a 40 percent reduction from 2006. An equally critical outcome – a carbon price could generate an additional $4.3 to $10.7 billion in revenue, depending on the ultimate price and implementation timeline, for implementing GHG emission reduction strategies through 2030.

What Other Benefits Do These Strategies Create? – The scope of strategies within the 2030 scenarios represent an opportunistic and innovative approach to reducing GHG emissions from on-road transportation sources while respecting the vision and goals of the MTP. These strategies will create the opportunity for significant co-benefits beyond just 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.

What Would It Take?

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.

What Are the Implementation Challenges? – There are three broad categories of challenges to successful implementation of the policy scenario strategies by 2030 – **financial, technological, and policy and resource feasibility**.

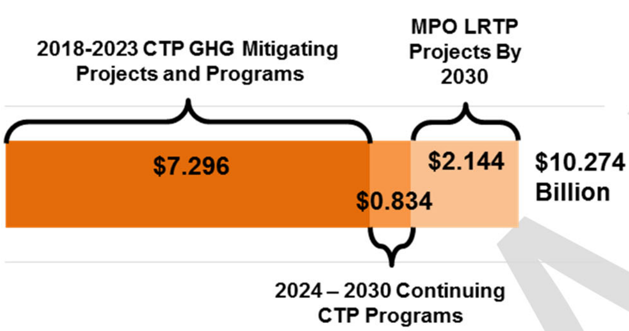
What Are the Uncertainties? – The major sources of uncertainty that may affect the effectiveness of the policy scenarios include – **economic futures, travel costs, and disruptive changes in travel choices induced by technology or public behavior**.

Challenges	Uncertainties
Financial – The strategies in Policy Scenario 2 are partially funded or unfunded for implementation by 2030. Identifying new sources of funding is a major challenge. These new and creative sources of revenue will need to be prioritized relative to other needs, such as system preservation.	**Economic Futures** – Economic growth or decline and its impact on personal and commercial travel activity, choice, and vehicle ownership can influence emissions. Innovation in new technologies is often fostered in times of higher economic output, when increased investment in research and development are more typical.
Technological – Some pivotal strategies in the scenarios including electric vehicles (EVs), CAVs, and Mobility-as-a-Service, are at various points along their technological maturity for widespread adoption. For example, the EV technology is grappling with challenges like range anxiety, perceptions about availability of charging infrastructure, and cost parity. Similarly, CAV technologies are still undergoing a transition from the research realm to the real-world rollout scenario. If technology deployment slows, there is potential that meeting the "40 by 30" goal becomes nearly impossible for transportation.	**Travel Costs** – The most variable component of travel costs historically is fuel cost. Volatile fuel prices often result in more attention to alternative modes and more proactive strategies by logistics firms to reduce shipping costs. Sustained significant increases or decreases in gasoline and diesel costs relative to the norm could also affect vehicle ownership decisions and lead to declines in economic productivity, affecting other economic sectors beyond transportation.

Policy and Resource Feasibility	Disruptive Changes
Policy and Resource Feasibility – Both the financial and technological challenges are manifested in public adoption of the strategies given that there are additional cost, behavioral, and regulatory challenges that need to be addressed for their implementation. Many transportation strategies require long lead times for engineering and environmental work, making accelerating key projects (even if the funding is available) a challenge.	**Disruptive Changes** – One major important source of uncertainty that is being seen across the transportation sector is the advent of disruptive technology that have already started to have a profound impact on travel choice and vehicle ownership among other factors. The shared mobility phenomenon has affected peoples' vehicle ownership and location choices thereby affecting travel patterns, mode choices and demand for services.

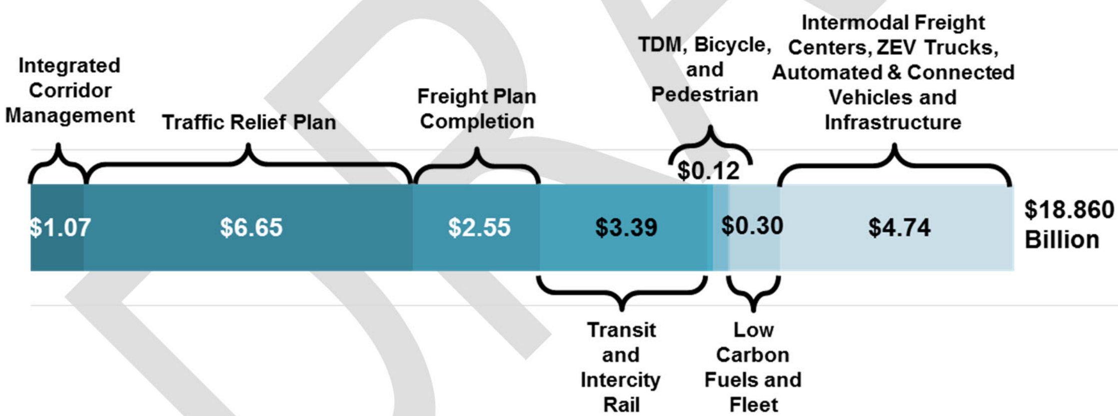
What Are the Costs? – A review of the strategies shows that a majority of them require an influx of capital funding for implementation. These include facility construction costs, cost of acquiring right of way, purchasing rolling stock or vehicles for transit, and technology costs for equipment and infrastructure.

Policy Scenario 1 - FUNDED



Policy Scenario 1 costs are based on CTP costs, ongoing investments in current MDOT programs from 2024 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 - UNFUNDED



Policy Scenario 2 total estimated costs, not including potential investments in MAGLEV or Loop, ranges from $18.860 billion up to $26.174 billion (funding levels of 180 to 250 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.

A market-based pricing approach in **Policy Scenario 3**, could generate up to $10.7 billion in revenue to support strategies in Policy Scenario 2 through 2030. Combined with other innovative sources, including private commitments, the revenue generated could help implement many of the more cost-effective strategies in Policy Scenario 2. This approach does not completely address the funding shortfall in Policy Scenario 2, with potentially as high as $15.4 billion in unfunded strategies.

1.0 Background and Approach

This plan presents the Maryland Department of Transportation's (MDOT) draft blueprint for reducing greenhouse gas (GHG) emissions from the transportation sector through 2030, including information on estimated emission benefits, co-benefits, implementation considerations, and costs of each GHG reduction strategy and combination of strategies within different scenarios.

1.1 Greenhouse Gas Reduction Act and Maryland Commission on Climate Change

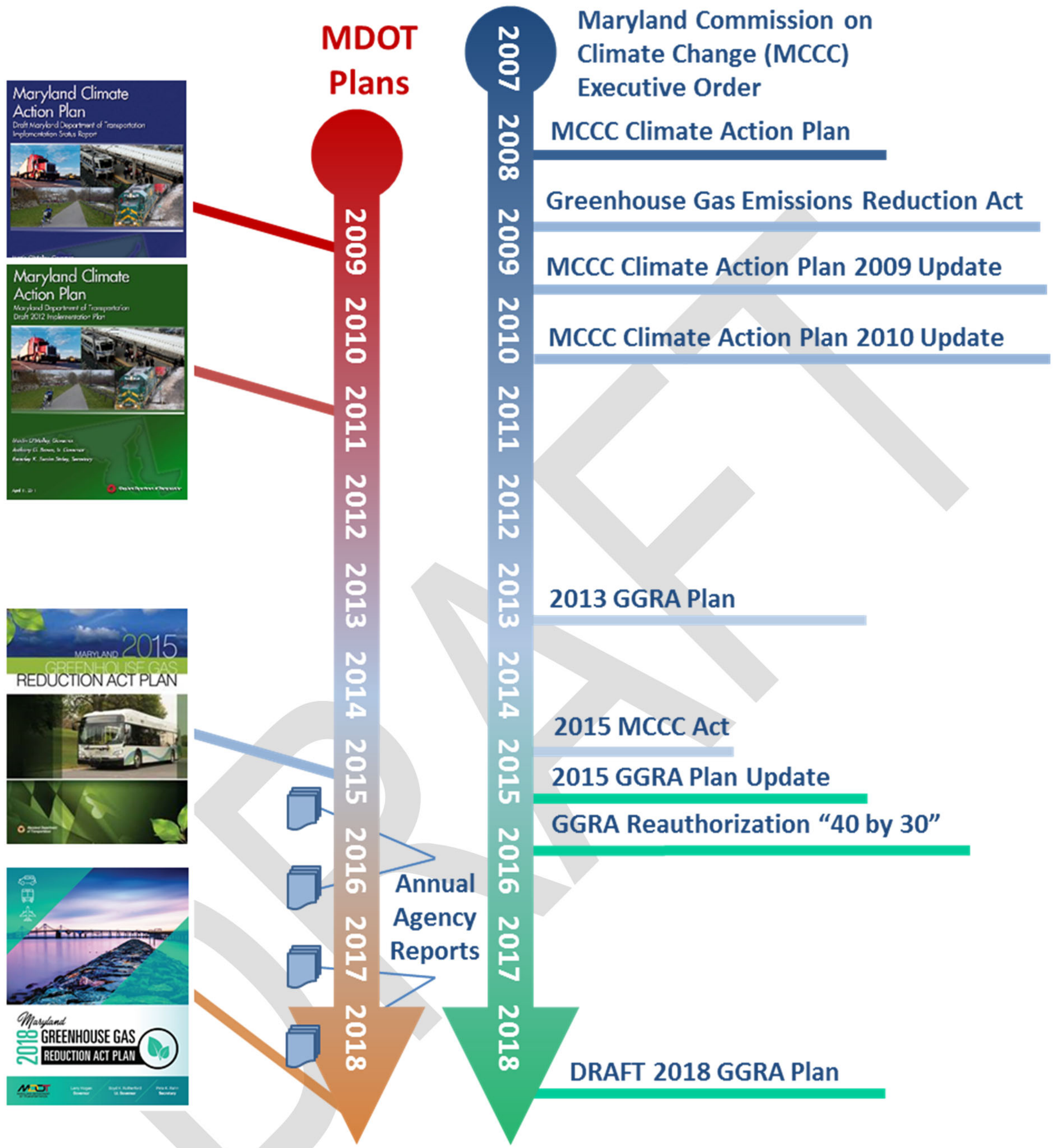
In response to the threat and growing concern with climate change, the Maryland Commission on Climate Change (MCCC or the Commission) was established in April 2007. The Commission released its initial plan of action for addressing climate change in August 2008, the starting point of over a decade of climate change planning in Maryland.

Maryland adopted the Greenhouse Gas Emission Reduction Act of 2009 (GGRA) in June 2009. Starting in 2009, MDOT began working with stakeholders to develop a comprehensive approach to reduce GHG emissions from the transportation sector through 2020 and beyond. This approach included careful planning, analysis, coordination, and outreach through the development of plans in 2009, 2011, and 2015 to highlight actions and progress toward achieving emission reduction goals. These efforts supported the Maryland Department of the Environment (MDE) and the MCCC in delivering regular reports to the Governor and General Assembly as required by the GGRA.

Maryland adopted the Maryland Commission on Climate Change Act in June 2015, which established a coordination and reporting protocol to institutionalize climate change planning across all Maryland agencies. Starting in 2015, MDOT supported MDE and the Commission through preparing Annual Agency Reports detailing progress and agency performance. MDOT has also been an active participant on workgroups and steering committees supporting the MCCC requirements.

In 2016, Maryland reauthorized the 2009 GGRA, refocusing efforts on a new goal of reducing greenhouse gas emissions 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 2019 GGRA Plan. An overview of the complete history, showing MDOT's role relative to the activities of the MCCC, is highlighted in Figure 1.1.

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



1.2 MDOT's Mission and Role in Addressing Climate Change

MDOT's mission statement communicates the importance of a customer-driven transportation system.

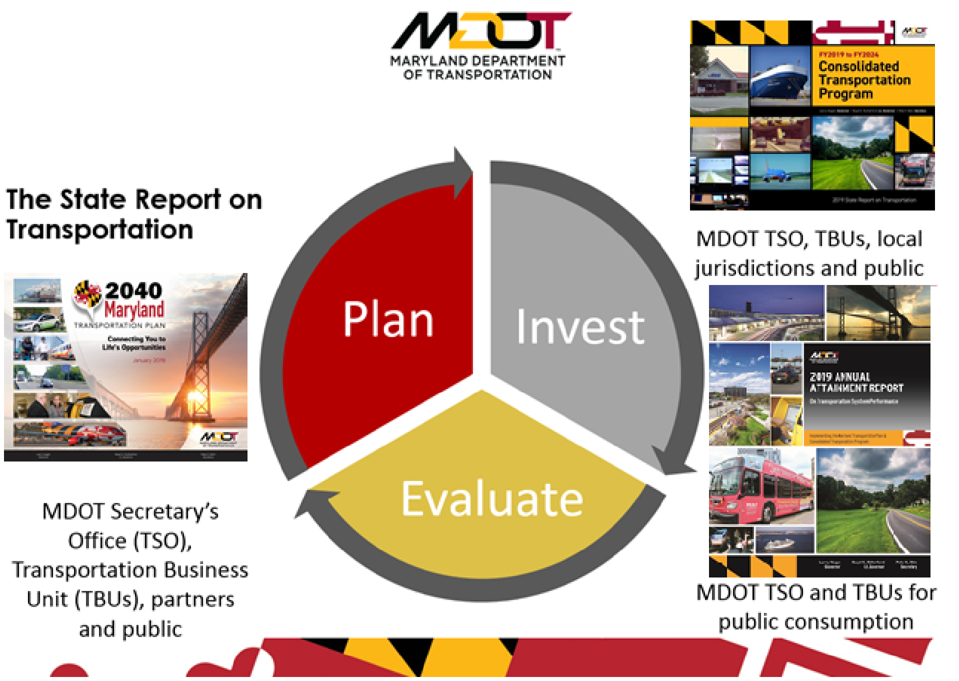
MARYLAND DEPARTMENT OF TRANSPORTATION

MISSION STATEMENT

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

MDOT's strategic approach is presented through the State Report on Transportation (SRT), which is comprised of three documents:

1. The Maryland Transportation Plan (MTP): A 20-year vision document for the State's transportation system;
2. The Consolidated Transportation Program (CTP): The six-year budget for transportation projects statewide, produced annually; and
3. The MDOT Excellerator and the Annual Attainment Report on Transportation System Performance (AR): Recurring evaluations of the performance of Maryland's transportation system.



MDOT's mission communicates the importance of a customer-driven transportation system. The mission, along with the seven goals identified in the 2040 Maryland Transportation Plan (MTP), guides MDOT through statewide transportation planning, programming and coordination across its transportation business units (TBUs) to facilitate the strategic development of Maryland's intermodal transportation system. MDOT developed the goals, objectives, strategies, and performance measures in the 2040 MTP through an interactive outreach process. The goals of the plan are as follows:

- Ensure a Safe, Secure, and Resilient Transportation System;
- Maintain a High Standard and Modernize Maryland's Multimodal Transportation System;
- Improve the Quality and Efficiency of the Transportation System to Enhance the Customer Experience;
- Provide Better Transportation Choices and Connections;
- Facilitate Economic Opportunity and Reduce Congestion in Maryland through Strategic System Expansion;
- Ensure Environmental Protection and Sensitivity; and
- Promote Fiscal Responsibility.

MDOT is a leader in the development, tracking, and reporting of performance measures that drive MDOT and its business units to achieve and maintain exceptional standards while meeting the transportation demands of Maryland residents and users of the transportation system. This State Agency Report draws from three sources of performance and budgetary/financial reporting systems: 1.) The Annual AR, 2.) The MDOT Excellerator, and 3.) The annually updated, six-year, CTP.

Attainment Report: The Annual Attainment Report on System Performance assesses progress towards achieving the goals and objectives of the Maryland Transportation Plan (MTP). Several measures within the AR are indicators for GHG emissions, such as vehicle miles traveled (VMT), transit ridership, transit service reliability, roadway congestion, traffic safety, quality of the bicycle and pedestrian environment, and regional emissions. New measures were introduced as part of the 2018 AR goals and objectives update, including the number of formal or informal telework arrangements and the number of total electric vehicles (EVs) registered in Maryland.

MDOT Excellerator: In 2016, MDOT deployed the MDOT Excellerator, a performance management system which summarizes tangible results of MDOTs performance on a quarterly basis. This program is a living, evolving performance process that is in a constant state of evaluation, analysis, and action. The results represent critical data points that drive daily business decisions.

Like the AR, several measures within the MDOT Excellerator are indicators for GHG emissions, including percent of tolls collected by cash, reliability of highway travel, average highway incident duration, and peak hour congested VMT highway trends. In 2018, new, GHG-specific measures, were added to Tangible Result #9 within the Excellerator, “Be a Good Steward of the Environment.” MDOT is now tracking total EV registrations in Maryland as well as total publicly available electric vehicle supply equipment (EVSE). MDOT is also tracking the total GHG emissions from MDOT fuel consumption, by fuel type, and from MDOT’s electricity use.

Consolidated Transportation Program: The goals of the MTP and the associated measures that illustrate Maryland’s progress reflect the diversity of current and future transportation conditions, challenges, and needs. The Consolidated Transportation Program, the State’s six-year capital investment program for transportation, identifies funding for specific road, bridge, transit, aviation, port, pedestrian and bikeway projects based on the priorities established in the MTP. Many of the goal areas identified in the MTP include projects and programs in the CTP that directly or indirectly yield GHG emission reductions from transportation system users or the actual operation of the transportation system itself.

1.3 Recent and Ongoing MDOT Actions

Within the FY 2018 – 2023 CTP, MDOT estimates that 43 percent (approximately $6.401 billion) of Maryland’s $14.815 billion six-year program (excluding capital salaries, wages, and other costs) is associated with investments that could reduce GHG emissions through 2030 and beyond.

When looking at total funding for major capital projects and programs only, MDOT is investing nearly three quarters of roughly $8.7 billion in funding for projects and programs that are expected to result in GHG emissions reductions.

The successful maintenance, operation, and expansion of Maryland's transportation system requires extensive coordination between MDOT and a diversity of Federal, State, regional, and local partners. This coordination is critical given the shared approach between multiple government agencies as well as private entities in delivering Maryland's transportation system. Regulatory, financial, political, legal, and contractual matters, among others, create a complex framework within which MDOT manages Maryland's transportation system. This framework guides how MDOT, other transportation planning agencies, and transportation service providers function.

Captured within the CTP and many of MDOT's ongoing strategic planning and policy activities are a diverse suite of actions that will help keep Maryland's transportation sector on a sustained path toward GHG emission reduction goals. Highlights of some of these actions in 2017 and 2018 are detailed in Table 1.1.

Table 1.1 MDOT and MDOT TBU Accomplishments

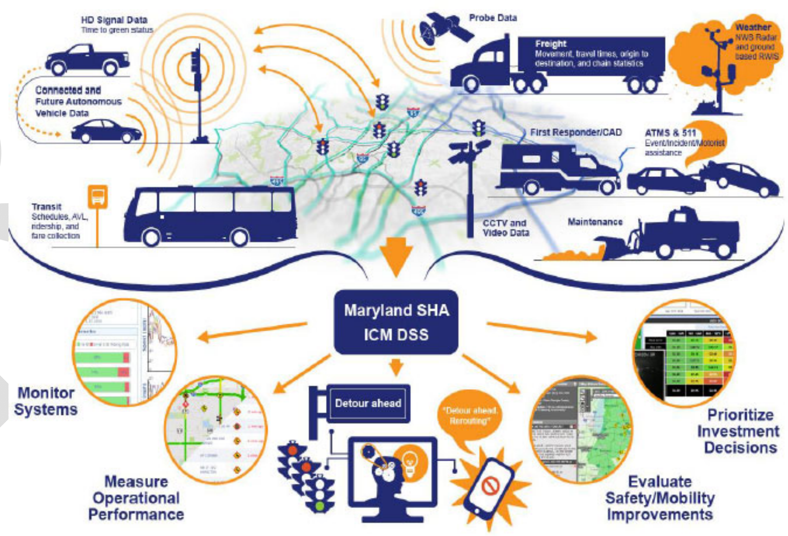
2018 Status Report Accomplishment Highlights	
Adaptation & Resilience	MDOT SHA completed a statewide coastal vulnerability assessment with the best available climate projections and LiDAR data to help inform all aspects of planning, programming and design to ensure resilient and reliable transportation.
	MDOT MTA completed a climate change focused Vulnerability Plan in 2016 and is continuing to utilize the results in development of adaptation measures and resiliency planning.
Transportation Technologies	MDOTs leadership of the Electric Vehicle Infrastructure Council (EVIC) continues to build opportunities, financial incentives and promotion of the purchase of EVs and the installation of EVSE to support the State's EV goals. Total battery-electric and plug-in hybrid electric vehicles registered in Maryland is approaching 14,000 vehicles in 2018.
	MDOT SHAs Coordinated Highway Action Response Team (CHART) program continues to yield substantial GHG reductions associated with the efficient management of incidents, provision of traveler information, and deployment of other on-road infrastructure technologies.
Public Transportation	After launching in June 2017, BaltimoreLink has been providing improved transit service to existing customers as well as roughly 130,000 additional people within a ¼ mile of a bus route.
	Supported by two TIGER Grant awards from US DOT, MDOT MTA is working with Baltimore City to deliver the North Avenue Rising project and Montgomery County to deliver the US 29 Bus Rapid Transit project. Both projects will provide enhanced and more efficient transit options.
	Groundbreaking for the Purple Line in August 2017 through securing of $900 million from the Federal Transit Administration to match State, local, and private funding.
Transportation Pricing	MDOT and MDOT MTA continue to work with Maryland's metropolitan planning organizations (MPOs), major employers, and universities, to expand transportation demand management programs, aimed at providing commuters and student's access to financial incentives and information to support ridesharing and transit use.
	MDTA continues to update the technical capabilities and efficient operations of toll facilities, including strategic planning and procurement of new tolling hardware and software which supports an eventual shift to all-electronic tolling.
Bicycle and Pedestrian	In the FY2018—FY2023 CTP, there is over $175 million programmed to bicycle and pedestrian investments, including ongoing support of Maryland's bikeways and bikeshare programs.

Source: MDOT 2018 State Agency Report to the Maryland Commission on Climate Change

MDOT and the TBUs are also taking innovative steps toward harnessing the potential benefits of emerging transportation technologies through research and development of new strategies including the use of renewable energy, connected and automated vehicles, and integrated corridor management.

- **Renewable Energy** - MDOT issued six Master Services Agreements (MSA) for qualified contractors to design, construct, commission, finance, operate, and maintain renewable energy facilities at MDOT locations throughout Maryland. The MSAs provide MDOT with the flexibility of developing renewable energy systems quickly and efficiently. The GHG benefit has increased by 10 percent over the last year and has already attributed to over 15 metric tons of CO_2 reductions.

- **Connected and Automated Vehicles (CAV)** - MDOT has established a CAV Working Group as the central coordination point for these emerging technologies. MDOT is developing Maryland's vision for a connected and automated vehicle future through extensive collaboration with MDOT's TBUs and planning partners. The Aberdeen Test Center has been recognized as a federal testing location for AV and US 1 was selected to pilot an innovative technology corridor.   Maryland is emerging as a national leader in CAV technology and is building on this progress by developing CAV strategic plans that documents opportunities, challenges, priorities, strategies, and recommendations to help guide the State in planning and implementing CAV technology.



- **Integrated Corridor Management** – MDOT SHA is a recognized national leader in the testing and deployment of real time technologies to adjust signal operation to maximize throughput and reduce delay. The system uses real-time traffic conditions and artificial intelligence (AI) to adjust the timing of traffic signals and synchronize the entire corridor. These updates, associated with the Traffic Relief Plan, will improve traffic operations for 700,000 drivers per day on 14 major corridors across the state ($50.3 million in the FY 2018-2023 CTP).

1.4 Purpose and Process of This Plan

The goal of this plan update is to present the progress the transportation sector has made 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.

To meet this goal, the plan:

- Presents the transportation sector's accomplishments since 2009;

- Discusses broad trends impacting VMT, vehicle technology, and fuel use and details the emission outcomes of these trends;
- Identifies specific actions, including costs and benefits, for implementation through 2030; and
- Assesses the transportation sector's contribution to the overall 2030 emission reduction goal.

