ITEM 9 – Information
May 19, 2021

TPB Climate Change Mitigation Study of 2021

Background:

The goal of this study is to demonstrate potential pathways for the region to reduce on-road transportation sector greenhouse gas (GHG) emissions to meet regional GHG reduction goals in 2030 and 2050. The study is divided into two phases: Phase 1, conducted by TPB staff, is a summary of major findings from past work done in this area by TPB and COG. Phase 2 will be a technical analysis conducted by a consultant. At today's meeting, TPB staff will summarize the findings of the Phase 1 report, which was presented to the Technical Committee in draft form in February and will be used as reference for Phase 2 of the study.

TPB CLIMATE CHANGE MITIGATION STUDY OF 2021

Phase 1 Report

Greenhouse Gas Emissions Reductions Strategies: Findings from Past Studies

March 2, 2021

National Capital Region
Transportation Planning Board

TPB CLIMATE CHANGE MITIGATION STUDY OF 2021 PHASE 1 REPORT
March 2, 2021

ABOUT THE TPB
The National Capital Region Transportation Planning Board (TPB) is the federally designated metropolitan planning organization (MPO) for metropolitan Washington. It is responsible for developing and carrying out a continuing, cooperative, and comprehensive transportation planning process in the metropolitan area. Members of the TPB include representatives of the transportation agencies of the states of Maryland and Virginia and the District of Columbia, 24 local governments, the Washington Metropolitan Area Transit Authority, the Maryland and Virginia General Assemblies, and nonvoting members from the Metropolitan Washington Airports Authority and federal agencies. The TPB is staffed by the Department of Transportation Planning at the Metropolitan Washington Council of Governments (COG).

CREDITS
Editor: Erin Morrow, TPB Transportation Engineer
Contributing Editors:
Dusan Vuksan, TPB Model Application Group Manager
Mark S. Moran, TPB Travel Forecasting and Emissions Analysis Program Director

ACCOMMODATIONS POLICY
Alternative formats of this document are available upon request. Visit www.mwcog.org/accommodations or call (202) 962-3300 or (202) 962-3213 (TDD).

TITLE VI NONDISCRIMINATION POLICY
The Metropolitan Washington Council of Governments (COG) fully complies with Title VI of the Civil Rights Act of 1964 and related statutes and regulations prohibiting discrimination in all programs and activities. For more information, to file a Title VI related complaint, or to obtain information in another language, visit www.mwcog.org/nondiscrimination or call (202) 962-3300.

El Consejo de Gobiernos del Área Metropolitana de Washington (COG) cumple con el Título VI de la Ley sobre los Derechos Civiles de 1964 y otras leyes y reglamentos en todos sus programas y actividades. Para obtener más información, someter un pleito relacionado al Título VI, u obtener información en otro idioma, visite www.mwcog.org/nondiscrimination o llame al (202) 962-3300.

TABLE OF CONTENTS

FIGURES AND TABLES

Introduction

In October 2020, the Metropolitan Washington Council of Governments (COG) Board of Directors approved and the National Capital Region Transportation Planning Board (TPB) affirmed the Interim 2030 Greenhouse Gas (GHG) Reduction Goals for the region. Consistent with these actions and TPB's own interest in climate change planning, TPB staff outlined a plan for climate change mitigation planning activities in calendar year 2021 that was shared with the TPB in December 2020.[1]

This report is the first product of the planned TPB Climate Change Mitigation Study (CCMS) of 2021 ("Review of Past COG and TPB Studies related to Climate Change"). This report reviews studies by TPB and COG that quantified greenhouse gas emissions (GHG) reductions from regional on-road transportation projects, programs, and policies. The three studies are the "What Would it Take?" scenario study (WWIT), the Multi-Sector Working Group (MSWG) study, and the Long-Range Plan Task Force (LRPTF) study. This report expands upon the summary of these studies that was provided to the TPB in October 2020 at the TPB Work Session on Climate Change Planning in the National Capital Region.[2]

This report also discusses the collaborative actions proposed to reduce GHG emissions from the on-road transportation sector that were identified in the Metropolitan Washington 2030 Climate and Energy Action Plan (CEAP) to support the region in achieving its 2030 GHG emission reduction goals.