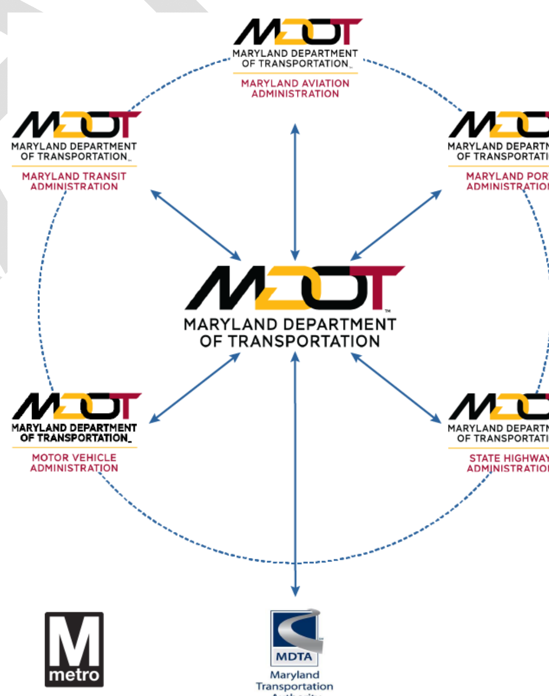
Technical Approach

The technical approach to analyzing GHG emission outcomes and co-benefits from transportation strategies is constantly evolving. New and updated tools and best practices require a rethinking of the analytical steps, data, and desired outputs for each iteration of transportation sector GHG emissions inventories and forecasts. In addition, with the focus on 2030, there are new assumptions for consideration including long-term economic growth, socioeconomic, vehicle and fuel technology, and transportation funding trends. As in prior analysis, the Environmental Protection Agency's (EPA) MOVES (Motor Vehicle Emissions Simulator) model remains the primary tool for estimating on-road GHG emissions. This model has improved from previous MDOT analyses, as have the inputs from Maryland's MPO metropolitan transportation plans and MDOT SHA's new statewide transportation demand model.

Coordination

Planning, implementation tracking, and emissions analysis within the transportation sector requires MDOT to coordinate regularly with MDE and other state and regional partners.

- MDOT is an organization comprised of five business units and one Authority. They are:
  The Secretary's Office (MDOT TSO), MDOT SHA, MDOT MTA, Motor Vehicle Administration (MDOT MVA), Maryland Port Administration (MDOT MPA), Maryland Aviation Administration (MDOT MAA), and MDTA.
- MDOT TSO works with the TBUs and the Washington Metropolitan Area Transit Authority (WMATA) to document operations and initiatives that are generating GHG emission reductions today and in the future.
- MDOT also coordinates with Maryland's MPOs to support short and long-range transportation planning, and the transportation conformity process.
- MDOT chairs the Electric Vehicle Infrastructure Council (EVIC), working with MDE, the Maryland Energy Administration (MEA), and other public and private stakeholders to develop policy regarding EVs.



- MDOT also works with the Maryland Department of Planning (MDP), Sustainable Growth Commission, Smart Growth Subcabinet, and National Center for Smart Growth at University of Maryland regarding land use decisions and their connection to travel demand. Coordination with MDP includes planning to support transit-oriented development (TOD).

2.0 2030 Context – Transportation Drivers and Trends

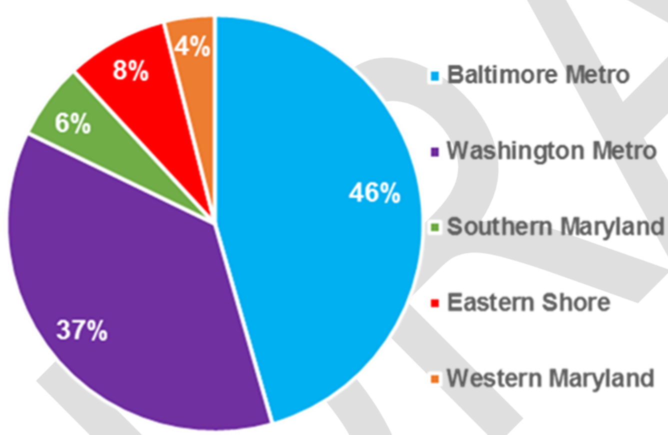
The last decade has seen shifts in Maryland's population and economy, and evolutions in how the transportation system provides mobility to Maryland's residents, and visitors, employers, and shippers. Ongoing development of the MTP has focused on these shifts to support creation of a new framework for transportation priorities and investments. In 2017 and early 2018, MDOT developed a [Conditions, Trends, and Challenges Technical Memorandum] that provides information that supported MDOT and stakeholder decisions regarding MTP goals, objectives, and strategies. Much of that work is summarized in this section.

2.1 Population

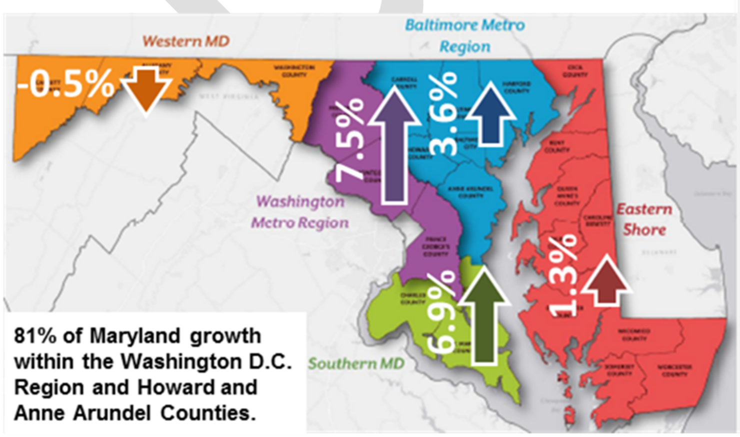
Demand for travel in Maryland is tied to population growth, density, and demographics. In areas of the state with high population density, residents tend to rely more on mass transit and non-motorized transportation modes, while less populated areas remain reliant on motor vehicles.

6.05 million people **#19 in US by population** **#5 in density**

2017 Share by Region



2010 to 2017 Growth = 4.8%



81% of Maryland growth within the Washington D.C. Region and Howard and Anne Arundel Counties.

Aging Population – The 65-and-older cohort grew 28 percent between 2010 and 2017, totaling 14.9 percent of Maryland's population. Much of this growth is occurring in rural locations, particularly on the Eastern Shore.

Millenial Generation – The 20-to-39 age cohort was the next highest rate of population growth. Most of this growth is occurring along the I-95 and I-270 corridor as well as in small city centers like Frederick.

Auto Ownership – 9.2 percent of Maryland's 2.17 million households do not own a car. Baltimore City has the highest share at over 29 percent, while Montgomery, Prince Georges, and Baltimore counties average 7.5 percent.

Poverty – Baltimore City faces a poverty rate (22.7 percent) more than double the statewide average of 9.9 percent. Outside of Baltimore City, poverty in Maryland tends to be concentrated in Western Maryland and the Eastern Shore.

2.2 Economic Growth and Diversity

A well-functioning transportation system is critical to Maryland's economic competitiveness and opportunities for its residents. Businesses seeking to relocate or open new facilities often consider transportation opportunities and efficiency as factors to ensure goods can be shipped on time and that employees can enjoy a high quality of life.

3.23 million civilian jobs in 2018 **5% growth** since 2010

Maryland's Gross State Product increased from $242.3 billion in 2000 to $329.1 billion in 2015. While Maryland has seen slower economic growth than the US since 2011, Maryland's economy did not contract as much during the Great Recession as peer states.

41% Finance/Insurance/ Real Estate, Professional/ Business, Information

21% Government

17% Trade, Construction Transportation

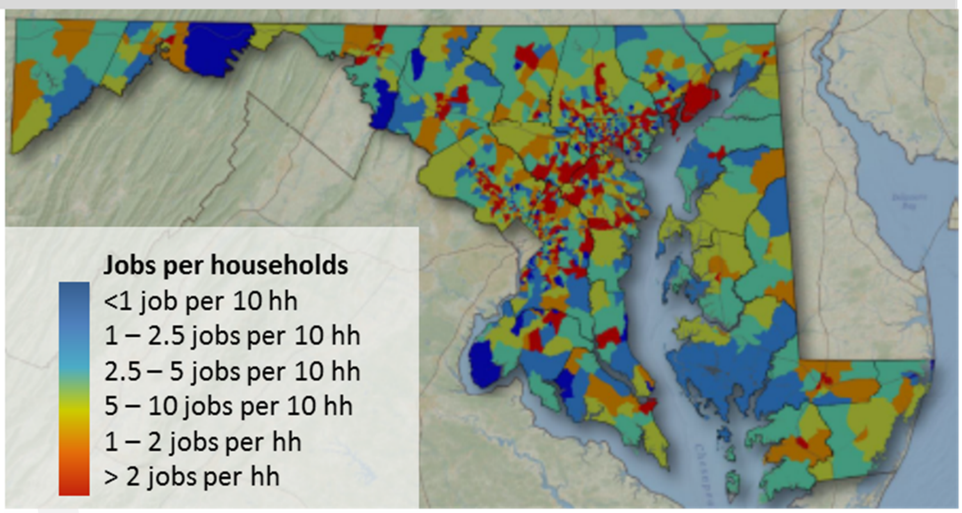
8% Education, Health

8% Manufacturing, Utilities

5% Entertainment, Recreation

Maryland's labor force participation rate has hovered between 65% and 70% since 2007. It currently stands at 68.4%, 5% above the national average.

Jobs – Housing Balance: There are relative imbalances between jobs and housing throughout Maryland. The map shows a concentration of jobs relative to housing units in central Maryland and an imbalance in other communities. This imbalance leads to longer commutes and congestion in the peak periods.



Freight contributes to nearly every aspect of the lives of people living, visiting, and working in Maryland. Freight goods include sensitive high-cost products, such as medicines and technology, household items purchased online, items found in grocery, convenience and retail stores, industrial goods, raw materials, finished goods, and even new vehicles. Industries in Maryland that compete on the global market, such as mining, agriculture, retail and wholesale trade, manufacturing, construction, and warehousing, depend on freight movement and account for over one million jobs in Maryland.

- Maryland's freight industry is a key driver of the economy employing over 1.5 million people and contributing over $123.0 billion (37 percent of the total) to the state's annual GDP.

- Truck, rail, water, and air modes moved nearly 631 million tons of freight, worth $835 billion, to, from, within, and through Maryland in 2012. By 2040, more than 1 billion tons of freight, worth close to $1.6 trillion, is expected to move within and through Maryland.
- **Over 95% of freight shipments (approximately 76% by tonnage) is moved by trucks on Maryland's Interstate highway and freight system,**
- The Port of Baltimore continues to see its investments in its facilities pay dividends as it is ranked as the **top port among all U.S. ports for handling autos and light trucks, farm and construction machinery, and imported sugar**. The Port of Baltimore handled **31.8 million tons of international cargo worth $49.9 billion in 2016** and is ranked ninth for the total dollar value of international cargo and 14th for international cargo tonnage for all U.S. ports.

2.3 Transportation Technology

Maryland is a leader in adopting strategies to advance cleaner vehicles and fuels, via the Maryland Clean Cars Program, which implemented California's low emissions vehicle (LEV) standards to vehicles purchased in Maryland starting in 2011. Since then, enhancements in Federal motor vehicle emissions standards have overlapped with this program, and further improvements in vehicle technologies and fuels are anticipated to play a key role in significantly improving air quality and reducing GHG emissions.

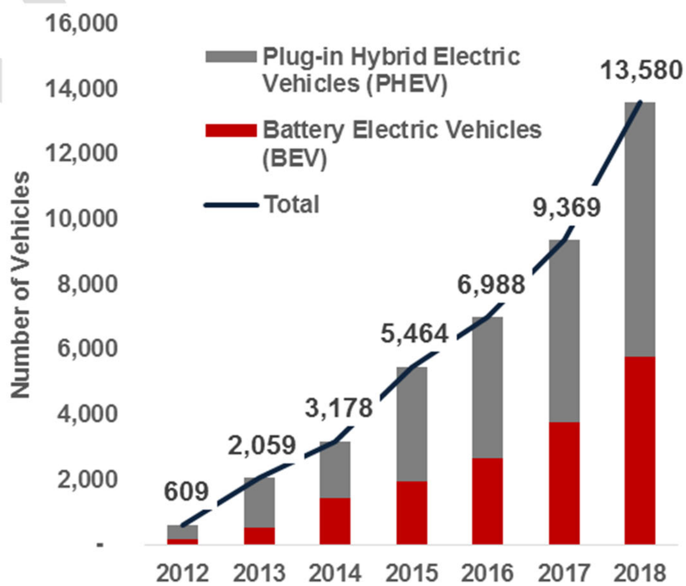
National light-duty GHG and fuel economy program –
These standards apply to passenger vehicles and light-duty trucks, and are projected to result in an average industry fleet level of 163 grams/mile of carbon dioxide in model year 2025, which is equivalent to 54.5 miles per gallon – **a more than doubling of fuel economy from 2010 model year vehicles.**

National medium and heavy-duty vehicle GHG and fuel efficiency standards –
Adopted Phase 1 and Phase 2 national standards for medium- and heavy-duty engines and vehicles through model year 2027 will result in reduced GHG emissions from trucks and other large vehicles traveling within and through Maryland.

Zero-Emission Vehicle (ZEV) Mandate –
The Maryland Clean Cars Program contains a ZEV mandate which requires that manufacturers make an increasing percentage of the vehicles available for sale in Maryland be ZEVs. **It is estimated that by 2025 this Program could result in approximately 300,000 ZEVs in Maryland.**

In 2012 there were two Battery Electric Vehicles (BEV) models available in Maryland - today, there are over 15 BEV models available for purchase in Maryland in addition to 20 plug-in hybrid vehicles.

As the number of electric vehicles increase, there is more need for charging stations. **Within Maryland there are 579 electric stations and 1,532 public charging outlets.**

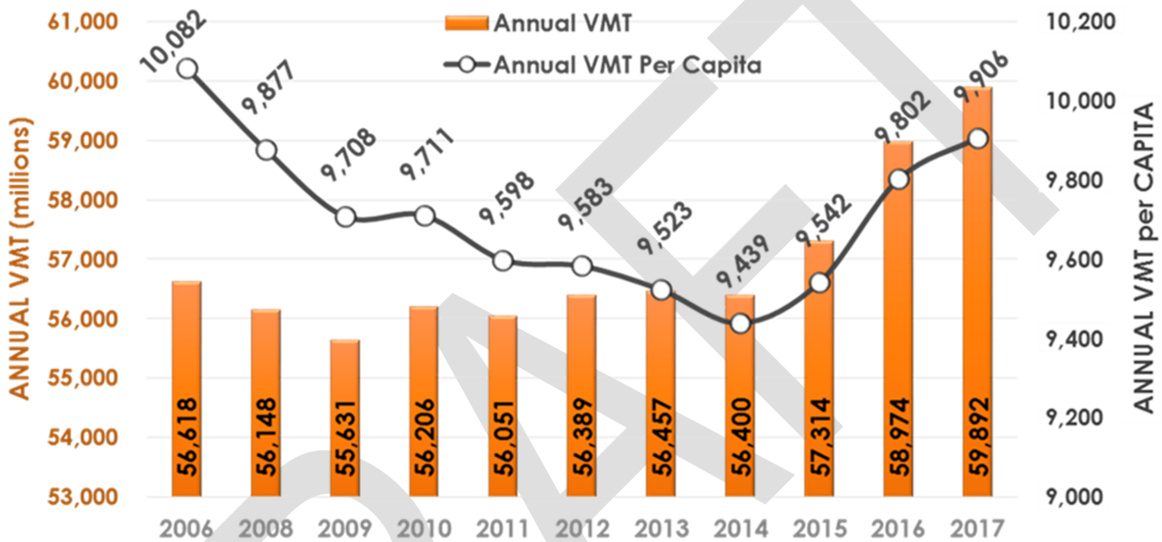


2.4 Transportation Mobility and Accessibility

Economic and population growth create more demand for mobility by residents, visitors, and companies conducting their business. As these demands increase, past trends indicate that it can be expected that total VMT will also increase, as will demand for all transportation services.

Vehicle Miles Traveled

2017 Maryland VMT is expected to total around 59.6 billion, representing a 6 percent increase from 2010, outpacing population growth since 2010, resulting in increases in VMT per capita. While still lower than pre-recession VMT per capita, recent economic growth and comparatively low fuel costs have accelerated VMT growth in 2015 through 2017.



Licensed Drivers and Registered Vehicles

The number of licensed drivers and registered vehicles relative to Maryland's population has remained generally constant since 2010.

71% of Maryland's population with a drivers license

5.1 million registered vehicles

Commute Time

Based on U.S. Census data, Maryland has some of the longest commute times in the nation – **32.3 minutes**. Carroll, Frederick, Montgomery, Prince George's, Charles, and Calvert Counties all have average commute times greater than the State average, with both Charles and Calvert over 40 minutes. This pattern has remained fairly constant in Maryland since 2010. Commute trips represent about 1/3rd of total travel.

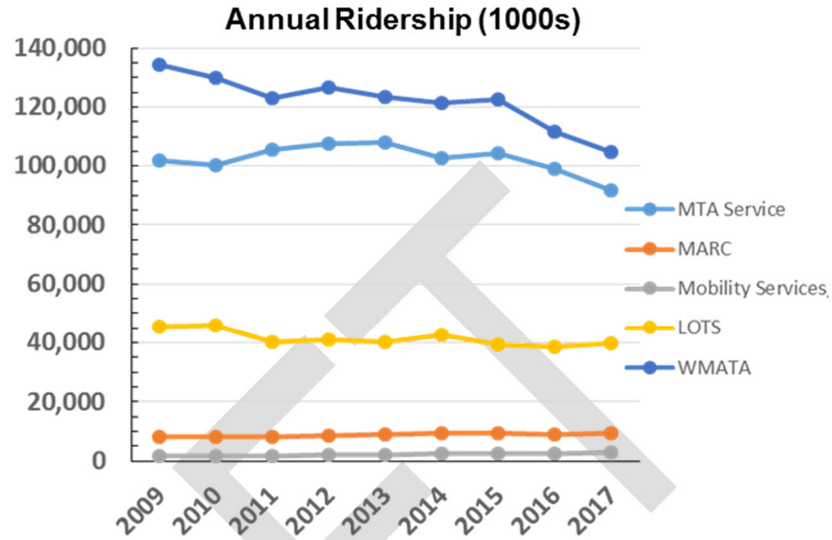
Commute Mode Split

Based on U.S. Census data, commuting by mode has remained overall constant since 2010. **Drive alone has hovered around 74%**, while **carpool (9%)** and **transit (8.5%)** have decreased and been replaced by increases in work at home, walk, and other (including shared-ride). The highest non-drive alone mode shares are in Baltimore City (40%) and Montgomery and Prince George's Counties (35%).

Transit Ridership

MDOT, MDOT MTA, WMATA, and local transit partners provide transit options for residents and visitors to urban and rural Maryland.

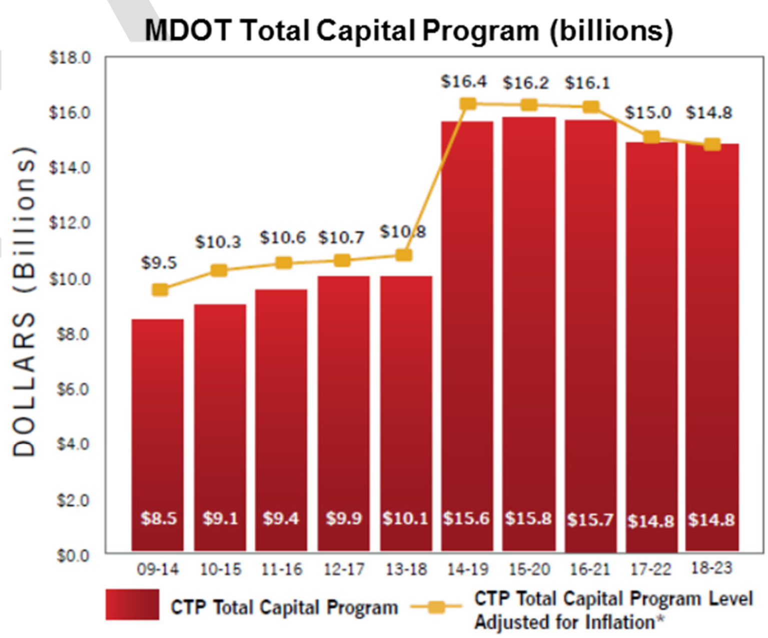
- Average annual growth rate in MTA service revenue vehicle miles from 2006 to 2017 was 3.1 percent, while ridership declined over that same period
- MD is #5 in transit commute mode share (9 percent) behind only IL, MA, NJ, NY
- Over the last 10 years, the share of the capital budget committed to MDOT MTA and WMATA has increased from 29.6 percent in 2006 to 33.1 percent in 2016



2.5 Transportation Policy and Funding

MDOT supports strategies across every mode of transportation – improving the customer experience on the transportation network by improving safety, reducing congestion, providing more and better non-motorized and transit options, increasing connections between modes, and improving the flow of goods. In the FY 2018–FY 2023 CTP, Maryland will invest $14.8 billion in transportation projects, ranging from connecting Maryland with transit options to addressing congestion to optimizing waterways for trade.

- **MDOT invests in the transportation system by applying all the resources it has available, the majority of which come from the Transportation Trust Fund (TTF).**
- **MDOT also engages private partners to minimize risk and maximize the efficiency of each dollar spent.** The Purple Line transit project is an example of a Public-Private- Partnership (P3). MDOT is also taking action to ease traffic on the state's most congested highways through a $9.0 billion P3 that will reduce congestion on three of Maryland's most congested highways – the Capital Beltway, I-270, and the Baltimore-Washington Parkway.

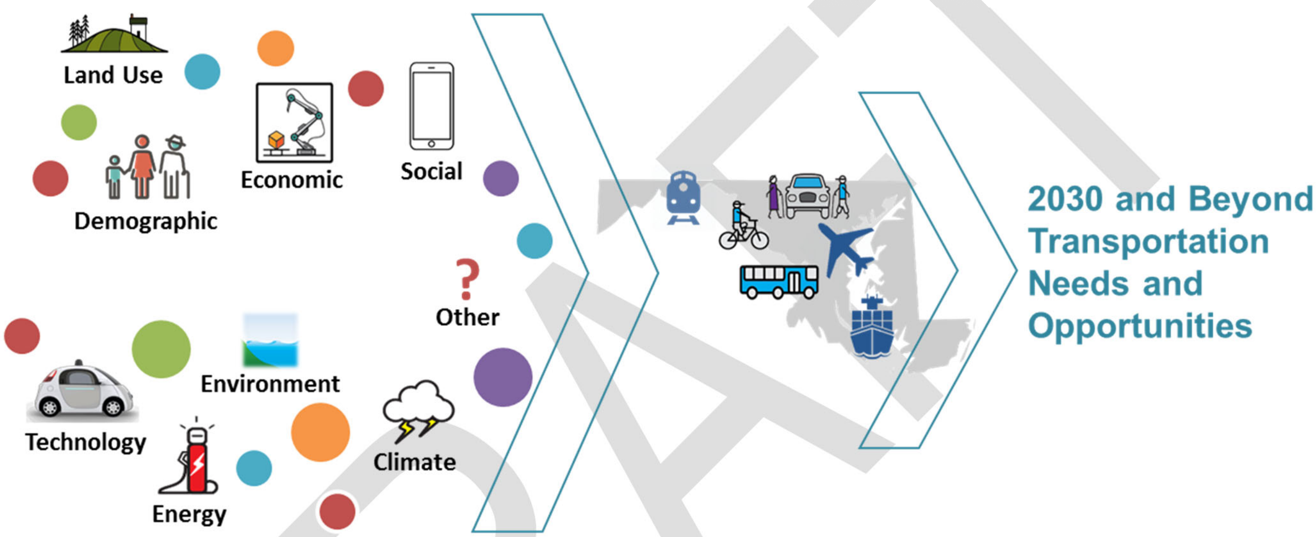


43% of the $14.8 billion 2018-2023 CTP support GHG emissions reductions.

This represents **73%** of major capital investments in the CTP.

2.6 What This Means for 2030 and Beyond

The performance of Maryland's transportation system, as well as MDOT's ability to maintain and enhance the system, is influenced by social, technological, and economic trends (including fuel prices, which have a significant impact on travel activity). Emerging trends toward a "sharing economy" in transportation, vehicle technology, fuel advancements including electric and connected / automated vehicles, and changing logistics and supply chain patterns will greatly influence the use of the transportation system. These trends will help shape Maryland's ability to reduce GHG emissions from the transportation sector over the coming decades. In many cases, MDOT has little control in how these trends 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.



The potential impacts of climate change on transportation infrastructure and operations are a growing concern, and Maryland's transportation infrastructure will be impacted by changes to the climate. For example, the Port is a water-dependent asset and since many of its facilities are within the flood plain, MDOT MPA has conducted a vulnerability assessment and implemented policies to increase resiliency. Rising sea level, increased flooding, changes in precipitation levels, and increased temperatures will stress infrastructure. Because those future factors are not always considered in the design specifications, infrastructure could meet today's standards, but fail in the future.

As growth spreads from Maryland's economic centers, it becomes harder to provide efficient transportation options. As jobs and housing locate further from each other, demands on the transportation network increase. Land use is a local decision; however, provision of transportation access has State implications. Maryland's TOD program promotes TOD as a tool to support economic development, grow transit ridership, and maximize the efficient use of transportation infrastructure.

As the Millennial generation continues to enter the workforce, Maryland's transportation system will face challenges associated with that generation's preferences. Maryland's population is also getting older, and the implications of this population shift are uncertain. Providing transportation for older Marylanders could impact public transportation agencies, non-profit transportation providers, and/or private providers.

Social

Ridesharing services, such as Uber and Lyft, substitute for traditional taxi services, providing a cheaper and immediate alternative. To date, ridesharing has been effective in large, dense urban areas with significant demand and a large number of drivers. It is uncertain how ridesharing, carsharing, and other mobility-on-demand providers like e-scooters will impact the number of vehicle registrations, licensed drivers, or transit riders. In addition, these services may be augmented or, conversely, reduced with the increase in automobile automation.

Economic

Retail in the United States is in the midst of a major shift and consolidation. The shift toward online shopping has reduced the number of individual shopping trips and increased the number of delivery trucks (or drones), leading to an overall reduction in vehicles on the road. An additional challenge for Maryland associated with online shopping is the tremendous growth in the development of very large warehouse and distribution centers. Technology in the manufacturing sector is also changing logistics patterns as distributed manufacturing, 3D printing, and other emerging tools may bring goods closer to market, increasing truck trips over marine, rail, or aviation.

These economic shifts might not unfold equally across Maryland. There are jobs and workers in other parts of the state, which also require transportation investments to ensure the continued growth of their economies. Striking a balance between the State's various transportation needs and economic shifts is an important policy challenge facing the State.

Technology

Connected and automated vehicles have the potential to both impact transportation system supply and demand. In a world where automation leads to lower auto ownership rates and transportation modes are interconnected through public and private providers though mobility-as-a-service, it is possible that VMT could increase as access to mobility is improved. Simultaneous to this, most, if not all of these vehicles will be electric, and presumably will make more efficient use of roadway capacity through new infrastructure technologies.

Energy

Technology changes in transportation are disruptive forces that could also create new challenges for transportation planning, including reduction in revenues from traditional motor vehicle fuel based taxes. Transition to an electric fleet will also have impacts on household and commercial electricity consumption, placing more pressure on the electric grid and Maryland's existing and future energy sources.

Environment

Population and economic growth will continue to stress Maryland's environment, particularly the Chesapeake Bay. How the expanding transportation system accommodates growing demand while mitigating impacts will remain a primary MDOT goal.

According to projections by the Maryland Department of Planning, **by 2030, Maryland is anticipated to grow to over 6.5 million people, nearly ½ million more people than in 2017**.

This growth, coupled with economic expansion and land use change could result in **statewide VMT over 71 billion by 2030**, compared to 59 billion in 2017.

This growth would lead to **significant challenges on the transportation system** – however, **emerging technology and proactive planning by MDOT** will help create opportunities and ensure a balanced transportation system providing equitable access for all and support Maryland's economy.

3.0 2030 Strategies and Scenarios

3.1 2030 Approach and Considerations

Prior MDOT GGRA Reports supporting requirements toward the 2020 goal relied on current trends and the suite of projects and programs fully funded within the CTP as the primary evidence for what 2020 may look like. Assumptions on potential new or expanded emission reduction strategies were tested as enhancements to MDOT's approach, with the recognition that additional funding or new policy would be required to make these a reality.

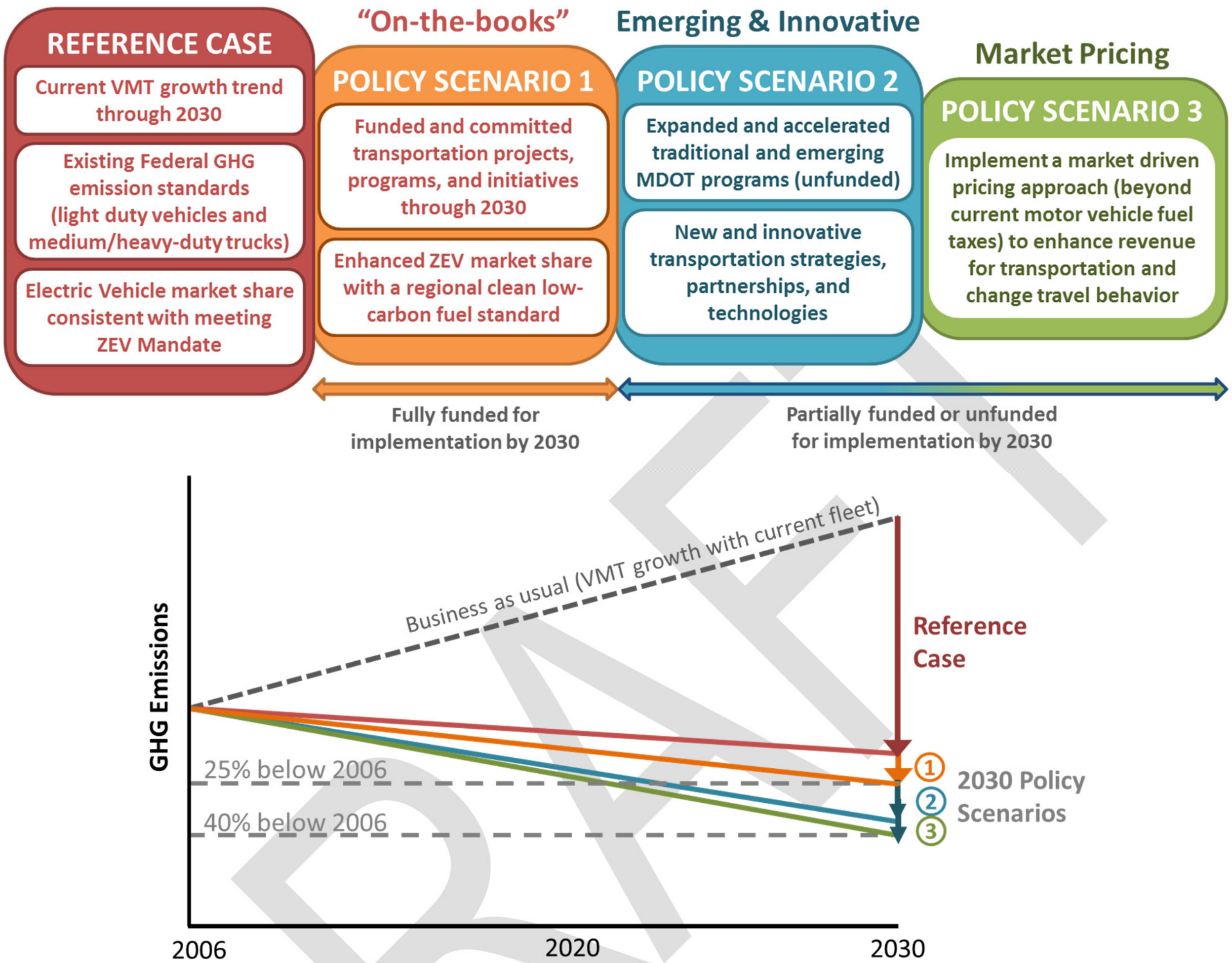
For the 2030 analysis, the opportunities and challenges within the transportation sector could greatly impact 2030 emission trends. As noted in the prior section, there are many forces creating disruptions and opportunities in transportation. While there is some certainty established with transportation funding over the next six years (2018 – 2023) 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. As a result, MDOT has developed a list of strategies and scenarios, consistent with the Draft goals, objectives, and strategies in the 2040 MTP, to put Maryland's transportation sector on a path toward the "40 by 30" goal.

Consistent with the GGRA, the development of emission reduction strategies and scenarios and the associated emissions analysis all pivot from the 2006 base year. Each 2030 scenario is modeled consistent with the assumptions of the prior scenario in order to account for synergies among scenario assumptions and avoid any double counting of emission benefits. MDOT followed the MCCC, Mitigation Work Group (MWG) scenario modeling organization, which covers all sectors, to inform development of transportation sector scenarios:

- **Reference Case:** "Business as usual" scenario incorporating effects of major policies as they currently exist on the books;
- **Policy Scenario 1:** Extension of the current policy and program framework within the Reference Case including funded plans, projects, and programs;
- **Policy Scenario 2:** New programs and policies beyond Policy Scenario #1;
- **Policy Scenario 3:** MWG driven scenario including market-based strategies; and
- **Policy Scenario 4:** Final 2018 Draft Plan scenario incorporating consensus findings from MWG

For the transportation sector, **Figure 3.1** 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 (e.g., aviation, marine, and rail) are developed and analyzed through a partnership approach between MDOT and MDE and presented separately.

Figure 3.1 2030 Approach Overview



The MDOT approach to GHG reduction from the transportation sector balances continuing challenges with emerging opportunities, including:

- Communication technology advances – EVs, CAV, & Smart Mobility with private sector participation,
- Sustainable funding remaining a challenge,
- Changing generational preferences on transportation and development, and
- Economics and logistics shifts due to technology.

These factors require MDOT to advance more complex and multimodal projects, deliver improvements ultra-efficiently with more partners, rely more on system optimization, and use emerging technologies.

3.1.1 GHG Mitigation Strategy Development

A comprehensive list of GHG mitigation strategies was compiled from previous MDOT GGRA plans, the MTP, other ongoing statewide and regional initiatives, and a review of national best practices. This preliminary list of strategies was qualitatively reviewed based on cost effectiveness, political feasibility, GHG reduction potential, MDOT's control over the strategy implementation, and the potential for strategy implementation by 2030. Based on these factors, strategies were grouped, and prioritized. Ultimately, very few strategies were removed from consideration for this analysis in the Draft 2018 GGRA Plan. Strategies that were excluded from consideration were likely those which had little or no chance of implementation under the current regulatory framework (for example, new post 2025 Federal fuel economy standards for light duty vehicles and renewed fuel economy standards for medium- and heavy-duty trucks beyond the current Phase 2 standards).

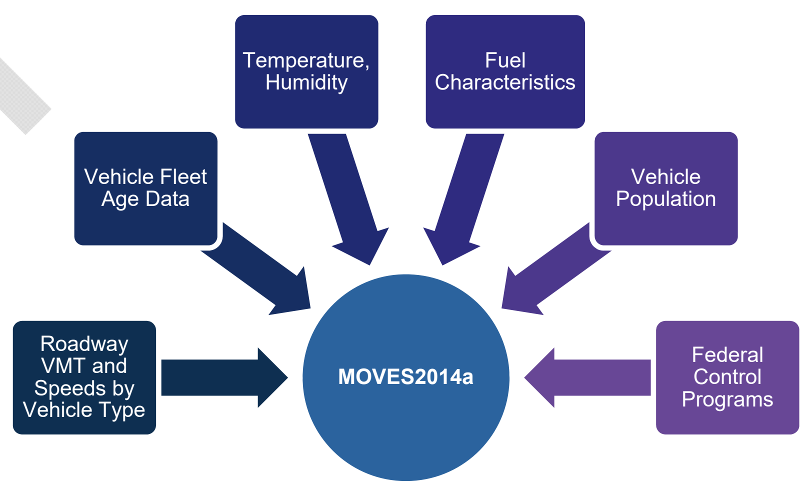
Some strategies were arranged or prioritized based on their likelihood of implementation by 2030 (for example, longer-term projects identified in the MARC Growth and Investment Plan or construction of Northeast Corridor High Speed Rail). In order to consider them in the strategy analysis, assumptions were made on enabling funding and policy changes that may be needed to promote implementation by 2030, particularly in Policy Scenario 2.

3.1.2 Technical Approach

The on-road portion of the GHG emissions inventory were estimated with EPA's latest emissions model, version MOVES2014a, released in November 2016. With MOVES, greenhouse gases are calculated from vehicle energy consumption rates and vary by vehicle operating characteristics including speed, engine size, and vehicle age. As illustrated in **Figure 3.2**, the MOVES2014a model is integrated with local traffic, vehicle fleet, environmental data, fuel, and emission control programs to estimate statewide emissions.

The on-road transportation emissions inventory includes emissions of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) converted to carbon dioxide equivalents (CO_2e) that are measured in units of million metric tons (mmt CO_2e) based on each pollutant's global warming potential (GWP). Carbon dioxide represents about 97 percent of transportation sector GHG emissions. The data sets, input values, analysis tools and methodologies employed to conduct the on-road vehicle GHG emissions inventory were developed in consultation with MDE and are consistent with EPA guidance.

Figure 3.2 Emissions Calculation Data Process



The MOVES model is best suited to estimate emissions based on state-wide and jurisdiction level data that accounts for vehicle miles traveled trends and fleet characteristics. It is not well suited to analyze the impacts of individual strategies or scenarios. The MOVES model was used, along with post-processing techniques, to estimate emissions within the Reference and Policy Scenario 1. The combined emission outcomes of these scenarios informed spreadsheet level analysis outside of MOVES in Policy Scenario 2 and Policy Scenario 3 through best-practice GHG emission reductions estimates based on research, analysis, and observed benefits in Maryland and peer regions.

4.0 Baseline and Reference Scenarios

4.1 Description

Consistent with the GGRA, the development of emission reduction strategies and scenarios all pivot from the 2006 Base Year inventory. Each approach presented in this section is modeled consistently, but with the latest planning assumptions in place for the year of the inventory. MDOT refers to the 2006, 2014, 2017, and the 2030 Business as Usual scenarios as "Baseline Scenarios".

2006. The 2006 Baseline Inventory established the base conditions for the GHG reduction goals in the GGRA that include 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 and traffic volumes. This approach utilizes emission rates from EPA's MOVES emissions model and Maryland reported VMT, combined with a robust forecasting process based on historic trends and regional population and employment forecasts.

2014 and 2017. MDOT annually reports on-road GHG emissions within the AR. GHG emission estimates for on-road transportation in 2014 and 2017 baselines reflect a "true up" of actual conditions based upon the process for developing EPAs National Emissions Inventory (NEI). The statewide inventories represent the traffic conditions (VMT, congestion and speeds) based on roadway segment counts, reported data from the Highway Performance Monitoring System (HPMS) developed by MDOT SHA and the vehicle technology standards in place for each inventory.

2030 Business as Usual (BAU). VMT trends show a total six percent growth from 2015 through 2017 compared to nearly no growth between 2006 and 2014. While the demand for the transportation system increases as a result of the economic recovery and other factors, GHG emissions continue to decline through 2017. The 2030 BAU scenario represents the expected forecast of GHG emissions and VMT projections based on existing fleet information and travel trends. This represents the future conditions without implementing any additional GHG reductions strategies or polices.

The 2030 BAU is the starting point for GHG reduction needs to meet the 40% reduction goal. The VMT forecast reflects the historic trends of 1990-2014 VMT growth. The average statewide annualized growth rate through 2030 for this scenario is 1.7 percent.

2030 Reference. The 2030 Reference scenario includes the Maryland and federal vehicle technology and GHG emissions standards, federal renewable fuels standards, and EV market share forecasts consistent with Maryland's commitment to the ZEV Mandate.

State and Federal Initiatives and Standards – State and federal initiatives that affect fuel economy standards significantly contribute to the 2030 transportation sector GHG reductions. The technology advances are designed to improve vehicle fuel economy and reduce average GHG emissions per mile. The standards have been adopted through EPA Final Rulemakings and include light-duty vehicles, medium- and heavy-duty trucks, and fuel standards. These benefits represent the largest contributor to

GHG reductions in the transportation sector. The benefits will increase over time as the fleet turns over with newer vehicles and older vehicles are removed from the fleet. A summary of these standards is presented in **Table 4.1**.

Table 4.1 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 electric vehicles (adopted 2007).
- ***Corporate Average Fuel Economy (CAFE) Standards (Model Years 2008-2011)*** – Vehicle model years through 2011 are covered under existing CAFE standards that will remain intact under the new 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 the year 2016. This equates to an average fuel economy near 35 mpg (published May 2010).
- ***National Program Phase 2 (Model Years 2017-2025)*** – The light-duty vehicle fuel economy standards for model years between 2017 and 2025. The standards are phased-in and projected to result in an average 163 gram/mile of CO_2 by model year 2025. This equates to an average fuel economy of 54.5 mpg (published October 2012).

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 greenhouse gas 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 (EVs) – Initiatives to encourage the use of electric and other low and zero-emitting vehicles are part of Maryland's efforts to reduce emissions of GHGs and other air pollutants from mobile sources by providing alternatives to conventional internal combustion engine vehicles. EVs include plug-in all-electric vehicles, battery electric vehicles (BEVs), and plug-in hybrid electric vehicles (PHEVs). Maryland has assumed a leadership role in facilitating the deployment of EVs and EV charging infrastructure in the State.

During the 2011 Maryland Legislative session, the General Assembly passed legislation creating EVIC, which was approved by the Governor in May 2011. MDOT chairs EVIC, working with MDE and MEA, as well as other public and private stakeholders to plan and develop policy regarding EVs. EVIC produces annual reporting on the progress of developing, evaluating and recommending strategies to facilitate the successful integration of EVs and EV infrastructure into Maryland's existing transportation infrastructure. In 2017, EVIC supported the passage of SB 393/HB 406, the Clean Cars Act of 2017, which Governor Hogan signed into law on May 4, 2017. This bill made the following changes:

- Extended the Electric Vehicle Recharging Equipment Rebate Program and authorization to issue motor vehicle excise tax credits for qualified PEV vehicles through fiscal year 2020.
- Increased the total amount of equipment rebates from up to $600,000 to a maximum of $1,200,000 per fiscal year, increasing the amount required to be transferred from the Strategic Energy Investment Fund to the Transportation Trust Fund (TTF).
- Increased the amount of motor vehicle excise tax credits that may be issued during a fiscal year. The credit value was reduced to $100 per kilowatt-hour (kWh) of battery capacity of the vehicle up to $3,000.
- Added additional eligibility requirements, capping qualifying vehicle purchase prices at $60,000, and requiring a minimum battery capacity of 5 kWh.
- Drivers of approved plug-in electric vehicles can use Maryland's high occupancy vehicle (HOV) lanes even if they are traveling solo.

Maryland's ZEV program is part of the California Clean Cars Program that Maryland adopted in 2007 and part of a seven-state memorandum of understanding (MOU) with auto manufacturers. The ZEV program requires an increasing number of ZEVs be made available for sale in the state. **The State goals for the number of registered EVs are – 60,000 by 2020, 300,000 by 2025, and 600,000 by 2030. These goals assume that 20 percent of the new passenger cars and truck sales are electric by 2025 and electric vehicle VMT represents 11 percent of the total VMT by 2030.**

4.2 2030 Emission Outcomes

The modeled Baseline Scenarios include the 2006 baseline that establishes the 2030 40 percent reduction goal and 2014 and 2017 baseline that reflects a true up of actual conditions and vehicle standards in place. The Baseline Scenarios also includes the 2030 BAU that assumes continued growth in vehicle travel and existing vehicle standards in 2030. **Table 4.2** summarizes annual VMT and GHG emissions for the Baseline Scenarios.

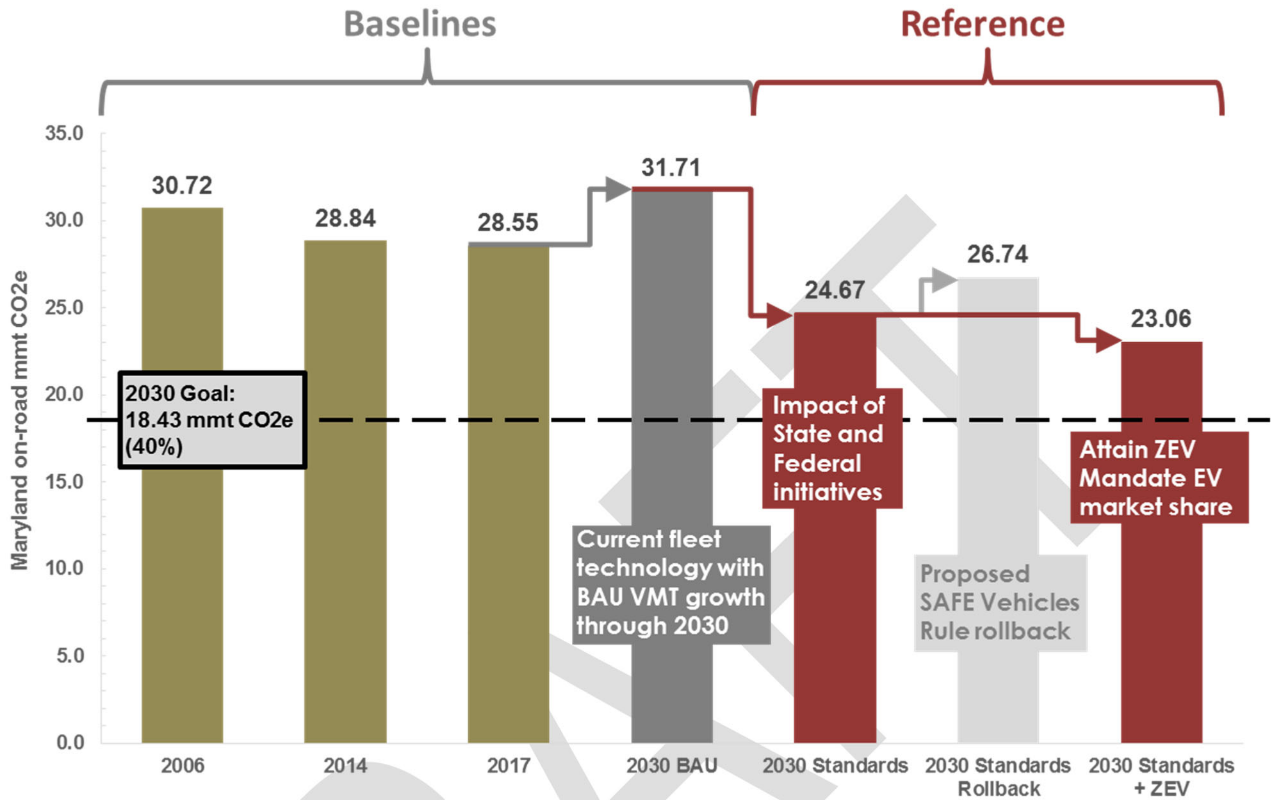
Table 4.2 Maryland VMT and GHG Emissions for Baseline Scenarios

Emissions Source	Measure	2006 Baseline	2014 Baseline	2017 Baseline	2030 Business as Usual
Light Duty Passenger Cars and Trucks	Annual VMT (millions)	51,823	52,253	55,799	66,517
	Annual mmt CO_2e	**23.34**	**22.49**	**22.45**	**24.35**
Medium/Heavy Duty Trucks & Buses	Annual VMT (millions)	4,795	4,147	4,092	5,304
	Annual mmt CO_2e	**7.38**	**6.35**	**6.10**	**7.36**
All On-road Vehicles	Annual VMT (millions)	56,618	56,400	59,892	71,821
	Annual mmt CO_2e	**30.72**	**28.84**	**28.55**	**31.71**

Figure 4.1 presents each component of the Baseline Scenarios and the Reference Scenario.