The findings from the studies and the CEAP provide a useful reference regarding the potential effectiveness of strategies to reduce GHG emissions and will inform the second phase of the TPB's climate change mitigation study, which will be a scenario analysis to quantify levels of outcomes needed from on-road transportation strategies to achieve regional greenhouse gas reduction goals.

Section A: Background

Climate change mitigation is the effort to reduce GHG emissions. The COG Board of Directors adopted the following GHG reduction goals for the region:

- By 2012, GHG levels will be 10% below "business as usual" forecasts
- By 2020, GHG levels will be 20% below 2005 levels
- By 2030, GHG levels will be 50% below 2005 levels
- By 2050, GHG levels will be 80% below 2005 levels

1 Vuksan, Dusan and Mark S. Moran. Memorandum to the Transportation Planning Board. "Overview of Upcoming Planned Climate Change Planning Work Activities in the Metropolitan Washington Region." Memorandum, December 10, 2020. https://www.mwcog.org/file.aspx?&A=CQBOw%2f9%2bWdI6C3uNhXMwmHK583WxgZ3MnDzxnrC9aXs%3d

2 Srikanth, K. Memorandum to the Transportation Planning Board. "Overview of COG and TPB Climate Change Planning Work Activities in the Metropolitan Washington Region." Memorandum, October 15, 2020. https://www.mwcog.org/file.aspx?&A=lXr81RdQN3mqk%2bshOxOy7IpWrxfob7oywjYOo12NYsw%3d

The 2012, 2020, and 2050 goals were established with the adoption of the National Capital Region Climate Change Report in November 2008.[3] The TPB accepted these in 2010 and affirmed those goals again in December 2014.[4]

The 2030 goal was adopted by the COG Board at the recommendation of its Climate, Energy, and Environment Policy Committee (CEEPC) in October 2020.[5] The 2030 goal was then endorsed by the TPB, also in October 2020.[6]

CEEPC was established in 2009 by the COG Board and is responsible for managing implementation of the National Capital Region Climate Change Report. In making its recommendation for adopting a 2030 goal, CEEPC reviewed the updated Intergovernmental Panel on Climate Change (IPCC) guidance and Global Covenant of Mayors for Climate and Energy (GCoM) protocols. COG and its members were recognized by GCoM as a U.S. Metro-Scale Climate Leader in 2019 and CEEPC became a GCoM Signatory committing to follow global best practices in climate planning.

Consistent with the GCoM climate change planning protocol, CEEPC developed the **Metropolitan Washington 2030 Climate and Energy Action Plan** (CEAP) in November 2020.[7] The CEAP outlines a Regional Mitigation Strategy that identifies a set of collaborative actions across all sectors that have the highest potential to reduce GHG emissions. The purpose of this plan is to "establish priority collaborative actions for COG and its members to work on together over the next ten years to help move the region towards meeting the 2030 goals" (p. 1) and notes that "achieving the regional goals would require unprecedented, aggressive cross-sectoral action from all COG members and its state and federal partners" (p. 1).

As shown in Figure 1, based on the latest analysis from **Visualize 2045**, which was published in 2018, between 2005 and 2019, GHG emissions from on-road transportation have decreased by 7%.[8] By 2045, the latest analysis from Visualize 2045 forecasts GHG emissions to be 23% below 2005 emissions levels (16% below 2019 levels), with a slight uptick between 2040 and 2045. The region is forecast to experience a 23% growth in population and a 29% growth in employment between 2019 and 2045.

The GHG emissions reductions forecasted for the Visualize 2045 plan are largely attributable to increased fuel efficiency standards, but the uptick between 2040 and 2045 occurs as cleaner vehicles have saturated the fleet, and the benefits from fuel efficiency standards can no longer keep pace with growth-induced increases in vehicle-miles of travel (VMT).