- In 2017, GHG emissions from on-road sources is estimated at 7 percent below 2006 emissions.
- From 2017 to 2030, total on-road GHG emissions could increase 3.16 mmt CO_2e to 31.71 mmt CO_2e resulting from average annual VMT growth at 1.7 percent and only vehicle turnover accounting for current technology and standards. This represents the BAU Baseline Scenario.
- With the full implementation of final federal vehicle and fuel standards through 2030, **total on-road GHG emissions could decrease by 7.04 mmt CO_2e, bringing 2030 emissions 20 percent below 2006 emissions.**
- If the federal rulemaking of the SAFE Vehicles Rule for rolling back or freezing the federal light-duty vehicle standards to 2020 standards is approved, the GHG emissions for 2030 may increase by 2.07 mmt CO_2e. This result represents a potential worst-case scenario associated with the SAFE Vehicles Rule. Ultimately, the emissions impact of this potential standard change is highly uncertain given that auto manufacturers may choose to exceed Federal standards, particularly in state's like Maryland that are committed to the California standards.
- Presuming the current federal vehicle standards are fully implemented, and Maryland meets the ZEV mandate market share goals by 2030, **total on-road GHG emissions could decrease another 1.61 mmt CO_2e, bringing 2030 emissions to 25 percent below 2006 emissions.**

Figure 4.1 Baseline and Reference Scenarios



Utilizing a composite emissions factor, in 2014, a reduction of 1.96 billion VMT was required to reduce GHG emissions by 1 mmt CO_2e. As vehicles become cleaner, and the federal fuel economy standards begin to take hold, that figure increases in 2030 to 2.87 billion VMT required to reduce GHG emissions by 1 mmt CO_2e. **In other words, 2030 VMT would have to be reduced by 4 percent to achieve a 1 mmt CO_2e reduction in on-road emissions.**

4.3 Implementation

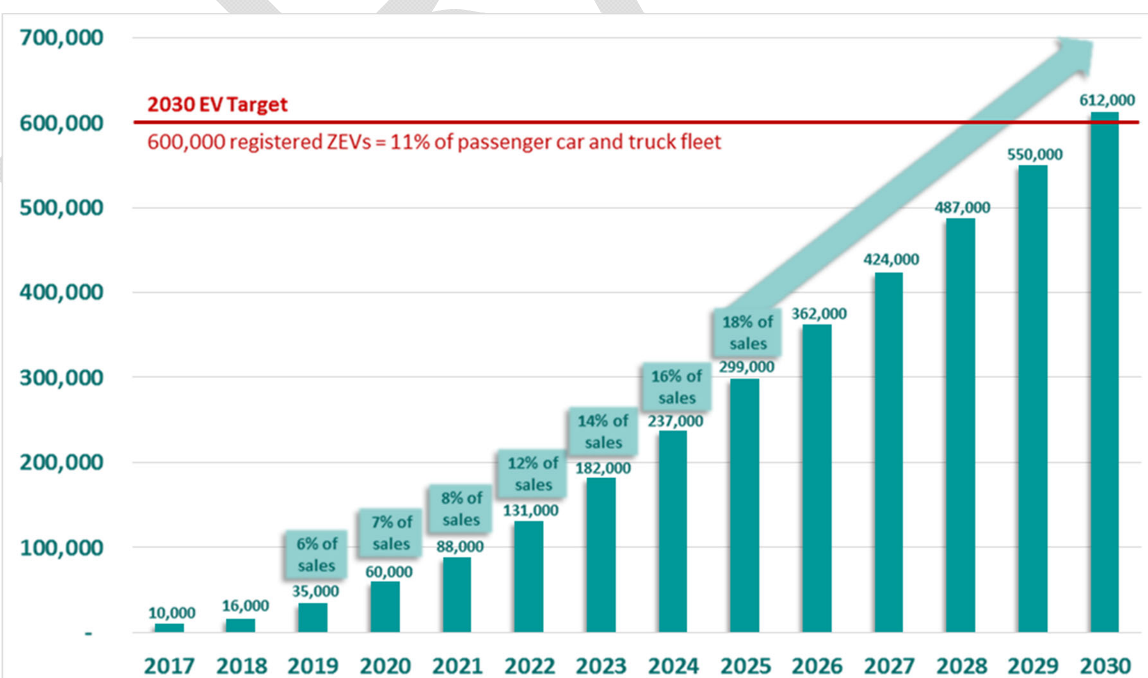
Implementation of the federal vehicle and fuel standards yields a significant GHG emissions benefit for on-road emissions from cars and trucks through 2030. Ultimately, vehicle turnover rates, vehicle purchase and operating costs, and other economic factors will impact exactly what the on-road fleet looks like in 2030. Taking these external forces into account, the forecasts developed through the robust analytical process within the MOVES model represents the state of the practice in estimating future emissions from on-road emission sources. The federal programs are managed by EPA and the National Highway Transportation Safety Administration (NHTSA) through partnerships with vehicle manufacturers.

For EVs, vehicle manufacturers will attain fleet-wide GHG emission requirements through a mix of different vehicle models and technologies. This will include traditional gasoline and diesel-powered vehicles, as well as hybrids, PHEVs, and BEVs, among other technologies. Achieving the goals within the ZEV mandate (300,000 EVs by 2025) reflects a commitment to a low-emissions fleet that well surpasses the federal standards. The path from nearly 10,000 PHEVs and BEVs registered in Maryland in 2017 to 300,000 vehicles by 2025 and 600,000 vehicles by 2030 requires a number of assumptions.

- ZEV sales and registrations have fallen well short of the original EV deployment goals. Implementation of the ZEV mandate as part of Maryland Clean Car Program starting in the year 2011 assumed a ramping up of ZEV sales until year 2018 when 16 percent of new light-duty vehicle (passenger cars, passenger trucks and light commercial trucks) sales are registered in Maryland are ZEVs. At this level of theoretical deployment, the total EV population in Maryland in the year 2017 was projected to be over 130,000 vehicles.
- To meet the goals, starting in 2018, EV deployment ramp-up is envisioned to start at a slower rate of 5 percent of sales in 2018, increased by a percentage point to 6 percent in 2019, which is then annually ramped up by two percentage points until hitting the Maryland Clean Car regulation of 16 percent of all new vehicles sold in the state by the year 2024. At this rate, Maryland would surpass 290,000 registered ZEVs by 2025.
- From 2025 to 2030, ZEV sales average 16 percent annually. With this rate of deployment, Maryland could reach over 600,000 registered ZEVs in 2030, which represents 11 percent of the light-duty fleet.
- Not all ZEVs are the same when considering GHG emission impacts. This approach assumes 75 percent of the ZEVs are PHEVs and the remaining 25 percent are BEVs. PHEVs are assumed to operate on electric power (no tailpipe emissions) for 55 percent of all vehicle miles traveled.

Figure 4.2 presents the projected ZEV deployment curve through 2030. Maryland costs 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 costs associated with matching Federal grants to expand public electric vehicle charging infrastructure throughout Maryland.

Figure 4.2 Electric Vehicle Deployment Approach



5.0 Policy Scenario 1 (On-the-books)

5.1 Description

Policy Scenario 1 includes projects and programs funded for implementation within MDOT's 2018-2023 CTP, expected investments in continuing MDOT GHG emission reduction strategies included in future CTPs through 2030, and projects in fiscally constrained MPO metropolitan transportation plans identified for implementation by 2030.

5.1.1 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.

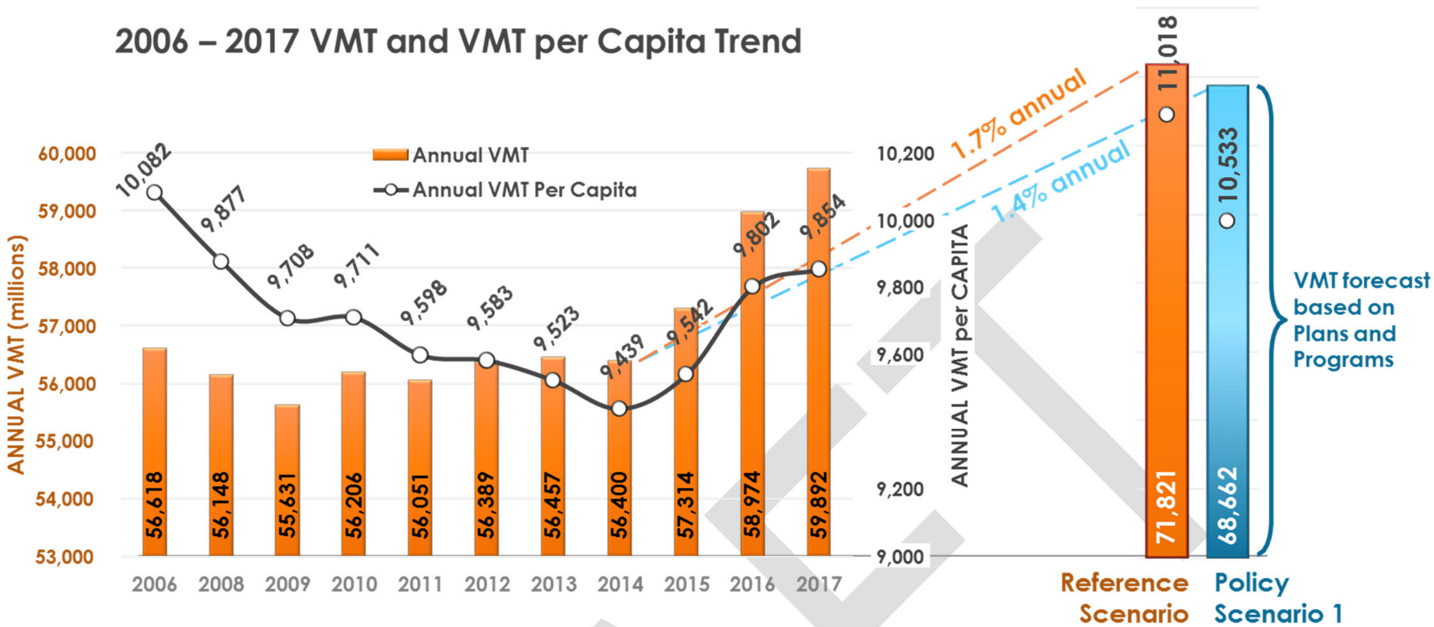
In coordination with MDOT, Maryland's MPOs develop federally required metropolitan transportation plans. These plans carefully combine locally driven projections of future land use with stakeholder input on transportation needs to develop fiscally constrained list of long-term transportation investments over the next 25 years.

The 2030 Plans and Programs uses information from the CTP, each MPO plan, and land use, population, and employment projections from 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 funded and programmed for implementation by MDOT. The primary benefit of the plans and programs relative to the Reference Scenario is the reduction in vehicle miles traveled and improved operational efficiency of the transportation system.

The diversity of planned and programmed multimodal investments within the CTP and the MPO metropolitan transportation plans through 2030, matched with forecasted land use change consistent with local plans, results in an estimated reduction of 3.159 billion vehicle miles traveled (4.4 percent) through 2030. This reduction is relative to the VMT growth trend through 2030 assumed within the Reference Scenario consistent with the average 1990 – 2014 trend of 1.7 percent annual growth. The key assumption for constructing this scenario is that the investment levels from the current MDOT CTP (FY 2018- FY 2023) continue at the same rate through 2030.

Figure 5.1 presents Maryland's VMT trend since 2006 and the alternative VMT projections (Reference Case compared to Policy Scenario 1) for 2030. Note, both of these projections through 2030 anticipate VMT to continue to grow faster than Maryland's population, resulting in an increase in VMT per capita.

Figure 5.1 VMT and VMT per Capita Trend and Forecasts



5.1.2 Other "On-the-Books" Strategies

Along with the traditionally funded transportation programs and investments that have been included in the State and MPO planning documents, 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 help in replacing drayage 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), WMATA, and shuttle buses at BWI Airport. The emissions impact of a conversion to electric buses is included in Policy Scenario 2.

5.1.3 Strategy, Emissions, and Cost Summary

Appendix B lists each GHG mitigation strategy evaluated under the three policy scenarios, with strategy descriptions, underlying assumptions, summary of estimation methodology, and implementation caveats. **Table 5.1** lists the Policy Scenario 1 strategies, their estimated GHG reduction potential, and their estimated costs for implementation.

Table 5.1 Policy Scenario 1 Strategies Summary

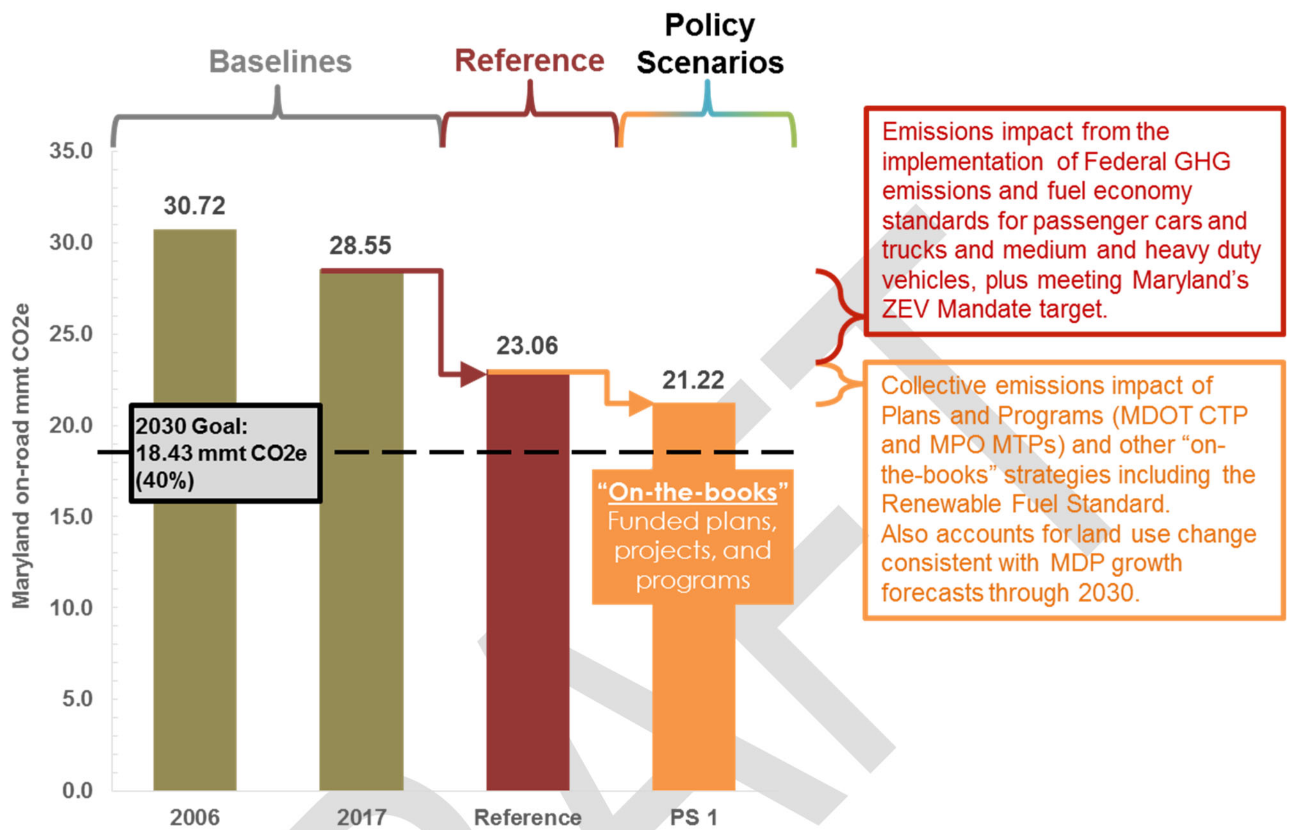
Strategy	GHG Emission Reduction (mmt CO_2e)	Reduction Potential	Estimated Costs ($M)	Estimated Cost
Cumulative impact of the 2018 MPO Plans & Programs	1.060	OOO	$7,296	$$$
On-Road Technology (CHART, Traveler Information)	0.163	OO	$246	$$
Freight and Freight Rail Programs (MDOT MTA rail projects and National Gateway)	0.072	O	$31	$
Public Transportation (New capacity, improved operations, Bus Rapid Transit in MPO MTPs by 2030)	0.033	O	$2,144	$$$
Public Transportation (fleet replacement / technology based on current procurement)	0.024	O	$256	$$
TDM (Commuter Choice MD, Commuter Connections ongoing and expanding programs)	0.142	OOO	$30	$
Pricing Initiatives (conversion to All Electronic Tolling)	0.018	OO	$49	$
Bicycle and Pedestrian Strategies (program continuation and expansion through 2030)	0.004	O	$205	$$
Land-Use and Location Efficiency (MDP assumptions)	0.318	OOO	N/A	$
Port of Baltimore Dray Track Replacements	0.005	O	$18	$
BWI Airport parking shuttle bus replacements	<0.001	O	$52	$
Total Policy Scenario #1 (30.9% reduction from 2006)	**1.841**		**$10,326**	

5.2 Emission Outcomes

Figure 5.2 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 1.825 mmt CO_2e.**
- Strategies that reduce VMT, including the Plans and Programs and other on-the-books strategies, result in a total reduction of 4.747 billion VMT in Maryland by 2030, equivalent to a 6.6 percent VMT reduction relative to business as usual VMT growth.
- Strategies that improve system operational efficiency and those that result in a cleaner fleet reduce fuel consumption by up to 18.0 million gallons of gasoline and 4.6 million gallons of diesel fuel in 2030 (in addition to fuel consumption reductions associated with the reduction of VMT).

Figure 5.2 Policy Scenario 1 Emission Outcomes



5.3 Implementation

Strategies listed as part of Policy Scenario 1 are funded in the six-year MDOT CTP (FY 2018-2023), MPO metropolitan transportation plans, or through Federal grants and funding sources. The total cost of Policy Scenario 1 totals $10.236 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. In other words, the degree of confidence that the emission reductions from these strategies will materialize is tied to the assumption that the funding levels for these existing programs and strategies will continue through 2030.

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

This analysis assumes funding levels and shares across modes based on the CTP and the MPO metropolitan transportation plans. The projected scenario for funding is based on the best information we have at this time (over the next six years), which may be subject to change as MDOT and its partners respond to changes in mobility choices and travel patterns, and technological advancements that may alter some funding priorities and allocations. These assumptions are based on trends from the last few CTPs and are modeled on the latest version of the adopted CTP. They do not consider any potential major capital-intensive infrastructure initiatives that may need to be funded through 2030 to address new or emerging needs. This reinforces the characterization of Policy Scenario 1 as a trend or status quo scenario tied to current funding levels.

Major projects and programs within the $10.236 billion cost estimate for Policy Scenario 1 include:

- $405 million for Traffic Relief Plan implementation, including innovative congestion management (ICM) on the I-270 corridor, implementation of smart traffic signals on 14 corridors throughout Maryland, and implementation of peak hour shoulder use on I-695.
- $981 million in combined Federal, state, and local funding to match the $5.6 billion contract with the Purple Line Transit Partners (PLTP) to design, construct, financing, operate and maintain the Purple Line (not included in total Policy Scenario 1 costs).
- $1.16 billion through 2023 to support WMATA's capital improvement program
- Over $300 million for MDOT MTA bus procurement for fleet replacement and efficiency improvements
- $148 million for MARC service quality and reliability improvements on the Camden, Brunswick, and Penn corridors
- $111 million for MDOT SHA to improve, maintain and enhance the CHART program
- $63.6 million in funding to implement the next generation electronic tolling system which would represent the technology platform enabling a conversion to all-electronic tolling (AET)
- $175.4 million for bike and pedestrian projects and programs including 103 funded roadway expansion projects that include pedestrian and bicycle elements, in addition to the Bikeways Program and the Transportation Enhancements program, which focus on bicycle and pedestrian projects.

Cost information provided in these scenarios are all in present-day dollars. The costs presented in **Table 5.1** and highlighted in the list above include the total capital cost, including planning, preliminary engineering, right-of-way acquisition, and construction costs. Operations and maintenance costs were not included as part of the total costs presented in this report. Another point to note is regarding implementation costs for some of these strategies that may be administrative or regulatory costs, which are relatively modest and often times absorbed into the implementing agency budgets. Those costs have been presented in **Table 5.1** as "N/A" or "negligible".

6.0 Policy Scenario 2 (Emerging and Innovative)

6.1 Description

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 has 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.

6.1.1 Emerging Strategies

Emerging strategies can be defined as logical next steps of strategies that are currently funded in the 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 reasonably demonstrable record of mitigating emissions from both technological and practice adoption perspectives. Many of these strategies have been successfully implemented in peer states and to varying extents in Maryland. However, there is still some uncertainty as it relates to roll-out of some of these strategies as 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.

Table 6.1 presents the list of emerging strategies, which consist of strategies that are extensions of Policy Scenario 1 strategies, and their associated emission reductions and cost estimate. The cost estimates indicate a range consistent with understanding on the potential low to high implementation cost associated with each strategy. These strategies acknowledge the potential to fully implement by 2030 and realize the benefits of more traditionally funded strategies in the event additional funding is made available or if there is considerable policy shift in the direction of funding some of those strategies through potential alternative financing mechanisms. Examples of such strategies include expanded bicycle and pedestrian projects, fiscally unconstrained transit capacity expansion, and expanded TDM coverage. Some strategies involve leveraging technology like CHART and expanding footprint in the areas of systems management including arterial, freeway, and access management systems. In addition, the emerging strategies assumes full implementation of the Traffic Relief Plan by 2030.

Table 6.1 Policy Scenario 2 Strategies Summary (Emerging)

Strategy	GHG Emission Reduction (mmt CO_2e)	Reduction Potential	Estimated Costs ($M)	Estimated Cost
Freeway Management/Integrated Corridor Management	0.052	OO	$506 to $760	$$
Arterial System Operations and Management	0.049	OO	$453 to $680	$$
Limited Access System Operations and Management	0.023	OO	$108 to $152	$$
Managed Lanes (I-270/I-495 Traffic Relief Plan Implementation)	0.051	OO	$6,650 to $9,840	$$$
Intermodal Freight Centers Access Improvement	0.017	OO	$2,240 to $3,136	$$$
Commercial Vehicle Idle Reduction, Low-Carbon Fleet	0.055	OO	Nominal §	$
Eco-Driving (informal implementation underway)	0.042	OO	$3 to $5	$
Lead by example - Alternative Fuel Usage in State Fleet	0.004	O	Nominal §	$
Truck Stop Electrification	0.007	O	$9 to $38	$
Transit capacity/service expansion (fiscally unconstrained)	0.069	OO	$2,307 to $2,659	$$$
Expanded TDM strategies (dynamic)	0.314	OOO	$15 to $30	$
Expanded bike/pedestrian system development	0.081	OO	$103	$$
Freight Rail Capacity Constraints/Access	0.072	OO	$300	$$
Regional Clean Fuel Standard	0.382	OOO	$148	$$
MARC Growth and Investment Plan / Cornerstone Plan	0.052	OO	$1,078	$$$
Additional 100K Ramp Up (total of 704,840 EVs)	0.322	OOO	$54	$$$
50% EV Transit Bus Fleet	0.036	OO	$93	$
Total Policy Scenario #2 "Emerging" (36.2% reduction from 2006)	**1.628**		**$14,068 - $19,077**	

§ Nominal costs are program implementation, regulatory facilitation, and support costs for implementing emission reduction strategies, where MDOT has limited control.

6.1.2 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 by providing a safe and conducive environment for Maryland residents and businesses to adopt the new technologies that are reshaping mobility choices and providing cleaner alternatives to single occupant vehicle travel. Challenges to implementing some of these strategies include 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).

Table 6.2 presents the list of innovative strategies, which consist of strategies that are extensions of Policy Scenario 1 strategies, and their associated emission reductions and cost estimate. The cost estimates indicate a range consistent with understanding on the potential low to high implementation cost associated with each strategy.

Table 6.2 Policy Scenario 2 Strategies Summary (Innovative)

Strategy	GHG Emission Reduction (mmt CO_2e)	Reduction Potential	Estimated Costs ($M)	Estimated Cost
Connected and Automated Vehicle Technologies	0.647	OOO	$43 - $62	$
Variable Speeds / Speed Management on Freeways	0.083	OO	$7 - $14	$
Zero-Emission Trucks/Truck Corridors	0.059	OO	$34 to $128	$$
Ride-hailing / Mobility-as-a-Service (MaaS)	0.256	OOO	Nominal §	$
Pay-As-You-Drive (PAYD) Insurance	0.062	OO	Nominal §	$
Freight Villages/Urban Freight Consolidation Centers *	0.023	OO	$4,705 - $ 6,893	$$$
SCMAGLEV/Loop **	0.056	OO	$45,300 to $47,300	$$$+
Total Policy Scenario #2 "Innovative" (40.3% reduction from 2006)	**1.186**		**$50,089 - $54,397**	

§ Nominal costs are program implementation, regulatory facilitation, and support costs for implementing emission reduction strategies, where MDOT has limited control.

* Freight Villages/Urban Freight Consolidation Center costs represent a combination of private sector investment and Maryland commitment (potentially MDOT sponsored or other funding mechanisms) investing in access improvements and site circulation.

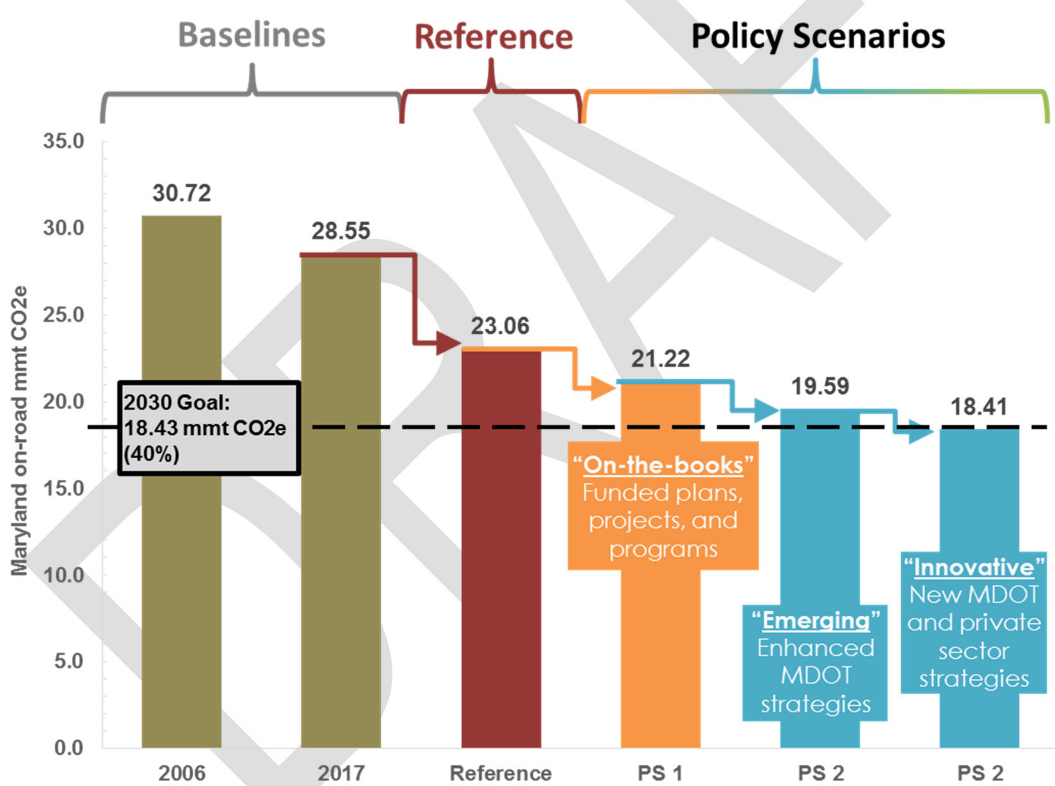
** High Speed Rail and SCMAGLEV costs include a majority of private costs and a mix of Federal and regional funding. Total funding estimate here reflects combined potential total of SCMAGLEV and Loop, but not implementation of the NEC Vision, which ultimately would be a Federal and regional funded effort.

6.2 Emission Outcomes

Figure 6.1 presents the emission outcomes from Policy Scenario 2, compared to Policy Scenario 1, the 2030 Reference, and the 2006 and 2017 Baselines.

- **The total estimated statewide reduction in 2030 is 2.816 mmt CO_2e.**
- Strategies that reduce VMT, including the Plans and Programs and other on-the-books strategies, result in a total reduction of 3.629 billion VMT in Maryland by 2030, equivalent to an additional 5.1 percent VMT reduction relative to business as usual VMT growth. In total, the combination of Policy Scenario 1 and Policy Scenario 2 strategies reduce VMT by 11.7 percent in 2030.
- Strategies that improve system operational efficiency and those that result in a cleaner fleet reduce fuel consumption by up to 140.2 million gallons of gasoline and 13.4 million gallons of diesel fuel in 2030 (in addition to fuel consumption reductions associated with the reduction of VMT).

Figure 6.1 Policy Scenario 2 Emission Outcomes



6.3 Implementation

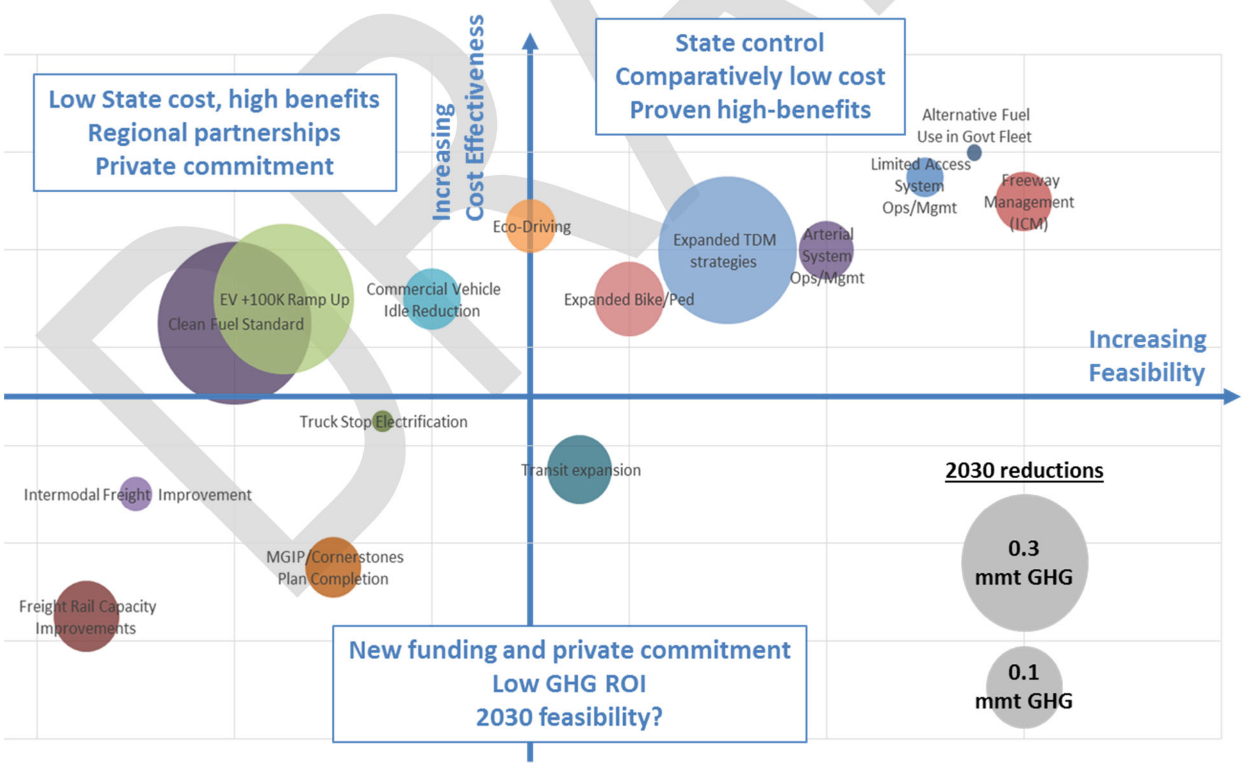
Strategies listed as part of Policy Scenario 2 are currently not funded within MDOT's CTP or the MPO MTPs for implementation by 2030. Policy Scenario 2 total estimated costs, not including potential investments in MAGLEV or Loop, ranges from $18.860 billion up to $26.174 billion (funding levels of 180 to 250 percent above current fiscally constrained plans).

The major underlying assumption for implementation of any of these strategies is that they require dedicated funding sources outside the current traditional investment sources and will require additional revenue to be generated for their implementation or necessitate funding from non-traditional sources of funding. 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.

The diverse suite of strategies in Policy Scenario 2 result in a wide spectrum of considerations regarding feasibility and cost effectiveness. **Figure 6.2** and **Figure 6.3** array each strategy in Policy Scenario 2 based on an objective look at feasibility and cost effectiveness relative to potential GHG reduction. For the purposes of this high-level scan, our definitions of feasibility and cost effectiveness are:

- **Feasibility** – Feasibility considers the extent of MDOT's level of control as it relates to strategy delivery and the engineering, technology, environmental, regulatory, and/or political hurdles to strategy implementation.
- **Cost Effectiveness** – Cost effectiveness considers the total implementation cost relative to the estimated GHG emission reduction while also considering the level of confidence in emission reductions as well as the potential for co-benefits.

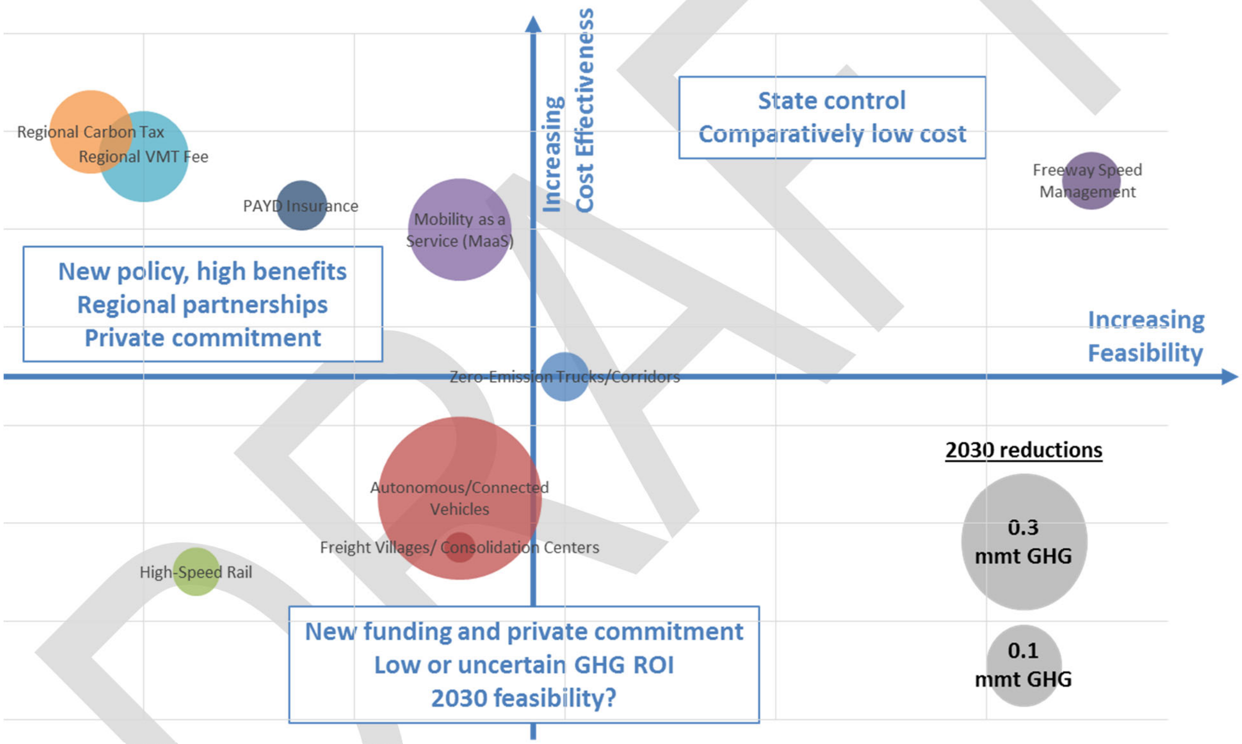
Figure 6.2 Feasibility and Cost Effectiveness for "Emerging Strategies"



Strategies in the upper right quadrant are those where MDOT is the primary strategy lead, costs are comparatively low relative to benefits, and the benefits are more reliable and less at risk to decrease because of external factors. Strategies in the upper left quadrant include some of the most cost effective and beneficial strategies from a GHG emission perspective, however, are less within MDOTs control or influence. In the case of a clean fuel standard and continued ramp-up of electric vehicle market share, MDOT may help facilitate implementation, but private commitment and market dynamics will impact long-term reductions. Strategies below the feasibility axis require significant capital investment (both public and private) and may yield significant economic and other transportation benefits (such as accessibility), they typically provide a low return in terms of cost relative to GHG emission reductions.

Figure 6.3 presents the same graphic for the Innovative Strategies in Policy Scenario 2. As noted above, these strategies are predominantly less within MDOTs control (i.e., they require more partnerships with the private sector and across State lines) and show on average, higher cost effectiveness given the lower share of public funding involved in implementation.

Figure 6.3 Feasibility and Cost Effectiveness for "Innovative Strategies"



7.0 Policy Scenario 3 (Pricing and Revenue)

7.1 Description

One potential policy mechanism for achieving the levels of reductions presented in Policy Scenario 2 would be to implement a transportation pricing policy, which could both achieve GHG reductions and generate revenue that could be used to fund clean and resilient transportation solutions. In the current transportation funding debate, mileage-based user fees, fuel fees indexed to inflation, carbon-content-based fees, and additional petroleum-based pricing policies have been discussed as potential options to reduce GHG emissions and raise proceeds for clean transportation policies. Policy Scenario 3 considers the potential effects of a hypothetical pricing policy on both GHG emissions and funding. The analysis considered a range of carbon-content-based fees, mileage-based user fees, and motor-fuel taxes. Ultimately, the emission impacts of these different policy approaches are comparable, while the potential revenue generated from each is subject to different external factors. For example:

- Carbon-content-based fees (or a carbon price) is based on a $ per unit of carbon. As the fleet moves toward lower carbon technologies (which in part may be encouraged by this policy), the revenue generated will decline relative to total VMT (although not as significantly as the motor vehicle fuels tax). The concept for a carbon price was drawn from the Transportation and Climate Initiative's (TCI) analysis supporting the *Reducing Greenhouse Gas Emissions from Transportation: Opportunities in the Northeast and Mid-Atlantic* report published in 2015.
- Mileage-based user fees (or a VMT fee) is based on $ per vehicle mile traveled. From a revenue perspective, this policy approach has no relationship to or impact on vehicle technology. It is strictly associated with total vehicle travel, which can have negative equity impacts on households unable to live close to where they work and on rural areas.
- Per the Code of Maryland, motor fuel tax rates are indexed for all fuels except aviation gasoline and turbine fuel to the annual change in the Consumer Price Index. The Transportation Infrastructure Investment Act of 2013 established this change in addition to imposing a sales and use tax equivalent on all motor fuel. Since 2013, the combined applicable tax rate has increased from $0.27 to $0.358 for gasoline and $0.2775 to $0.3605 for diesel. The continuing move toward a more efficient and electric fleet will decrease the revenue generating power of this tax relative to VMT growth.

Among these options, MDOT developed an estimation of a potential Carbon Pricing strategy based on its more sustainable revenue source, ability to encourage further transformation to a low-carbon or zero carbon fleet, and lower equity concerns. **This analysis was conducted for the MWG's scenario planning purposes and is in no way indicative of MDOT's policy position.**

At this phase of the GGRA planning effort, MDOT's support is limited to generating a high-level estimate of GHG emission reductions and potential for revenue generation from the Carbon Pricing strategy. MDOT analyzed four different Carbon Pricing tests based on the following assumptions:

- **Test 1** – $30 per ton CO_2e (consistent with TCI analysis) applied to all on-road mobile source emissions starting in 2025 – **$4.3 billion cumulative revenue potential through 2030**

- **Test 2** – \$30 per ton CO_2e (consistent with TCI analysis) applied to all on-road mobile source emissions starting in 2021 – **\$7.5 billion cumulative revenue potential through 2030**
- **Test 3** – Carbon price increasing annually from \$20 per ton in 2020 to the social cost of carbon, \$62.25 by 2030, applied to all on-road mobile source emissions starting in 2025 – **\$7.4 billion cumulative revenue potential through 2030**
- **Test 4** – Carbon price increasing annually from \$20 per ton in 2020 to the social cost of carbon, \$62.25 by 2030, applied to all on-road mobile source emissions starting in 2021 – **\$10.7 billion cumulative revenue potential through 2030**

As described in the TCI report, implementation of a pricing policy works best at the regional scale. There are risks associated with Maryland acting independently in the transportation sector that could result in economic disbenefits to the state, such as relocation of firms due to higher transportation costs.

7.2 Emission Outcomes

The emissions reduction (0.098 mmt CO_2e) from carbon pricing only accounts for the potential of the price to reduce vehicle miles traveled through encouraging mode shift or less and/or shorter vehicle trips. The indirect impact of the pricing policy on encouraging low or zero-emission vehicle purchases was not analyzed (Note: Policy Scenario 2 already assumes an aggressive share of electric vehicles in the Maryland fleet (12 – 14 percent).

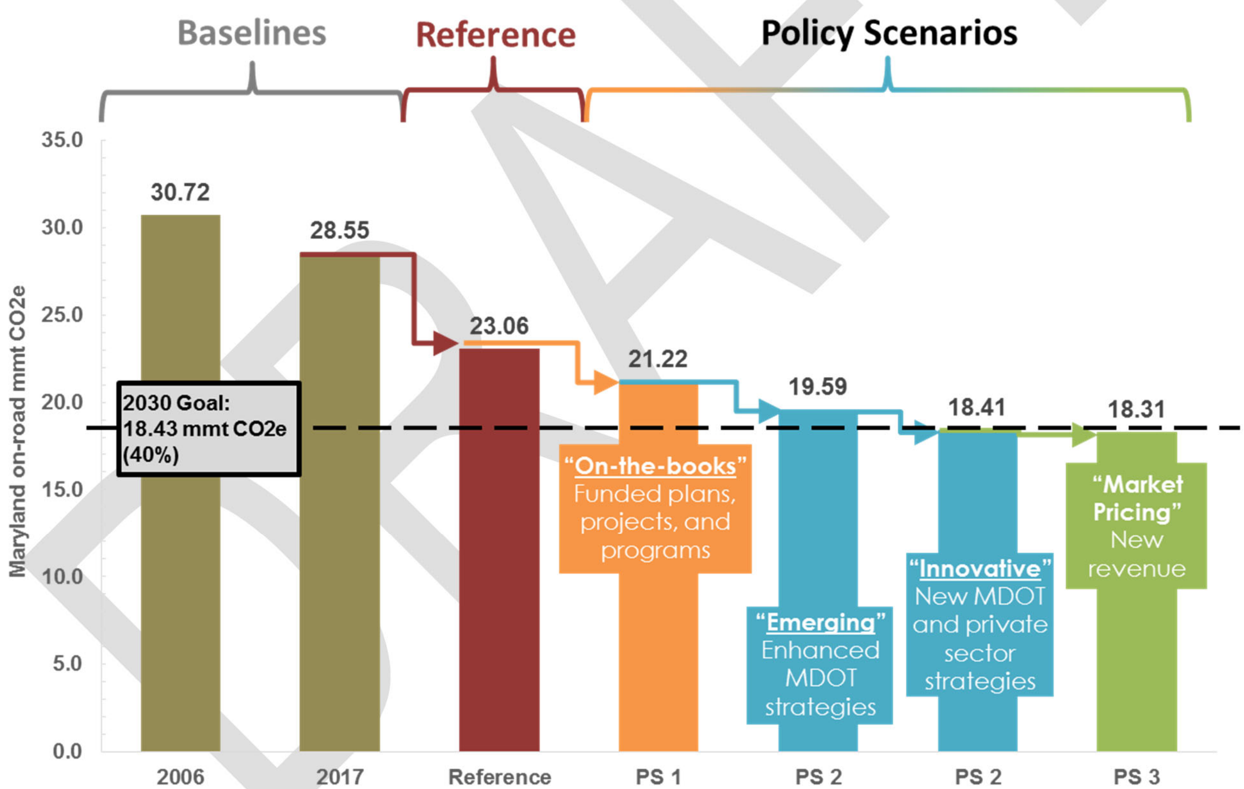
8.0 Findings Summary and Next Steps

8.1 Emission Outcomes

The on-road transportation sector in Maryland could achieve the “40 by 30” goal as highlighted by the results of the analysis presented in previous sections and summarized in **Figure 8.1**.

There is a multitude of approaches MDOT and its partners could take to facilitate achievement of the goal. These include substantial investments in multimodal options and 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 for example, EV market penetration.

Figure 8.1 2030 Draft Emission Results



8.2 Implementation

Maryland’s multimodal transportation network faces a number of challenges. Some are inherent to the network itself – continuing to maintain and modernize infrastructure and ensure the safe and efficient movement of people and goods – while others are related to changing transportation needs associated with technological, societal, demographic, land use, climate, and other environmental changes. An 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. MDOT maintains and delivers a transportation system that addresses these critical 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 TBUs, and Maryland's share of the WMATA system. O&M expenses include the costs of service for 104 million annual transit trips, maintenance of highways and bridges, dredging for the Port of Baltimore, and operations for the BWI and MTN airports. Capital needs focus on existing assets and strategic expansion with the goal being to maintain and modernize.

8.2.1 Transportation Revenue Sources

Transportation needs in Maryland are primarily funded from an integrated account called the Transportation Trust Fund (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.

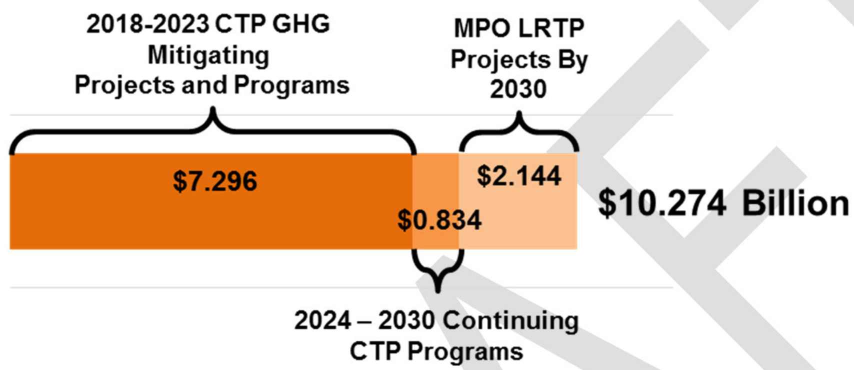
The Transportation Infrastructure Investment Act of 2013 (Transportation Act) substantially increased and advanced the TTF revenues. The changes included an increase in state motor fuel taxes; the indexing of principal revenue streams (e.g. motor fuel taxes and MDOT MTA passenger fares) to inflation; and restrictions on the transfer of funds from the Trust Fund to the State's General Fund. Funds from the TTF are not necessarily earmarked for specific agencies or programs. This approach affords Maryland tremendous flexibility to meet the varying service and infrastructure needs to support its diverse transportation system. With the exception of MDTA, which is funded primarily through tolls and concessions revenues, all activities of MDOT are supported by the TTF.

Though the Transportation Act provided a boost to the TTF over the past 5 years, MDOT's transportation infrastructure needs to maintain and preserve the extensive system, strategically expand the system, and modernize the system is projected to exceed MDOT's ability to fund all needed improvements. This coupled with the conservative assumptions about availability of future federal funds, highlights the importance of other project funding options including partnerships. Partnerships with other state and local agencies, and increasingly private entities are critical to ensuring the available funding to implement projects and meet the State's transportation needs.

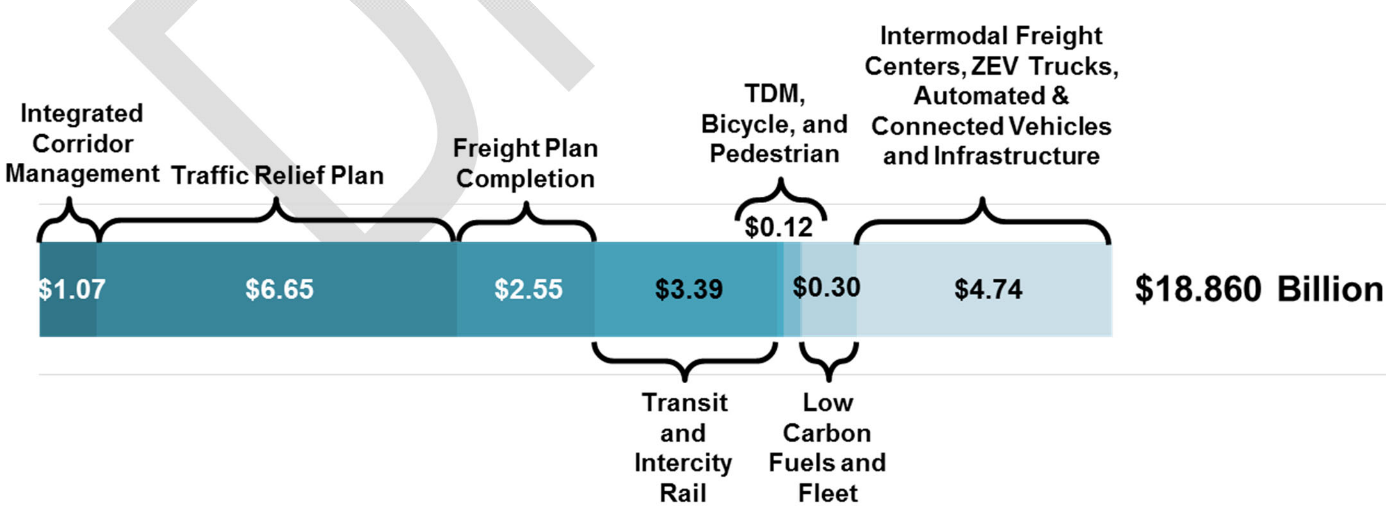
8.2.2 Projected 2030 Scenario Costs

The analysis of Policy Scenario 1, 2, and 3 included cost estimates for the complete implementation of strategies through 2030. These costs represent cumulative MDOT capital cost estimates in constant dollars through 2030.