---

3 National Capital Region Climate Change Report. Washington, D.C.: Prepared by the Climate Change Steering Committee for the Metropolitan Washington Council of Governments Board of Directors. November 12, 2008. https://www.mwcog.org/documents/2008/11/12/national-capital-region-climate-change-report-climate-change/

4 TPB R10- 2015: Resolution on the Metropolitan Washington Council of Governments' Regional Multi-Sector Goals for Reducing Greenhouse Gases. Washington, D.C.: National Capital Region Transportation Planning Board. December 17, 2014. https://www.mwcog.org/file.aspx?&A=NQRpyfkLR1A9O4KiCx0%2bhAVEs%2fYo7kI1bNCWYEItoHU%3d

5 COG R45-2020: Resolution Endorsing Regional Climate Mitigation and Resiliency Goals. https://www.mwcog.org/documents/2020/10/14/certified-resolution-r45-2020---endorsing-regional-climate-mitigation-and-resiliency-goals/

6 TPB Resolution R8-2021: Interim 2030 Regional Greenhouse Gas Reduction Goal. Washington, D.C.: National Capital Region Transportation Planning Board. October 21, 2020. https://www.mwcog.org/file.aspx?&A=ccJq0SmcRHpcRYOyJqF3NDMMJvruFbAiLY3FhFiY%2f6o%3d

7 Metropolitan Washington Council of Governments. "Metropolitan Washington 2030 Climate and Energy Action Plan". Washington, D.C. November 2020. https://www.mwcog.org/documents/2020/11/18/metropolitan-washington-2030-climate-and-energy-action-plan/

8 Visualize 2045: A Long-Range Transportation Plan for the National Capital Region. Washington, D.C.: National Capital Region Transportation Planning Board. October 17, 2018. https://www.mwcog.org/assets/1/28/Visualize_2045_Plan_2018_10_23_No_Crops_Single.pdf

Figure 1: Greenhouse Gas On-Road Mobile Source Emissions from Visualize 2045

According to the CEAP:

> *COG's greenhouse gas inventories show that the region's progress to date towards the GHG emission reduction goals has been mixed. The region exceeded its 2012 goal but is lagging on progress towards its 2020 goal. The most recent inventory indicates that 2018 GHG emissions in the region decreased by approximately 13 percent below 2005 levels, despite a 19 percent growth in population. Per capita emissions decreased between 2005 and 2018 from 15.6 metric tons of carbon dioxide equivalent (MTCO2e) in 2005 to 11.4 MTCO2e in 2018. Expedited and concerted actions will be needed throughout the region to achieve future goals of 50 percent GHG emission reduction by 2030 and 80 percent by 2050…*
>
> *The inventories measure GHG-emitting activities undertaken by residents, businesses, industry, and government located in metropolitan Washington, as well as emissions from visitors. More than 90 percent of metropolitan Washington's GHG emissions come from residential and commercial building energy consumption and transportation. Building energy consumption accounts for 50 percent and 40 percent is from transportation.*[9] *The*

[9] Transportation emissions in the regional GHG inventory for 2018 include emissions from on-road transportation (34%), commuter rail (1%), aviation (3%), and other non-road sources (3%; e.g. construction vehicles and water transportation). (Davis, Maia. Email to Kanti Srikanth. "Question on CEAP Document Citation," February 1, 2021.) For additional details on the regional GHG inventory for 2018, please refer to Appendix F: Metropolitan Washington Council of Governments. "Metropolitan Washington 2030 Climate and Energy Action Plan Appendices". Washington, D.C. November 2020. https://www.mwcog.org/documents/2020/11/18/metropolitan-washington-2030-climate-and-energy-action-plan/

remainder of emissions comes from other activities and sources including solid waste, wastewater treatment, agriculture, and fugitive emissions.[10] (p. 3)

The CEAP's Regional Mitigation Strategy contains collaborative, voluntary actions in all sectors to move the region towards its 2030 goals. A planning level analysis of the various actions in all sectors was undertaken to illustrate how the region could achieve the 2030 GHG reduction goal. Details of the development of the baseline inventory, future projections, and the assumptions in the scenario analysis can be found in the technical appendices to the CEAP.[11]