- **Policy Scenario 1** includes total costs for all GHG mitigating project and programs funded in the 2018-2023 CTP, estimates of ongoing investments in current MDOT programs from 2024 – 2030 based on annual trendline investments in the CTP, and funded projects and programs in MPO MTPs planned for implementation by 2030. All of these programs are included within fiscally constrained plans, meaning that revenue sources are projected to be available to fully fund for implementation.



- **Policy Scenario 2** includes planning level cost estimates based on current cost information, where available, and other best practice data. Policy Scenario 2 strategies fall into two general buckets – emerging strategies and innovative strategies. The emerging strategies have more cost information as they generally represent expansion and evolution of current MDOT programs. The innovative strategies have minimal cost information and, in many cases, rely on a majority share of investment from the private sector for implementation. In both cases, these strategy cost estimates are for strategies not currently within fiscally constrained plans. In other words, either additional funding, reprioritization of investments, or new private partnerships would be required for implementation.



Total estimated costs in Policy Scenario 2 not including potential investments in SCMAGLEV or Loop in Maryland ranges from $18.860 billion up to $26.174 billion. The total cost of SCMAGLEV and/or Loop is estimated at an additional $45.3 billion based on publicly available information on cost per mile and anticipated corridor length and alignment in Maryland.

- **Policy Scenario 3** includes a pricing mechanism, for the purposes of this analysis tested as a $ per ton of carbon price, that will generate additional revenue for transportation investment and potentially impact travel behavior and electric vehicle market share. At this time, there is no policy or regulatory commitment to a carbon pricing approach in Maryland. **Four alternative pricing tests were analyzed by MDOT generating between $4.3 billion and $10.7 billion in additional revenue for transportation beyond traditional sources.**

Cost effectiveness of the Policy Scenarios is presented in **Table 8.1**, excluding the emission reductions and costs from the SCMAGLEV / Loop strategy. The table introduces the concept of net cost, in order to compare the revenue generated by the low and high carbon price options to the total implementation costs associated with Policy Scenario 1 and Policy Scenario 2 strategies. Ultimately, the cost per ton of CO_2e reduced across the three policy scenarios ranges from $5,200 to $3,300 (exclusive of the costs and emission reductions from the SCMAGLEV / Loop strategy).

Table 8.1 Policy Scenario Cost Effectiveness

Scenario	GHG Emission Reduction (mmt CO_2e)	Net Cost (millions) (Low Range)	Net Cost (millions) (High Range)	Cost Effectiveness (Low Range) ($ per ton CO_2e)	Cost Effectiveness (High Range) ($ per ton CO_2e)
Policy Scenario 1	1.825	$10,236		$5,609	
Policy Scenario 2 (Emerging)	1.628	$14,068	$19,077	$8,600	$11,700
Policy Scenario 2 (Innovative, excluding SCMAGLEV/Loop)	1.130	$4,789	$7,097	$4,200	$6,300
Policy Scenario 3	0.098	- $4,280	- $10,680	- $43,700	- $109,000
Total Across All Scenarios	**4.998**	**$24,813**	**$15,494**	**$5,300**	**$3,300**

8.3 Co-Benefits and Economic Impact

The scope of strategies within the 2030 scenarios presented in this Plan represent an integrated, multimodal, and innovative approach to reducing GHG emissions from on-road transportation sources throughout Maryland. These strategies will create the opportunity for significant co-benefits beyond just 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.

8.3.1 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 MDOT Draft GGRA Plan's transportation scenarios strive to achieve the 40 percent GHG reduction goal. These strategies, policies and programs also achieve substantial reductions of the National Ambient Air Quality Standards (NAAQS) criteria pollutants, including ozone producing volatile organic compounds (VOC) and nitrogen oxides (NO_x), and fine particulates ($PM_{2.5}$). Transportation related control measures and improvements to vehicle technologies that reduce ozone and $PM_{2.5}$ 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.

The implementation of EPA's Tier 3 Motor Vehicle Emission and Fuel Standards represents one of the largest NO_x control strategies that reduce emissions from passenger cars, light-duty trucks, medium-duty passenger vehicles, and some heavy-duty vehicles. The enhanced vehicle technology standards combined with fleet turnover to newer vehicles provide significant reductions to criteria pollutants in 2030 as compared to the 2014 Baseline. In addition, the Tier 3 gasoline sulfur standard will make emission control systems more effective for both existing and new vehicles and removing sulfur allows the vehicle's catalyst to work more efficiently for improved fuel economy.

The Tier 3 tailpipe standards are being phased-in with full implementation by 2025. The final gasoline fuels standard of not more than 10 parts per million (ppm) of sulfur on an annual average was implemented in January 2017.

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.

Table 8.2 below provides the criteria pollutant co-benefits (in tons/year) for ozone and fine particulates from the implementation of Baseline, Reference, and Policy Scenarios. Starting with the 2014 Baseline scenario, the transportation technologies that include federal fuel economy standards for light- and heavy-duty vehicles and Tier 3 tailpipe and gasoline standards contribute 60 to 76 percent emissions reductions in 2030. The forecast of over 600,000 electric vehicles provide 844 tons of NO_x and 1,124 of VOC benefit. Overall, the 2030 Reference Scenario contributes 69 to 78 percent emissions reductions in 2030.

Policy Scenario 1 contributes an additional one percent NO_x benefit. Policy Scenarios 2 and 3 also yield an additional 1 percent benefit for NO_x and PM. In 2030, the total criteria co-benefits contribute 65 percent VOC (22.4k tons), 79 percent NO_x (58.8k tons) and 67 percent $PM_{2.5}$ (1.9k tons) of reductions from the 2014 Baseline.

Table 8.2 Transportation Sector Criteria Pollutants Co-Benefits

Pollutant	Scenario	Total Annual Emissions (tons)	Percent Reduction from 2014 (cumulative)
VOC	2014 Statewide On-road Baseline	28,513	
	2017 Statewide On-road Baseline	22,366	22%
	2030 Reference	10,216	69%
	Policy Scenario 1	10,185	69%
	Policy Scenario 2	10,077	69%
	Policy Scenario 3	10,063	69%
NO_x	2014 Statewide On-road Baseline	70,290	
	2017 Statewide On-road Baseline	48,342	31%
	2030 Reference	15,797	78%
	Policy Scenario 1	15,539	79%
	Policy Scenario 2	14,593	80%
	Policy Scenario 3	14,447	80%
$PM_{2.5}$	2014 Statewide On-road Baseline	2,520	
	2017 Statewide On-road Baseline	1,999	21%
	2030 Reference	882	68%
	Policy Scenario 1	874	68%
	Policy Scenario 2	840	69%
	Policy Scenario 3	836	70%

8.3.2 Public Health

The criteria pollutant emission reductions highlighted above would improve public health. Reductions in these emissions could help prevent premature deaths and asthma cases in Maryland, translating to reductions in public health costs. Other associated public health benefits include:

- Travelers would spend less personal time in traffic due to reduced congestion, saving significant hours of delay, enabling time for other activities and improving employee satisfaction;
- Reduced vehicle travel would result in fewer traffic accidents, while new technologies, such as connected and automated vehicles could significantly reduce the frequency and severity of crashes; and
- Increased walking and cycling as a result of investments in pedestrian and bicycle infrastructure is also expected to result in public health improvements.

8.3.3 Equity

The MTP includes goals regarding facilitating economic opportunity and improving quality of life. These 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 Maryland's distressed economic regions. 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. Strategies referenced in the Maryland Transportation Plan supporting equity in transportation include:

- Pursuing capital improvements to the transportation system that will improve access to jobs and tourism and leverage economic growth opportunities;
- Target infrastructure and incentive programs towards improving job access and reducing household transportation costs; and
- Assess productivity benefits through travel cost savings, reliability benefits of industry, delivery logistics and supply chain benefits, and agglomeration effects on access to specialized skills and services to facilitate business opportunities throughout Maryland.

8.3.4 Economic Vitality

Consumer Cost Savings – The combination of all policy scenarios would likely lead to consumers initially experiencing cost increases as they purchase more advanced clean vehicles and pay the cost of the pricing policy. These increases would be more than offset in a short time 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 – The combination of all policy scenarios would likely lead to businesses experiencing initial cost increases due to higher vehicle prices and the pricing policy. 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.

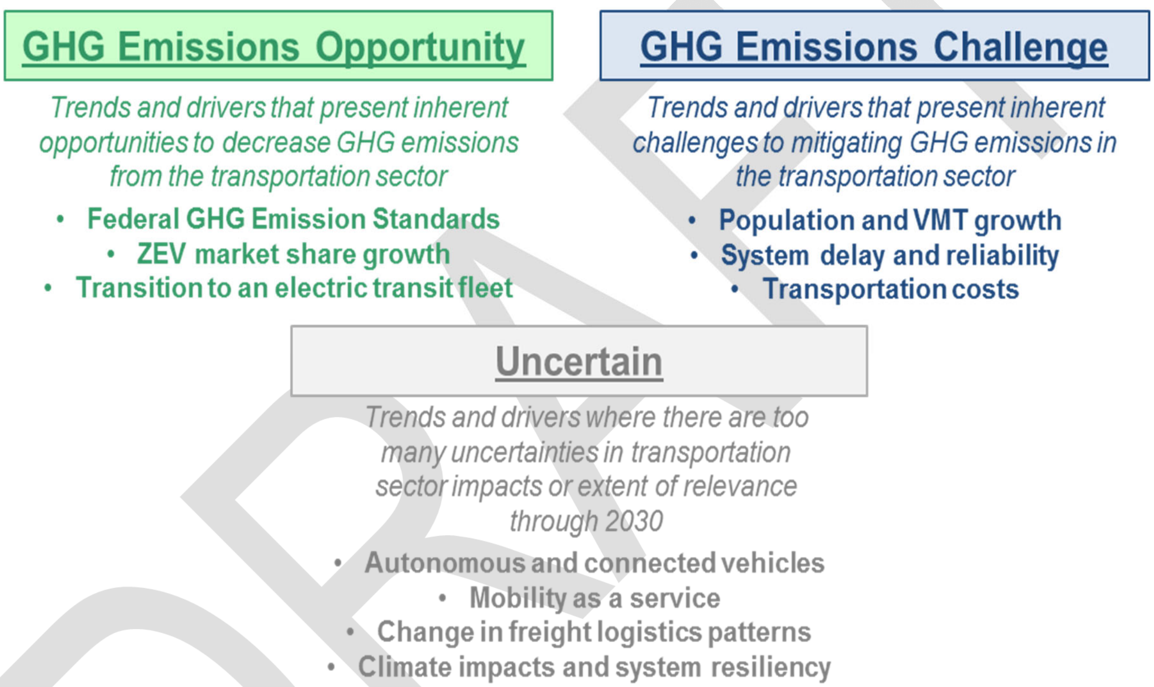
Changes in Government Expenditures – Maryland could receive an additional $4 to $10 billion in revenue for transportation investments through 2030 as a result of the pricing policy. The analysis assumes that the new funds would be reinvested in transportation strategies, resulting in direct benefits (construction jobs and logistics delivering materials) and indirect benefits (supporting retail and services).

Net Macroeconomic Benefits – Towson University, Division of Strategic Partnerships and Applied Research, is working with the MWG and MDE to assess the economic impacts of the GGRA policy scenarios. This analysis will report total job gains in Maryland and change in gross state product because of the combined effects of the carbon price and new infrastructure investments relative to the Reference Scenario.

8.4 Looking Toward 2050

As discussed in Section 2, through the MTP and other long-range planning activities, including those led by Maryland's MPOs, MDOT will continue to balance demand and available resources so that it can accommodate current needs as well as create the 2030 and beyond transportation network. Moving from 2030 to 2050, the extent of the impact of emerging trends and disrupters in the transportation sector and the relationship to GHG emissions is far more significant. **Figure 8.2** presents some high-level perspectives on the opportunities, challenges, and uncertainty facing the transportation sector through 2050. As further analysis in 2019 and beyond look at 2050, these general areas will represent a starting point for evaluating GHG emission trends and opportunities.

Figure 8.2 2050 Perspective on Opportunities, Challenges, and Uncertainty



Appendix A. 2014 Baseline and 2030 BAU 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 2014 baseline and 2030 forecast business as usual (BAU) 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.

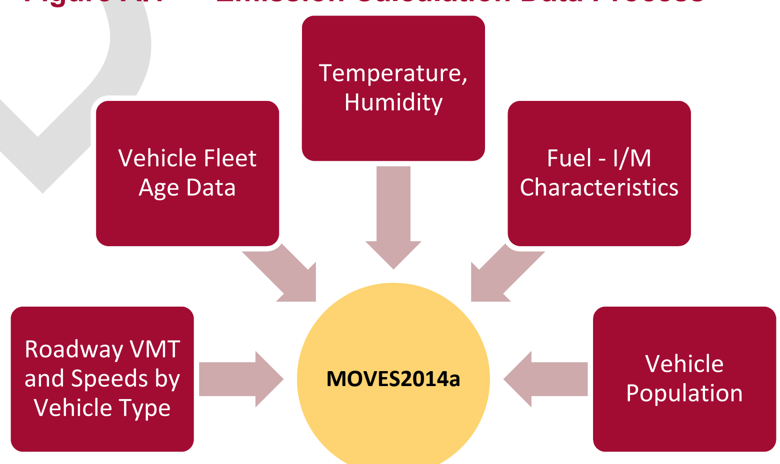
The on-road portion of the inventory was developed using EPA's latest emissions model MOVES2014a (Motor Vehicle Emissions Simulator) released in November 2016. The MOVES2014a model includes minor updates to the default fuel tables, corrects an error in MOVES2014 brake wear emissions, and add new options for the input of local VMT over the earlier version. 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 and MOVES2014a Technical Guidance: Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity, EPA-420-B-15-093, November 2015*. MOVES2014a incorporates all existing CAFE standards in place in 2014 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 MOVES2014a 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 2014 baseline and 2030 BAU 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 2014 and 2030 BAU 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 and MOVES2014a Technical Guidance: Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity, EPA-420-B-15-093,* *November 2015* 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 BAU 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 (2014). 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 2014 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

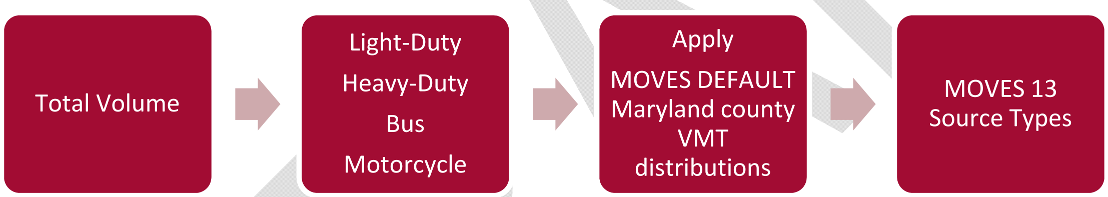


Table A.1 Summary of Key Data Sources

Data Item	Source	Description	Difference between 2014 and 2030BAU
Roadway Characteristics	2014 MDOT SHA Universal Database	Includes lanes, segment distance, facility type, speed limit	*Same Data Source*
Traffic Volumes	2014 MDOT SHA Universal Database	Average Annual Daily Traffic Volumes (AADT)	Volumes forecasted for 2030 BAU
Seasonal Adjustments	SHA 2014 *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 2014	Used to adjust VMT to the reported 2014 HPMS totals by county and functional Class	VMT forecasted for 2030 BAU

Hourly Patterns	MDOT SHA 2014 *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	2014 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	2014 Maryland Registration data; MOVES2014 national default age distribution data	Provides the percentage of vehicles by each model year age	*Used 2014 registration data for light duty vehicles and MOVES2014 national default data for trucks (source types 52, 53, 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 BAU
I/M Data	Provided by MDE	Based on current I/M program	Different I/M Program Characteristics
Fuel Characteristics	Provided by MDE for MOVES2014a model	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 2014 baseline and applied growth rates to forecast population to 2030 BAU Heavy duty trucks: Calculated by PPSUITE Post Processor; MOVES2014a Default Miles/Vehicle Population Data	Number of vehicles by MOVES source type which impact forecasted start and evaporative emissions	2030 BAU based on projected demographic and VMT growth

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 BAU scenario, the forecasts were determined based on historic trends of 1990-2014 highway performance monitoring system (HPMS) VMT growth. The average statewide annualized growth rate through 2030 for this scenario is 1.7 percent. Table A.2 summarizes the growth rates by county.

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

County	2030 BAU (Based on 1990-2014 HPMS)
Allegany	1.2%
Anne Arundel	1.7%
Baltimore	1.3%
Calvert	2.6%
Caroline	1.3%
Carroll	1.8%
Cecil	2.2%
Charles	2.1%
Dorchester	1.4%
Frederick	2.5%
Garrett	1.9%
Harford	1.6%
Howard	2.9%
Kent	0.1%
Montgomery	1.4%
Prince George's	1.6%
Queen Anne's	2.3%
Saint Mary's	1.8%
Somerset	1.11%
Talbot	1.8%
Washington	2.2%
Wicomico	2.1%
Worcester	1.1%
Baltimore City	0.7%
Statewide	**1.7%**

Table A.3 summarizes total 2014 baseline and 2030 forecast VMT by vehicle type.

Table A.3 2014 Baseline and 2030 BAU VMT by Vehicle Type

Annual VMT (millions)	2014 Baseline	2030 BAU
Light-Duty	52,253	66,517
Medium/Heavy-Duty Truck & Bus	4,147	5,304
TOTAL VMT (in millions)	**56,400**	**71,821**

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 MOVES2014a emission model includes the effects of the following post-2014 vehicle programs on future vehicle emission factors:

- **National Program (Model Years 2012-2016)** – The light-duty vehicle fuel economy for model years between 2012 and 2016 are based on the May 7, 2010 Rule “Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule” (EPA-HQ-OAR-2009-0472-11424). Fuel economy improvements begin in 2012 until an average 250 gram/mile CO_2 standard is met in year 2016. This equates to an average fuel economy near 35 mpg.
- **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.

The above technology programs that apply to model years 2015 and beyond vehicles were not included in the 2030 BAU, as they are included as credits applied to BAU emissions. To remove the potential emission credits of these programs, the MOVES2014a default database was revised. Fuel economy assumptions within MOVES2014a are provided as vehicle energy consumption rates within the “EmissionRates” table as illustrated in Figure A.4.

Figure A.4 MOVES Default "EmissionRate" Table

sourceBinID	polProcessID	opModelID	meanBaseRate	meanBaseRateCV	meanBaseRateIM	meanBaseRateIMCV	dataSourceId
1010142940000000000	9101	16	2990000	0.5	2990000	0.5	8597
1010142940000000000	9101	15	2093000	0.5	2093000	0.5	8597
1010142940000000000	9101	14	1495000	0.5	1495000	0.5	8597
1010142940000000000	9101	13	897001	0.5	897001	0.5	8597
1010142940000000000	9101	12	309133	0.5	309133	0.5	8597
1010142940000000000	9101	11	130195	0.5	130195	0.5	8597
1010142940000000000	9101	1	96819.4	0.5	96819.4	0.5	8597
1010142940000000000	9101	0	122412	0.5	122412	0.5	8597
1010142930000000000	9101	40	4450150	0.5	4450150	0.5	8597
1010142930000000000	9101	39	3641030	0.5	3641030	0.5	8597
1010142930000000000	9101	38	2831910	0.5	2831910	0.5	8597
1010142930000000000	9101	37	2022800	0.5	2022800	0.5	8597
1010142930000000000	9101	35	1213680	0.5	1213680	0.5	8597
1010142930000000000	9101	33	590005	0.5	590005	0.5	8597
1010142930000000000	9101	30	5004750	0.5	5004750	0.5	8597
1010142930000000000	9101	29	4094790	0.5	4094790	0.5	8597
1010142930000000000	9101	28	3184840	0.5	3184840	0.5	8597
1010142930000000000	9101	27	2274890	0.5	2274890	0.5	8597
1010142930000000000	9101	25	1592420	0.5	1592420	0.5	8597
1010142930000000000	9101	24	1137440	0.5	1137440	0.5	8597
1010142930000000000	9101	23	959934	0.5	959934	0.5	8597
1010142930000000000	9101	22	365300	0.5	365300	0.5	8597
1010142930000000000	9101	21	173057	0.5	173057	0.5	8597
1010142930000000000	9101	16	2990000	0.5	2990000	0.5	8597
1010142930000000000	9101	15	2093000	0.5	2093000	0.5	8597

To remove the benefits of the post-2014 programs, the database was revised so that all energy rates beyond 2014 were the same as model year 2014 for each vehicle type, model year and fuel type. The table was updated per the following steps:

1. Open the "EmissionRate" table in the latest MOVES2014a default database (named: movesdb20161117). The fields to be modified include: *meanBaseRate* & *meanBaseRateIM* (values in both fields are the same)
2. Select records in the table that are related to energy consumption. This includes records with the polProcessID = 9101, 9102, 9190 and 9191.
3. Use the sourceBinID field to determine how each record correlates to vehicle type, model year and fuel type.
4. Modify meanBaseRate & meanBaseRateIM fields to be same for all model years beyond 2014 for the applicable vehicle type, model year and fuel type.

Emission Results

The 2014, and 2030 BAU scenarios emission results for the Maryland statewide GHG inventories are provided in Table A.4 for 2014 Baseline, and A.5 for the 2030 BAU scenario. Within each table, emissions are also provided by fuel type and vehicle type.

Table A.4 2014 Annual On-Road GHG Emissions (mmt)

	VMT (Millions)	CO_2	CH_4	N_2O	CO_2e
TOTAL	**56,399**	**28.58**	**0.00108**	**0.00078**	**28.84**
By Fuel Type					
Gasoline	51,824	22.185	0.000759	0.000767	22.433
Diesel	4,491	6.355	0.000287	0.000010	6.365
CNG	7.2	0.009	0.000036	0.000001	0.010
E-85	77	0.033	0.000002	0.000001	0.033
By MOVES Vehicle Type					
Motorcycle	340	0.125	0.000010	0.000001	0.126
Passenger Car	25,765	9.336	0.000242	0.000277	9.425
Passenger Truck	20,927	10.229	0.000399	0.000364	10.348
Light Commercial Truck	5,221	2.561	0.000117	0.000100	2.593
Intercity Bus	71	0.125	0.000002	0.000000	0.125
Transit Bus	51	0.067	0.000038	0.000001	0.068
School Bus	127	0.122	0.000006	0.000000	0.122
Refuse Truck	43	0.078	0.000002	0.000000	0.078
Single Unit Short-haul Truck	1,437	1.478	0.000072	0.000028	1.488
Single Unit Long-haul Truck	79	0.076	0.000004	0.000001	0.076
Motor Home	20	0.021	0.000002	0.000001	0.022
Combination Short-haul Truck	526	0.945	0.000018	0.000001	0.946
Combination Long-haul Truck	1,793	3.418	0.000173	0.000004	3.424

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

	VMT (Millions)	CO_2	CH_4	N_2O	CO_2e
TOTAL	**71,821**	**31.57**	**0.00099**	**0.00041**	**31.71**
By Fuel Type					
Gasoline	63,611	23.337	0.000332	0.000386	23.460
Diesel	5,947	7.370	0.000608	0.000013	7.389
CNG	10.1	0.011	0.000025	0.000001	0.012
E-85	2,253	0.848	0.000026	0.000014	0.853
By MOVES Vehicle Type					
Motorcycle	432	0.160	0.000013	0.000002	0.161
Passenger Car	32,707	10.601	0.000163	0.000165	10.654
Passenger Truck	26,713	10.762	0.000200	0.000179	10.820
Light Commercial Truck	6,665	2.701	0.000070	0.000048	2.717
Intercity Bus	90	0.151	0.000005	0.000000	0.151
Transit Bus	64	0.079	0.000028	0.000001	0.080
School Bus	164	0.145	0.000012	0.000000	0.145
Refuse Truck	47	0.078	0.000003	0.000000	0.078
Single Unit Short-haul Truck	1,850	1.734	0.000113	0.000012	1.740
Single Unit Long-haul Truck	101	0.089	0.000006	0.000000	0.089
Motor Home	22	0.022	0.000001	0.000000	0.022
Combination Short-haul Truck	673	1.101	0.000036	0.000002	1.103
Combination Long-haul Truck	2,293	3.945	0.000342	0.000005	3.954

Appendix B. 2030 Strategy Definitions and Assumptions

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.

2030 Plans & Programs yield lower annual vehicle miles traveled (VMT) growth (1.4 percent per year compared to 1.7 percent per year for business as usual)

Strategy Description: Modeled VMT and emissions outcomes (through MOVES2014a) from implementation of most recently adopted MPO fiscally constrained long-range transportation plans and cooperative land use forecasts.

Key Assumptions: The VMT projections of implementing the plans and programs that include MPO planned projects (highway and transit) and future regional demographic projections developed by the jurisdictions in cooperation with Maryland Department of Planning (MDP), show an expected decrease of 3.159 billion VMT in 2030 relative to the business as usual VMT growth rate. Annual VMT growth rates as forecast by the Baltimore Metropolitan Council (BMC) and Metro Washington Council of Governments (MWCOG) within their modeling areas have been used for modeling purposes. Outside of these MPO counties, SHA developed highway performance monitoring system (HPMS) VMT growth rates from 1990 to 2014 are used.

Estimation Methodology: The 2030 Plans and Programs use information from the CTP, each MPO TIP and MTP, and land use, population, and employment projections from the Maryland Department of Planning (MDP) to estimate the emission trend-line through 2030. The average statewide annualized VMT growth rate through 2030 for the plans and programs scenario is 1.4 percent as compared to a 1.7 percent BAU, based on which emission reductions have been estimated using MOVES by attributing it to VMT based on travel activity inputs by source types (vehicle types).

On-Road Technology (CHART, Traveler Information)

Strategy Description: This strategy covers on-road technology as it relates to the statewide implementation of CHART system with its five components including Traffic and Roadway Monitoring; Incident Management; 511 - Traveler's Information; System Integration and Communication; and Traffic Management.

Key Assumptions: Based on the existing coverage and effectiveness of CHART in the areas of incident response and other streamlined operations, the total annual emission reductions are estimated based on existing rates of coverage and coverage expansion, and effectiveness from SHA's annual CHART reports.

Estimation Methodology: Based on CHART's existing coverage area, VMT affected is estimated by facility types (roadway types – rural/urban and restricted/unrestricted access). Emission reductions are based on VMT for all vehicles on those roadway facilities impacted by the existing and expanded CHART coverage.

Freight and Freight Rail Programs (Class I railroad improvements and MTA rail projects)

Strategy Description: Implementation of the Norfolk Southern Crescent Corridor and CSX National Gateway provides new capacity and eliminates bottlenecks for access to the Port of Baltimore and rail access westward toward PA and OH and south toward VA and NC. These privately funded programs are in addition to ongoing MTA investments in Maryland freight rail corridor improvements.

Key Assumptions: Potential projects to enable double-stack rail access to the Port of Baltimore have evolved over the last decade. Prior 2020 analysis assumed the planned components of the National Gateway project would be complete by 2020. Using that same analysis, but assuming it now is complete by 2030 (given the current status) is more realistic.

Estimation Methodology: Truck VMT impacted due to these improvements is estimated based on information collected from project studies (for example: 850,000 long-haul trucks annually impacted by the Crescent Corridor project) and similar information from the National Gateway project (share of MD truck VMT only included in the estimation).

Public Transportation (projects not included in current modeling assumptions for MPO MTPs, but determined to be fully funded for implementation by 2030)

Strategy Description: This strategy includes projects designed to increase public transit capacity, improve operations and frequency, and implementation of new BRT corridors. Projects include dedicated bus lanes/transit service priority, bus rapid transit (US 29) in Montgomery and Howard Counties, other Montgomery County BRT corridors include MD 355 and Randolph Road, the Baltimore North Avenue Rising project, and the Southern Maryland Commuter Bus initiative.

Key Assumptions: Ridership estimates from recent and ongoing studies for each project corridors are converted into annual transit trips, which are then multiplied by an average commute trip length (16 miles based on MWCOG model estimates) to obtain annual VMT and emission reductions. Emissions from transit vehicles are included within the baseline MOVES modeling.

Estimation Methodology: Projects and initiatives with data on projected ridership and other indicators for estimation of reduced travel activity, use of transit as a lower alternative emissions intensive mode of travel have been included in the analysis.

Public Transportation (fleet replacement / technology based on current procurement)

Strategy Description: This strategy includes MTA planned fleet replacement to Clean Diesel and WMATA planned fleet replacement based on current replacement strategy.

Key Assumptions: Based on MTA's planned bus replacement schedule and other fleet replacement information, total number of active bus fleet that need to be replaced was estimated from FY 2018-2030. It is assumed that 3,000 gallons of fuel is reduced per year by new clean diesel buses.

Estimation Methodology: Reduction of 100 - 160 tons of greenhouse gas per year compared to a 40' diesel bus and 75 - 110 tons compared to an existing 40' diesel-hybrid bus.

TDM (Commuter Choice MD, Commuter Connections ongoing/expanding programs)

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, and Transit Store in Baltimore.

Key Assumptions: A trend-line extrapolation of annual VMT reductions from the full suite of TDM programs is used as a proxy for funding levels and strategy effectiveness, resulting in a VMT reduction 0.82 percent proportional to 2030 VMT, which is applied to the VMT for the year 2030.

Estimation Methodology: MWCOG's TERMS documentation has information on potential daily reduction in vehicle trips and daily VMT reductions by TDM program, which have been used to estimate the total potential VMT reduction for 2030. This data was applied to MD's share of the regional VMT. TDM program data from BMC region was added to the Metro Washington total to estimate the total TDM program emission reduction potential.

Pricing Initiatives (MDTA conversion to All Electronic Tolling)

Strategy Description: Ongoing Conversion to All-Electronic Tolling.

Key Assumptions: It is assumed that 92.6 percent of LDVs and 7.4 percent of HDVs are impacted in the year 2030 based on Attainment Report data on all electronic tolling. Assume 1 minute of idling per transaction for 50 percent of transactions and 1.5 minutes for other 50 percent obtained from MDOT (MDTA estimate)

Estimation Methodology: Reduced emissions from avoided idling is estimated for the share of fleet to estimate avoided emissions.

Bicycle and Pedestrian Strategies (continuation of State and local programs)

Strategy Description: Continued system expansion through SHA, MTA, and MVA programs in the CTP such as Bikeshare, Bikeways, retrofit programs, and Federal grants as summarized in the 2018-2023 CTP in addition to locally funded projects within the MWCOG and BMC 2017-2022 TIPs.

Key Assumptions: Assumes VMT reductions due to availability of bicycle and pedestrian facility lane miles (assuming connectivity is maintained and incrementally added to the existing network).

Estimation Methodology: Baseline VMT reductions for bike trips less than 5 miles in length and walk trips less than a mile in length were estimated using their existing mode shares. Ratios of baseline VMT reduction to linear mile of facility was estimated thereafter. Future linear miles of pedestrian and bicycle facility based on targets indicated in the 2018 MDOT Attainment Report (2018 AR) were estimated and factored to the increased extent based on the ratio of baseline reductions to arrive at the 2030 VMT reductions to estimate the emission reductions in the form of avoided auto-trips.

Land-Use and Location Efficiency (consistent with MDP assumptions)

Strategy Description: MDP projection of 75 percent compact development for 10 percent of development / redevelopment through 2030. Compact development is assumed to reduce VMT by 30 percent relative to standard density / mix development. This strategy partially captures MDOT/MDP commitment to TOD across 20 designated locations in Maryland.

Key Assumptions: The approach is based on the methodology provided in *CO2 Reductions Attributable to Smart Growth in California* by Reid Ewing, Ph.D., National Center for Smart Growth, University of Maryland, and Arthur C. Nelson, Ph.D., FAICP, Director of Metropolitan Research, University of Utah.

Estimation Methodology: 75 percent compact development for 10 percent of development / redevelopment is multiplied by the assumed 30 percent VMT reduction from the study noted above, and an assumed ratio of 90% CO_2 reduced for every unit of VMT reduction results in a total 2 percent CO_2 reduction for this strategy. **MDP 2030: % CO_2 reduction = 0.75 x 0.1 x 0.3 x 0.9 = 2%**

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: This strategy assumes current funding program implementation levels to continue through 2030.

Estimation Methodology: Emission reductions are based on increased fuel efficiency (and thereby the total fuel use reductions) of dray trucks which replace the current trucks in operation.

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 20 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.

Estimation Methodology: Emission reductions are based on increased fuel efficiency of clean diesel and CNG as fuel for improved emissions in operation.

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 25 strategies in this scenario (17 emerging and 8 innovative) represent a combination of approaches to reduce GHG emissions with varying levels of confidence and MDOT responsibility.

Emerging

Freeway Management/Integrated Corridor Management

Strategy Description: This strategy assumes implementation of an Integrated Corridor Management strategy on all urban limited access corridors.

Key Assumptions: This strategy assumes integrated corridor management, intelligent transportation systems, or advanced traffic management systems for the three corridors listed.

Estimation Methodology: Deployment of these strategies are already widespread throughout Maryland. Through 2030, this strategy assumes that some level of corridor management (including ramp metering), intelligent transportation systems, or advanced traffic management systems are in place on all urban restricted access facilities. The FHWA, "Travel and Emissions Impacts of Highway Operations Strategies," Final Report, by Cambridge Systematics, and the work of MWCOG's multisector working group (as documented in the January 2016 report) are used to support this analysis.

Arterial System Operations and Management

Strategy Description: This strategy estimates the benefits of implementing Arterial System Operations and Management including expanded signal coordination and control on all urban principal and minor arterials by 2030.

Key Assumptions: Only urban arterials are being assumed to be covered as part of this strategy through 2030.

Estimation Methodology: Emission reductions are attributed to VMT impacted during the peak period resulting in improved speeds for travel happening on select facilities (urban arterials) for all traffic.

Limited Access System Operations and Management

Strategy Description: This strategy evaluates the emission reductions benefits of implementation of a Limited Access System Operations and Management including deployment of technologies like ramp metering.

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 percent from MOVES defaults.

Estimation Methodology: Improvement of speeds on urban restricted access facilities causes emission reductions. This is offset by a fraction by the waiting vehicles on the ramps, which results in additional idling emissions. Net emission reductions are estimated for this strategy.

Managed Lanes (Traffic Relief Plan Implementation)

Strategy Description: This strategy estimates the emissions benefit of Chapter 30 projects (Traffic Relief Plan) to add express toll lanes to the routes of three of Maryland's most congested highways — the Interstate 495 Capital Beltway, the I-270 spur connecting Frederick to D.C., and the Baltimore-Washington Parkway between the two cities.

Key Assumptions: The congestion affects 260,000 motorists daily on I-270, 240,000 motorists daily on I-495 and 120,000 motorists each day on the Baltimore-Washington Parkway.

Estimation Methodology: Based on the project list and benefits as estimated by SHA, estimated daily fuel reductions were translated into 2030 emission reductions.

Intermodal Freight Centers Access Improvement

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 percent (as data on intermodal facilities mileage in MD was not able to be estimated based on available data).

Estimation Methodology: Potential reduction is based on the share of truck VMT operating in congested conditions (less than 50 percent of free-flow speed) and the potential extent of a strategy aimed at reducing the share of truck VMT operating in congested conditions. Benefits would be 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.

Commercial Vehicle Idle Reduction, Low-Carbon Fleet

Strategy Description: Commercial Vehicle Idle Reduction assumes enforcement of anti-idling law Maryland's Idling Law (Transportation Article §22-402) and have expanded regulations on use of auxiliary power units (APUs) in MD truck areas.

Key Assumptions: Daily total HDV idling is limited by the number of parking spaces, occupancy, and non-TSE installed spaces. This strategy definition considers extended idling only and not short-term idling (e.g., at a delivery/pick-up point). It is assumed that APUs will be used to power the trucks during the time spent idling. Idling emission rates for HDV and APUs are derived and given that this is also a strategy with implications for PM emission reductions, PM emissions are also presented in the results.

Estimation Methodology: It is estimated that trucks would have spent time idling in absence of this law. A high case and a low case for emission reductions is estimated considering all or just 50 percent of extended idling is handled by APUs. High case adopted and presented in the results estimates 2,173 total HDVs avoiding extended idling as a result of this strategy.

Eco-Driving

Strategy Description: This strategy is assumed to be undertaken as a general marketing program with basic outreach and information brochure about the savings included.

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 percent of the statewide population are reached using these general marketing programs. Out of these people, only 50 percent (1 percent of total population) have on-board display tools that have on-board display tools that provide feedback from eco-driving. The benefits of eco-driving are 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.

Estimation Methodology: Adoption rates and skill/habit retention are kept intentionally low as this campaign is just a marketing and education campaign. They are typically higher for rigorous training and educational campaigns.

Lead by example - Alternative Fuel Usage in State Fleet

Strategy Description: This strategy is already being tracked as part of MDOT's Excellerator program and includes deployment of alternative fuel vehicles and fuels including ultra-low Sulphur diesel, biodiesel, and E-85 as the proposed as alternatives.

Key Assumptions: It is assumed that the program continues to be implemented at current levels resulting in reduced diesel and gasoline fuel use as it is replaced by blended fuels.

Estimation Methodology: Reductions are based on changes in carbon intensity due to diverse fuel choices and blends.

Truck Stop Electrification

Strategy Description: This strategy assumes equipping all public truck bays to be equipped with electrification for powering trucks during overnight stays or time otherwise spent as extended idling.

Key Assumptions: Strategy assumes a range of deployment of electrification of truck stops throughout the state. Three scenarios of deployment (all public spaces, 50 percent of public spaces, and 10 percent of public spaces are considered). Average rates of truck stop utilization is set at 50 percent. It is assumed that the electricity source for powering the truck is similar to using an APU (without having to compute the power supplied for the duration and its source and its energy footprint).

Estimation Methodology: Three scenarios for deployment in 2030 – 100 percent, 50 percent and 10 percent of public spaces available across the state are considered and presented as high/medium/and low cases. The high case of deployment (all public places) is chosen for estimation purposes.

Transit capacity/service expansion (fiscally unconstrained)

Strategy Description: Projects in fiscally constrained LRTPs **post-2030** or in needs or aspirations-based plan (unconstrained). These potential enhancements/expansions to Maryland's transit system are extensive, including extension of the Baltimore Metro Green Line and multiple bus rapid transit corridors in Montgomery, Prince Georges, Howard, and Anne Arundel Counties. Most of these projects are identified in the BMC and MWGOG LRTPs for implementation post-2030 or identified as a need for a corridor study. This includes every other potential BRT corridor, TOD build outs, MGIP/Cornerstone Plan build out, and references to a Green Line extension in Baltimore and new/updated MARC stations at West Baltimore and Bayview.

Key Assumptions: Assumes that some of these projects will have the necessary funding and will be operationalized by 2030 to realize potential GHG reduction benefits.

Estimation Methodology: Emission reductions estimated based on individual project information including potential ridership estimates as reduced VMT. MTA fleet replacement and benefits of TOD build-out from 20 incentive zones is estimated using MDP's TOD planning tool. Estimated reductions of TOD are based on zonal classifications based on number of households impacted and trips reduced (by location coefficient types).

Expanded TDM strategies (dynamic), telecommute, non-work strategies

Strategy Description: The implementation and coverage of TDM strategies considered in the Policy Scenario 1 is doubled and the impact of those programs resulting in an increased share of VMT reductions by 2030. This approach reflects a renewed and expanded commitment to TDM, including more extensive financial incentives or disincentives to driving alone and dynamic ridesharing options.

Key Assumptions: Assuming increased coverage of TDM strategies based on additional funding influx resulting in the same proportion of increase in VMT reductions.

Estimation Methodology: Reduced VMT due to expansion of the TDM programs is doubled under this scenario and emission reductions are estimated for the share of passenger car VMT impacted.

Expanded bike/pedestrian system development

Strategy Description: Expanded bicycle and pedestrian facility infrastructure by an increased pace which corresponds to 150 percent of the existing bicycle and pedestrian infrastructure provision target.

Key Assumptions: Future linear miles of pedestrian and bicycle facilities were estimated based on targets provided in the 2018 MDOT Attainment Report (2018 AR). In each case, two numbers were estimated. The first number corresponds to the target indicated in the 2018 AR and is referred to below as "existing rate" strategy below. The second number corresponds to 150 percent of the 2018 AR target and is referred to below as the "increased rate" strategy below.

Estimation Methodology: The above growth rates were applied to the existing linear miles of sidewalk and bicycle facility on state-owned roads in urban areas, as determined from data provided by SHA, to calculate future linear miles of sidewalk and bicycle facility in urban areas for each strategy.

Freight Rail Capacity Constraints/Access (Howard St. Tunnel)

Strategy Description: Potential projects to enable double-stack rail access to the Port of Baltimore have evolved over the last decade. The new direction is to expand the Howard Street tunnel as described in the recent FASTLANE Grant application submitted jointly by MDOT and CSX. Regardless of how this project is funded, this strategy assumes implementation by 2030, and estimates the impacts on truck movements to and from the Port.

Key Assumptions: Building out the Howard Street Tunnel and enabling double-stacking directly to the Port of Baltimore by 2030.

Estimation Methodology: Reduced emissions based on VMT reduction due to double-stacking. VMT reduced is for combination long-haul trucks affected by this improvement only.

Regional Clean Fuel Standard

Strategy Description: Similar to approach in the 2015 Transportation and Climate Initiative (TCI) analysis, a clean fuels standard to achieve a 15 percent reduction in carbon intensity by 2030 was evaluated.

Key Assumptions: Emission reductions estimated for the year 2025 in the TCI analysis were used for the year 2030, to correspond to a 12-year base-year and scenario year gap (TCI analysis used 2013 as the base year).

Estimation Methodology: Emission reductions due to reduction from baseline in the TCI study have been applied to the 2030 VMT (discounted for EVs).

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

Strategy Description: This strategy involves advancing the MGIP 2030-2050 vision for projects to be accelerated to be operational by 2030.

Key Assumptions: Assumes no fiscal constraints and includes projects that are assumed to be accelerated for implementation by 2030.

Estimation Methodology: Projected ridership potential attributable to the total plan implementation is estimated to occur by 2030 as a result of accelerated improvement of the plan.

EV Scenario + Additional 100K Ramp Up (total of 704,840 EV s)

Strategy Description: An additional 100,000 EVs are assumed to be rolled-out from 2025 along the same splits of BEV and PHEV shares to make up a total of 704,840 total EVs on the road in the year 2030.

Key Assumptions: Keeping the share of BEV/PHEVs same as in the MDOT/MDE scenario. 55 percent of PHEV VMT is assumed to be electric.

Estimation Methodology: All the emissions except for the PHEV's fuel driving share of 45 percent are assumed to be avoided.

50 percent EV Transit Bus Fleet

Strategy Description: This is a what-if scenario to estimate the emission reduction benefits of having a 50 percent transit bus fleet in the year 2030.

Key Assumptions: Procurement policies change as early as 2020 with a commitment to 100 percent of bus replacements as a battery electric or plug-in hybrid electric through 2030.

Estimation Methodology: Half of the emissions attributable to transit buses in Maryland in 2030 are estimated to be avoided.

Connected and Automated Vehicle Technologies

Strategy Description: This strategy estimates the emission reduction benefits of market penetration of ACVs and provision of adequate infrastructure to enable V2V and V2I technologies.

Key Assumptions: Core assumptions regarding market penetration of AVs, change in VMT, and fuel savings have been adopted from a 2015 ENO Transportation Center study on AV deployment which lays out three scenarios of AV deployment, of which the low-end penetration of 10 percent by 2030 is considered in this analysis.

Estimation Methodology: The following changes are estimated due to deployment of AVs from an emissions perspective:

- 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).

Variable Speeds / Speed Management on Freeways

Strategy Description: This strategy estimates the potential emission reduction benefits of speed limit enforcement on urban restricted roadways.

Key Assumptions: This strategy assumes applying speed management strategies during non-peak periods. Different emission factors for average speeds used for LDVs and HDVs to reflect marginal differences between the two classes of vehicles. Note enforcement may come about more through automated vehicle technology rather than traditional means.

Estimation Methodology: Difference between emission rates of VMT without enforcement (higher speed) and under speed enforcement (55 mph) applied to the VMT for that vehicle type.

Zero-Emission Trucks/Truck Corridors

Strategy Description: This strategy considers establishment of infrastructure and vehicle replacements for implementation of zero emission corridors connecting to the Port of Baltimore in comparison with the I-710 Calstart Corridor study.

Key Assumptions: This strategy assumes participation of 700 dray trucks in Maryland that operate in the Port of Baltimore area only.

Estimation Methodology: Emission reductions estimated from savings during both running and idling times and applied to annual dray truck VMT and total dray trucks in Maryland.

Ride-hailing / Mobility as a Service (MaaS)

Strategy Description: Ride-hailing services not only encourage cost-saving and emission reducing measures like carpooling (the price savings of serves like Uber pool and Lyft Line), but also as a first/last mile connection between users and other modes, reducing the needs for SOV ownership. Mobility as a Service deployment at scale will be the replacement of private auto trips with the use of ride-hailing services either shared or SOV**.**

Key Assumptions: Impacts on reduced vehicle ownership, reduced travel activity to be estimated based on national literature pointing to a range of anywhere between 10 to 20 percent adoption of car sharing by 2030.

Estimation Methodology: Reduction in passenger trips due to decreased car ownership, impact due to reduced travel activity, and impact due to trip consolidation and increased occupancy of vehicles

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: 5 percent of Maryland drivers are enrolled in PAYD by 2030. The assumed VMT reduction associated with PAYD insurance premiums is 8 percent based on national studies.

Estimation Methodology: Reduction in travel activity due to reduced mileage as a result of PAYD. Reduction assumed at 8 percent (low case) as documented in a range of PAYD studies and literature review.

Freight Villages/Urban Freight Consolidation Centers

Strategy Description: Consolidated freight distribution centers to utilize cleaner last-mile delivery trucks for urban areas.

Key Assumptions: It is being assumed that only short haul truck VMT is being impacted. The regional extent to which this strategy is applied is confined to the “urban freight corridor mileage distribution” as cited in the MD Strategic Goods Movement Plan 2018 (75 miles).

Estimation Methodology: Improved emission factor applied for short haul trucks VMT (1.759 billion VMT in 2030) attributable to the urban freight corridor mileage distribution.

High-Speed Passenger Rail / SCMAGLEV / Loop

Strategy Description: This strategy assumes a build out of the NEC Vision, or construction of the SCMAGLEV and/or Loop, to facilitate intercity passenger rail travel through 2030.

Key Assumptions: Ridership potential based on Maryland's share of NEC's ridership. Potential next generation passenger rail trips in 2030 estimated on the same share of total corridor ridership. Further analysis pending ridership estimates from ongoing SCMAGLEV and Loop research.

Estimation Methodology: Amtrak's America 2050 report provides projected ridership numbers for Next Gen HSR for NE Corridor for the year 2030.

Policy Scenario 3 (Pricing and Revenue)

This scenario takes a look at possibilities for addressing the primary challenge associated with implementing Policy Scenario 2 – funding. A market pricing approach could include current revenue sources, or augment or replace some of these sources with a VMT or carbon pricing approach. Among these options, MDOT estimated the outcomes of a carbon pricing strategy based on potential as a more sustainable and equitable revenue source. **This analysis was conducted for the scenario planning purposes of this report and is in no way indicative of MDOT's policy position.**

Regional Carbon Price comparable to TCI Approach (RGGI for Transportation Sector)

Strategy Description: For the purpose of supporting MWG's scenario planning process, MDOT developed an estimation of a potential Carbon Pricing mechanism based on its more sustainable revenue source, ability to encourage further transformation to a low-carbon or zero carbon fleet, and lower equity concerns.

Key Assumptions: Used consistent assumptions with the 2015 TCI analysis, including ranges of cost per ton and VMT change to travel cost elasticities.

Estimation Methodology: MDOT analyzed four different Carbon Pricing tests based on the following assumptions:

- **Test 1** – \$30 per ton CO_2e (consistent with TCI analysis) applied to all on-road mobile source emissions starting in 2025
- **Test 2** – \$30 per ton CO_2e (consistent with TCI analysis) applied to all on-road mobile source emissions starting in 2021
- **Test 3** – Carbon price increasing annually from \$20 per ton in 2020 to the social cost of carbon, \$62.25 by 2030, applied to all on-road mobile source emissions starting in 2025
- **Test 4** – Carbon price increasing annually from \$20 per ton in 2020 to the social cost of carbon, \$62.25 by 2030, applied to all on-road mobile source emissions starting in 2021

Appendix B. 2030 Strategy Definitions and Assumptions

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.

2030 Plans & Programs yield lower annual vehicle miles traveled (VMT) growth (1.4 percent per year compared to 1.7 percent per year for business as usual)

Strategy Description: Modeled VMT and emissions outcomes (through MOVES2014a) from implementation of most recently adopted MPO fiscally constrained long-range transportation plans and cooperative land use forecasts.