For on-road transportation, actions fall into two categories: Zero Emission Vehicles (ZEV) and Mode Shift and Travel Behavior (MSTB). While ZEV strategies reduce GHG emissions by changing the type of fuel consumed (fossil fuel to clean fuel) for vehicular travel, the MSTB strategies reduce GHG emissions by reducing the amount of fossil fuel consumed by reducing the amount of travel. The actions, along with examples of how COG member jurisdictions can support implementation, are:

Zero Emission Vehicles

1. ZEV-1: Expand Light-Duty Electric Vehicle (EV) Deployment
    - Implement community-wide electric vehicle (EV) buying co-ops
    - Promote state and national incentives and mandates for purchasing EVs
    - Transition fleets to zero emission vehicles. Adopt green fleet policy and plans or participate in cooperative procurement opportunities for public fleets to support transition
2. ZEV-2: Accelerate Electrification of Medium- and Heavy-Duty Vehicles
    - Transition public fleet medium- and heavy-duty vehicles (MHDVs) to electric
    - Connect private fleets with partners and opportunities to educate and incentivize electrification
3. ZEV-3: Build Out Regional Electric Vehicle Charging Network
    - Require new developments to install EV infrastructure or be EV-Ready
    - Provide or promote incentives for EV infrastructure deployment in the community
    - Develop EV infrastructure plans for community deployment
    - Develop EV infrastructure strategy for the public fleet and deploy EV infrastructure at public facilities, garages, and refueling facilities
    - Partner with utilities, transit agencies, and EV infrastructure providers to deploy in community
    - Implement innovative pilot initiatives to advance new technologies, including vehicle-to-grid, regenerative power, and solar-powered EV infrastructure

10 Fugitive emissions are emissions that are not physically controlled but result from the intentional or unintentional release of GHGs. They commonly arise from the production, processing, transmission, storage and use of fuels or other substances, often through joints, seals, packing, gaskets, etc. Examples include hydrofluorocarbons (HFCs) from refrigeration leaks, SF6 from electrical power distributors, and CH4 from solid waste landfills. (ICLEI - Local Governments for Sustainability)

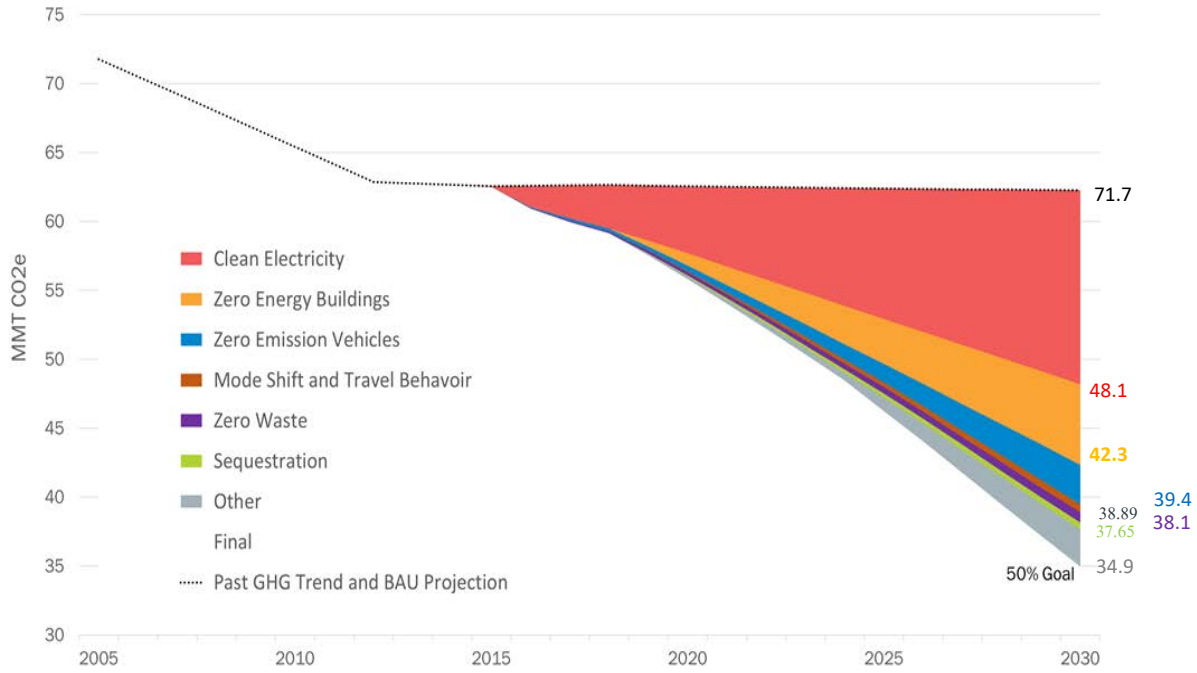
11 Metropolitan Washington Council of Governments. "Metropolitan Washington 2030 Climate and Energy Action Plan Appendices". Washington, D.C. November 2020. https://www.mwcog.org/documents/2020/11/18/metropolitan-washington-2030-climate-and-energy-action-plan/