Key Assumptions: The VMT projections of implementing the plans and programs that include MPO planned projects (highway and transit) and future regional demographic projections developed by the jurisdictions in cooperation with Maryland Department of Planning (MDP), show an expected decrease of 3.159 billion VMT in 2030 relative to the business as usual VMT growth rate. Annual VMT growth rates as forecast by the Baltimore Metropolitan Council (BMC) and Metro Washington Council of Governments (MWCOG) within their modeling areas have been used for modeling purposes. Outside of these MPO counties, SHA developed highway performance monitoring system (HPMS) VMT growth rates from 1990 to 2014 are used.

Estimation Methodology: The 2030 Plans and Programs use information from the CTP, each MPO TIP and MTP, and land use, population, and employment projections from the Maryland Department of Planning (MDP) to estimate the emission trend-line through 2030. The average statewide annualized VMT growth rate through 2030 for the plans and programs scenario is 1.4 percent as compared to a 1.7 percent BAU, based on which emission reductions have been estimated using MOVES by attributing it to VMT based on travel activity inputs by source types (vehicle types).

On-Road Technology (CHART, Traveler Information)

Strategy Description: This strategy covers on-road technology as it relates to the statewide implementation of CHART system with its five components including Traffic and Roadway Monitoring; Incident Management; 511 - Traveler's Information; System Integration and Communication; and Traffic Management.

Key Assumptions: Based on the existing coverage and effectiveness of CHART in the areas of incident response and other streamlined operations, the total annual emission reductions are estimated based on existing rates of coverage and coverage expansion, and effectiveness from SHA’s annual CHART reports.

Estimation Methodology: Based on CHART’s existing coverage area, VMT affected is estimated by facility types (roadway types – rural/urban and restricted/unrestricted access). Emission reductions are based on VMT for all vehicles on those roadway facilities impacted by the existing and expanded CHART coverage.

Freight and Freight Rail Programs (Class I railroad improvements and MTA rail projects)

Strategy Description: Implementation of the Norfolk Southern Crescent Corridor and CSX National Gateway provides new capacity and eliminates bottlenecks for access to the Port of Baltimore and rail access westward toward PA and OH and south toward VA and NC. These privately funded programs are in addition to ongoing MTA investments in Maryland freight rail corridor improvements.

Key Assumptions: Potential projects to enable double-stack rail access to the Port of Baltimore have evolved over the last decade. Prior 2020 analysis assumed the planned components of the National Gateway project would be complete by 2020. Using that same analysis, but assuming it now is complete by 2030 (given the current status) is more realistic.

Estimation Methodology: Truck VMT impacted due to these improvements is estimated based on information collected from project studies (for example: 850,000 long-haul trucks annually impacted by the Crescent Corridor project) and similar information from the National Gateway project (share of MD truck VMT only included in the estimation).

Public Transportation (projects not included in current modeling assumptions for MPO MTPs, but determined to be fully funded for implementation by 2030)

Strategy Description: This strategy includes projects designed to increase public transit capacity, improve operations and frequency, and implementation of new BRT corridors. Projects include dedicated bus lanes/transit service priority, bus rapid transit (US 29) in Montgomery and Howard Counties, other Montgomery County BRT corridors include MD 355 and Randolph Road, the Baltimore North Avenue Rising project, and the Southern Maryland Commuter Bus initiative.

Key Assumptions: Ridership estimates from recent and ongoing studies for each project corridors are converted into annual transit trips, which are then multiplied by an average commute trip length (16 miles based on MWCOG model estimates) to obtain annual VMT and emission reductions. Emissions from transit vehicles are included within the baseline MOVES modeling.

Estimation Methodology: Projects and initiatives with data on projected ridership and other indicators for estimation of reduced travel activity, use of transit as a lower alternative emissions intensive mode of travel have been included in the analysis.

Public Transportation (fleet replacement / technology based on current procurement)

Strategy Description: This strategy includes MTA planned fleet replacement to Clean Diesel and WMATA planned fleet replacement based on current replacement strategy.

Key Assumptions: Based on MTA's planned bus replacement schedule and other fleet replacement information, total number of active bus fleet that need to be replaced was estimated from FY 2018-2030. It is assumed that 3,000 gallons of fuel is reduced per year by new clean diesel buses.

Estimation Methodology: Reduction of 100 - 160 tons of greenhouse gas per year compared to a 40' diesel bus and 75 - 110 tons compared to an existing 40' diesel-hybrid bus.

TDM (Commuter Choice MD, Commuter Connections ongoing/expanding programs)

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, and Transit Store in Baltimore.

Key Assumptions: A trend-line extrapolation of annual VMT reductions from the full suite of TDM programs is used as a proxy for funding levels and strategy effectiveness, resulting in a VMT reduction 0.82 percent proportional to 2030 VMT, which is applied to the VMT for the year 2030.

Estimation Methodology: MWCOG's TERMS documentation has information on potential daily reduction in vehicle trips and daily VMT reductions by TDM program, which have been used to estimate the total potential VMT reduction for 2030. This data was applied to MD's share of the regional VMT. TDM program data from BMC region was added to the Metro Washington total to estimate the total TDM program emission reduction potential.

Pricing Initiatives (MDTA conversion to All Electronic Tolling)

Strategy Description: Ongoing Conversion to All-Electronic Tolling.

Key Assumptions: It is assumed that 92.6 percent of LDVs and 7.4 percent of HDVs are impacted in the year 2030 based on Attainment Report data on all electronic tolling. Assume 1 minute of idling per transaction for 50 percent of transactions and 1.5 minutes for other 50 percent obtained from MDOT (MDTA estimate)

Estimation Methodology: Reduced emissions from avoided idling is estimated for the share of fleet to estimate avoided emissions.

Bicycle and Pedestrian Strategies (continuation of State and local programs)

Strategy Description: Continued system expansion through SHA, MTA, and MVA programs in the CTP such as Bikeshare, Bikeways, retrofit programs, and Federal grants as summarized in the 2018-2023 CTP in addition to locally funded projects within the MWCOG and BMC 2017-2022 TIPs.

Key Assumptions: Assumes VMT reductions due to availability of bicycle and pedestrian facility lane miles (assuming connectivity is maintained and incrementally added to the existing network).

Estimation Methodology: Baseline VMT reductions for bike trips less than 5 miles in length and walk trips less than a mile in length were estimated using their existing mode shares. Ratios of baseline VMT reduction to linear mile of facility was estimated thereafter. Future linear miles of pedestrian and bicycle facility based on targets indicated in the 2018 MDOT Attainment Report (2018 AR) were estimated and factored to the increased extent based on the ratio of baseline reductions to arrive at the 2030 VMT reductions to estimate the emission reductions in the form of avoided auto-trips.

Land-Use and Location Efficiency (consistent with MDP assumptions)

Strategy Description: MDP projection of 75 percent compact development for 10 percent of development / redevelopment through 2030. Compact development is assumed to reduce VMT by 30 percent relative to standard density / mix development. This strategy partially captures MDOT/MDP commitment to TOD across 20 designated locations in Maryland.

Key Assumptions: The approach is based on the methodology provided in *CO2 Reductions Attributable to Smart Growth in California* by Reid Ewing, Ph.D., National Center for Smart Growth, University of Maryland, and Arthur C. Nelson, Ph.D., FAICP, Director of Metropolitan Research, University of Utah.

Estimation Methodology: 75 percent compact development for 10 percent of development / redevelopment is multiplied by the assumed 30 percent VMT reduction from the study noted above, and an assumed ratio of 90% CO2 reduced for every unit of VMT reduction results in a total 2 percent CO2 reduction for this strategy. **MDP 2030: % CO2 reduction = 0.75 x 0.1 x 0.3 x 0.9 = 2%**

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: This strategy assumes current funding program implementation levels to continue through 2030.

Estimation Methodology: Emission reductions are based on increased fuel efficiency (and thereby the total fuel use reductions) of dray trucks which replace the current trucks in operation.

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 20 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.

Estimation Methodology: Emission reductions are based on increased fuel efficiency of clean diesel and CNG as fuel for improved emissions in operation.

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 25 strategies in this scenario (17 emerging and 8 innovative) represent a combination of approaches to reduce GHG emissions with varying levels of confidence and MDOT responsibility.

Emerging

Freeway Management/Integrated Corridor Management

Strategy Description: This strategy assumes implementation of an Integrated Corridor Management strategy on all urban limited access corridors.

Key Assumptions: This strategy assumes integrated corridor management, intelligent transportation systems, or advanced traffic management systems for the three corridors listed.

Estimation Methodology: Deployment of these strategies are already widespread throughout Maryland. Through 2030, this strategy assumes that some level of corridor management (including ramp metering), intelligent transportation systems, or advanced traffic management systems are in place on all urban restricted access facilities. The FHWA, “Travel and Emissions Impacts of Highway Operations Strategies,” Final Report, by Cambridge Systematics, and the work of MWCOG's multisector working group (as documented in the January, 2016 report) are used to support this analysis.

Arterial System Operations and Management

Strategy Description: This strategy estimates the benefits of implementing Arterial System Operations and Management including expanded signal coordination and control on all urban principal and minor arterials by 2030.

Key Assumptions: Only urban arterials are being assumed to be covered as part of this strategy through 2030.

Estimation Methodology: Emission reductions are attributed to VMT impacted during the peak period resulting in improved speeds for travel happening on select facilities (urban arterials) for all traffic.

Limited Access System Operations and Management

Strategy Description: This strategy evaluates the emission reductions benefits of implementation of a Limited Access System Operations and Management including deployment of technologies like ramp metering.

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 percent from MOVES defaults.

Estimation Methodology: Improvement of speeds on urban restricted access facilities causes emission reductions. This is offset by a fraction by the waiting vehicles on the ramps, which results in additional idling emissions. Net emission reductions are estimated for this strategy.

Managed Lanes (Traffic Relief Plan Implementation)

Strategy Description: This strategy estimates the emissions benefit of Chapter 30 projects (Traffic Relief Plan) to add express toll lanes to the routes of three of Maryland's most congested highways — the Interstate 495 Capital Beltway, the I-270 spur connecting Frederick to D.C., and the Baltimore-Washington Parkway between the two cities.

Key Assumptions: The congestion affects 260,000 motorists daily on I-270, 240,000 motorists daily on I-495 and 120,000 motorists each day on the Baltimore-Washington Parkway.

Estimation Methodology: Based on the project list and benefits as estimated by SHA, estimated daily fuel reductions were translated into 2030 emission reductions.

Intermodal Freight Centers Access Improvement

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 percent (as data on intermodal facilities mileage in MD was not able to be estimated based on available data).

Estimation Methodology: Potential reduction is based on the share of truck VMT operating in congested conditions (less than 50 percent of free-flow speed) and the potential extent of a strategy aimed at reducing the share of truck VMT operating in congested conditions. Benefits would be 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.

Commercial Vehicle Idle Reduction, Low-Carbon Fleet

Strategy Description: Commercial Vehicle Idle Reduction assumes enforcement of anti-idling law Maryland's Idling Law (Transportation Article §22-402) and have expanded regulations on use of auxiliary power unites (APUs) in MD truck areas.

Key Assumptions: Daily total HDV idling is limited by the number of parking spaces, occupancy, and non-TSE installed spaces. This strategy definition considers extended idling only and not short term idling (e.g., at a delivery/pick-up point). It is assumed that APUs will be used to power the trucks during the time spent idling. Idling emission rates for HDV and APUs are derived and given that this is also a strategy with implications for PM emission reductions, PM emissions are also presented in the results.

Estimation Methodology: It is estimated that trucks would have spent time idling in absence of this law. A high case and a low case for emission reductions is estimated considering all or just 50 percent of extended idling is handled by APUs. High case adopted and presented in the results estimates 2,173 total HDVs avoiding extended idling as a result of this strategy.

Eco-Driving

Strategy Description: This strategy is assumed to be undertaken as a general marketing program with basic outreach and information brochure about the savings included.

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 percent of the statewide population are reached using these general marketing programs. Out of these people, only 50 percent (1 percent of total population) have on-board display tools that have on-board display tools that provide feedback from eco-driving. 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.

Estimation Methodology: Adoption rates and skill/habit retention are kept intentionally low as this campaign is just a marketing and education campaign. They are typically higher for rigorous training and educational campaigns.

Lead by example - Alternative Fuel Usage in State Fleet

Strategy Description: This strategy is already being tracked as part of MDOT's Excellerator program and includes deployment of alternative fuel vehicles and fuels including ultra low Sulphur diesel, bio-diesel, and E-85 as the proposed as alternatives.

Key Assumptions: It is assumed that the program continues to be implemented at current levels resulting in reduced diesel and gasoline fuel use as it is replaced by blended fuels.

Estimation Methodology: Reductions are based on changes in carbon intensity due to diverse fuel choices and blends.

Truck Stop Electrification

Strategy Description: This strategy assumes equipping all public truck bays to be equipped with electrification for powering trucks during overnight stays or time otherwise spent as extended idling.

Key Assumptions: Strategy assumes a range of deployment of electrification of truck stops throughout the state. Three scenarios of deployment (all public spaces, 50 percent of public spaces, and 10 percent of public spaces are considered). Average rates of truck stop utilization is set at 50 percent. It is assumed that the electricity source for powering the truck is similar to using an APU (without having to compute the power supplied for the duration and its source and its energy footprint).

Estimation Methodology: Three scenarios for deployment in 2030 – 100 percent, 50 percent and 10 percent of public spaces available across the state are considered and presented as high/medium/and low cases. The high case of deployment (all public places) is chosen for estimation purposes.

Transit capacity/service expansion (fiscally unconstrained)

Strategy Description: Projects in fiscally constrained LRTPs **post-2030** or in needs or aspirations based plan (unconstrained). These potential enhancements/expansions to Maryland's transit system are extensive, including extension of the Baltimore Metro Green Line and multiple bus rapid transit corridors in Montgomery, Prince Georges, Howard, and Anne Arundel Counties. Most of these projects are identified in the BMC and MWGOG LRTPs for implementation post-2030 or identified as a need for a corridor study. This includes every other potential BRT corridor, TOD build outs, MGIP/Cornerstone Plan build out, and references to a Green Line extension in Baltimore and new/updated MARC stations at West Baltimore and Bayview.

Key Assumptions: Assumes that some of these projects will have the necessary funding and will be operationalized by 2030 to realize potential GHG reduction benefits.

Estimation Methodology: Emission reductions estimated based on individual project information including potential ridership estimates as reduced VMT. MTA fleet replacement and benefits of TOD build-out from 20 incentive zones is estimated using MDP's TOD planning tool. Estimated reductions of TOD are based on zonal classifications based on number of households impacted and trips reduced (by location coefficient types).

Expanded TDM strategies (dynamic), telecommute, non-work strategies

Strategy Description: The implementation and coverage of TDM strategies considered in the Policy Scenario 1 is doubled and the impact of those programs resulting in an increased share of VMT reductions by 2030. This approach reflects a renewed and expanded commitment to TDM, including more extensive financial incentives or disincentives to driving alone and dynamic ridesharing options.

Key Assumptions: Assuming increased coverage of TDM strategies based on additional funding influx resulting in the same proportion of increase in VMT reductions.

Estimation Methodology: Reduced VMT due to expansion of the TDM programs is doubled under this scenario and emission reductions are estimated for the share of passenger car VMT impacted.

Expanded bike/pedestrian system development

Strategy Description: Expanded bicycle and pedestrian facility infrastructure by an increased pace which corresponds to 150 percent of the existing bicycle and pedestrian infrastructure provision target.

Key Assumptions: Future linear miles of pedestrian and bicycle facilities were estimated based on targets provided in the 2018 MDOT Attainment Report (2018 AR). In each case, two numbers were estimated. The first number corresponds to the target indicated in the 2018 AR and is referred to below as "existing rate" strategy below. The second number corresponds to 150 percent of the 2018 AR target and is referred to below as the "increased rate" strategy below.

Estimation Methodology: The above growth rates were applied to the existing linear miles of sidewalk and bicycle facility on state-owned roads in urban areas, as determined from data provided by SHA, to calculate future linear miles of sidewalk and bicycle facility in urban areas for each strategy.

Freight Rail Capacity Constraints/Access (Howard St. Tunnel)

Strategy Description: Potential projects to enable double-stack rail access to the Port of Baltimore have evolved over the last decade. The new direction is to expand the Howard Street tunnel as described in the recent FASTLANE Grant application submitted jointly by MDOT and CSX. Regardless of how this project is funded, this strategy assumes implementation by 2030, and estimates the impacts on truck movements to and from the Port.

Key Assumptions: Building out the Howard Street Tunnel and enabling double-stacking directly to the Port of Baltimore by 2030.

Estimation Methodology: Reduced emissions based on VMT reduction due to double-stacking. VMT reduced is for combination long-haul trucks affected by this improvement only.

Regional Clean Fuel Standard

Strategy Description: Similar to approach in the 2015 Transportation and Climate Initiative (TCI) analysis, a clean fuels standard to achieve a 15 percent reduction in carbon intensity by 2030 was evaluated.

Key Assumptions: Emission reductions estimated for the year 2025 in the TCI analysis were used for the year 2030, to correspond to a 12 year base-year and scenario year gap (TCI analysis used 2013 as the base year).

Estimation Methodology: Emission reductions due to reduction from baseline in the TCI study have been applied to the 2030 VMT (discounted for EVs).

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

Strategy Description: This strategy involves advancing the MGIP 2030-2050 vision for projects to be accelerated to be operational by 2030.

Key Assumptions: Assumes no fiscal constraints and includes projects that are assumed to be accelerated for implementation by 2030.

Estimation Methodology: Projected ridership potential attributable to the total plan implementation is estimated to occur by 2030 as a result of accelerated improvement of the plan.

EV Scenario + Additional 100K Ramp Up (total of 704,840 EV s)

Strategy Description: An additional 100,000 EVs are assumed to be rolled-out from 2025 along the same splits of BEV and PHEV shares to make up a total of 704,840 total EVs on the road in the year 2030.

Key Assumptions: Keeping the share of BEV/PHEVs same as in the MDOT/MDE scenario. 55 percent of PHEV VMT is assumed to be electric.

Estimation Methodology: All the emissions except for the PHEV's fuel driving share of 45 percent are assumed to be avoided.

50 percent EV Transit Bus Fleet

Strategy Description: This is a what-if scenario to estimate the emission reduction benefits of having a 50 percent transit bus fleet in the year 2030.

Key Assumptions: Procurement policies change as early as 2020 with a commitment to 100 percent of bus replacements as a battery electric or plug-in hybrid electric through 2030.

Estimation Methodology: Half of the emissions attributable to transit buses in Maryland in 2030 are estimated to be avoided.

Innovative

Connected and Automated Vehicle (CAV) Technologies

Strategy Description: This strategy estimates the emission reduction benefits of market penetration of ACVs and provision of adequate infrastructure to enable V2V and V2I technologies.

Key Assumptions: Core assumptions regarding market penetration of AVs, change in VMT, and fuel savings have been adopted from a 2015 ENO Transportation Center study on AV deployment which lays out three scenarios of AV deployment, of which the low-end penetration of 10 percent by 2030 is considered in this analysis.

Estimation Methodology: The following changes are estimated due to deployment of AVs from an emissions perspective:

- 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).

Variable Speeds / Speed Management on Freeways

Strategy Description: This strategy estimates the potential emission reduction benefits of speed limit enforcement on urban restricted roadways.

Key Assumptions: This strategy assumes applying speed management strategies during non-peak periods. Different emission factors for average speeds used for LDVs and HDVs to reflect marginal differences between the two classes of vehicles. Note enforcement may come about more through automated vehicle technology rather than traditional means.

Estimation Methodology: Difference between emission rates of VMT without enforcement (higher speed) and under speed enforcement (55 mph) applied to the VMT for that vehicle type.

Zero-Emission Trucks/Truck Corridors

Strategy Description: This strategy considers establishment of infrastructure and vehicle replacements for implementation of zero emission corridors connecting to the Port of Baltimore in comparison with the I-710 Calstart Corridor study.

Key Assumptions: This strategy assumes participation of 700 dray trucks in Maryland that operate in the Port of Baltimore area only.

Estimation Methodology: Emission reductions estimated from savings during both running and idling times and applied to annual dray truck VMT and total dray trucks in Maryland.

Ride-hailing / Mobility as a Service (MaaS)

Strategy Description: Ride-hailing services not only encourage cost-saving and emission reducing measures like carpooling (the price savings of serves like Uber pool and Lyft Line), but also as a first/last mile connection between users and other modes, reducing the needs for SOV ownership. Mobility as a Service deployment at scale will be the replacement of private auto trips with the use of ride-hailing services either shared or SOV**.**

Key Assumptions: Impacts on reduced vehicle ownership, reduced travel activity to be estimated based on national literature pointing to a range of anywhere between 10 to 20 percent adoption of car sharing by 2030.

Estimation Methodology: Reduction in passenger trips due to decreased car ownership, impact due to reduced travel activity, and impact due to trip consolidation and increased occupancy of vehicles

Intercity Bus Service Expansion

Strategy Description: This strategy evaluates the emission reduction benefits of expansion of planned long distance bus service in Maryland. MDOT MTA administers the MDOT MTA Intercity Bus (ICB) Program. MDOT MTA ICB Program sponsors intercity bus services in the following corridors: I-86, US-50, US-40.

Key Assumptions: Expanded service assumes additional service to other corridors or capacity addition (headway improvement) on existing routes as needed.

Estimation Methodology: Estimate the benefits of long distance auto VMT now traveled in long-distance buses. Emission reductions are a result of lower carbon intensive travel.

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: 5 percent of Maryland drivers are enrolled in PAYD by 2030. The assumed VMT reduction associated with PAYD insurance premiums is 8 percent based on national studies.

Estimation Methodology: Reduction in travel activity due to reduced mileage as a result of PAYD. Reduction assumed at 8 percent (low case) as documented in a range of PAYD studies and literature review.

Freight Villages/Urban Freight Consolidation Centers

Strategy Description: Consolidated freight distribution centers to utilize cleaner last-mile delivery trucks for urban areas.

Key Assumptions: It is being assumed that only short haul truck VMT is being impacted. The regional extent to which this strategy is applied is confined to the "urban freight corridor mileage distribution" as cited in the MD Strategic Goods Movement Plan 2018 (75 miles).

Estimation Methodology: Improved emission factor applied for short haul trucks VMT (1.759 billion VMT in 2030) attributable to the urban freight corridor mileage distribution.

High-Speed Passenger Rail/SCMAGLEV

Strategy Description: This strategy assumes a build out of the NEC Vision, or construction of the SCMAGLEV and/or Hyperloop, to facilitate intercity passenger rail travel through 2030.

Key Assumptions: Ridership potential based on Maryland's share of NEC's ridership. Potential next generation passenger rail trips in 2030 estimated on the same share of total corridor ridership. Further analysis pending ridership estimates from ongoing SCMAGLEV and Hyperloop research.

Estimation Methodology: Amtrak's America 2050 report provides projected ridership numbers for Next Gen HSR for NE Corridor for the year 2030.

Policy Scenario 3 (Pricing and Revenue)

This scenario takes a look at possibilities for addressing the primary challenge associated with implementing Policy Scenario 2 – funding. A market pricing approach could include current revenue sources, or augment or replace some of these sources with a VMT or carbon pricing approach. Among these options, MDOT estimated the outcomes of a carbon pricing strategy based on potential as a more sustainable and equitable revenue source. **This analysis was conducted for the scenario planning purposes of this report and is in no way indicative of MDOT's policy position.**

Regional Carbon Price comparable to TCI Approach (RGGI for Transportation Sector)

Strategy Description: For the purpose of supporting MWG's scenario planning process, MDOT developed an estimation of a potential Carbon Pricing mechanism based on its more sustainable revenue source, ability to encourage further transformation to a low-carbon or zero carbon fleet, and lower equity concerns.

Key Assumptions: Used consistent assumptions with the 2015 TCI analysis, including ranges of cost per ton and VMT change to travel cost elasticities.

Estimation Methodology: MDOT analyzed four different Carbon Pricing tests based on the following assumptions:

- **Test 1** – \$30 per ton CO_2e (consistent with TCI analysis) applied to all on-road mobile source emissions starting in 2025
- **Test 2** – \$30 per ton CO_2e (consistent with TCI analysis) applied to all on-road mobile source emissions starting in 2021

- **Test 3** – Carbon price increasing annually from $20 per ton in 2020 to the social cost of carbon, $62.25 by 2030, applied to all on-road mobile source emissions starting in 2025
- **Test 4** – Carbon price increasing annually from $20 per ton in 2020 to the social cost of carbon, $62.25 by 2030, applied to all on-road mobile source emissions starting in 2021