Mode Shift and Travel Behavior

1. MSTB-1: Invest in Infrastructure that Increases Transit, Carpooling, and Non-Motorized Travel
    - Expand bus rapid transit and transitways
    - Expand express highway (toll) network
    - Move more people on Metrorail
    - Improve walk and bike access to transit
    - Complete the National Capital Trail Network
2. MSTB-2: Bring Jobs and Housing Closer Together
    - Take actions to achieve regional housing targets
    - Coordinate local policy revisions to zoning and plans to allow more people to live closer to their job.
3. MSTB-3: Enhance Options for Commuters
    - Continue, expand, or initiate transit benefits and teleworking for public sector employees
    - Support teleworking and transit benefits programs for private sector employees
    - Discontinue free parking at employment sites within Activity Centers and near high capacity transit stations

Figure 2 shows the results of the 2030 CEAP scenario analysis.

Figure 2: 2030 Scenario Results from CEAP Analysis



Source: Page 5 of the CEAP

The 2030 CEAP scenario analysis identified potential reductions from various strategies in the ZEV category of actions based on the EV adoption rates in the National Renewable Energy Laboratory's "Electrification Futures Study" which had low, medium, and high levels. For the CEAP's ZEV-1 and ZEV-2 strategies, the analysis assumed the "high EV adoption rates," i.e., adoption rates of greater than 20 percent for light-duty cars, 9 percent for light-duty trucks, 4 percent for medium/heavy-duty trucks, and 30 percent for transit buses. These levels of EVs informed the implementation action for ZEV-3.

The 2030 CEAP scenario analysis identified potential reductions from various MSTB strategies based primarily on the MSWG study with supportive actions based on the TPB's Aspirational Initiatives, which were analyzed in the LRPTF study. The MSTB strategies include increasing transit, carpooling, and non-motorized travel; bringing jobs and housing closer together; and travel demand management (teleworking, transit benefits). While the analysis from the MSWG study was used to identify the level of implementation for strategies derived from the MSWG study, the level of implementation for the Aspirational Initiatives was not explicitly identified in the CEAP.

Sections B-E of this report will present the major findings from the past TPB and COG studies, all of which studied similar actions, and provide discussion of the potential for GHG reductions from various transportation strategies to help inform the development of scenarios to be analyzed now.

Section B. Past TPB and COG Studies

In 2008, the TPB began a scenario study to see how the region could achieve the regional GHG reduction goals in the transportation sector. The **"What Would it Take?" Scenario Study** (WWIT) was completed in 2010 and showed the challenge of meeting those goals.[12]

In 2015, the TPB partnered with the Metropolitan Washington Air Quality Committee (MWAQC) and CEEPC to form the **Multi-Sector Working Group** (MSWG), which was tasked with identifying potentially viable and implementable local, regional, and state strategies for reducing GHG emissions across key sectors - Energy, the Built Environment, Land Use, and Transportation.[13]

In 2016, the TPB convened its **Long-Range Plan Task Force** (LRPTF) to identify projects, programs, and policies to improve the performance outcomes of the region's transportation system.[14] While the work of the Long-Range Plan Task Force was not specifically focused on climate change, many of the initiatives that were analyzed contained projects, programs, and policies that have been shown to reduce GHG emissions and the analysis, completed in 2017, reported estimated CO2 emissions.

The summary of findings from the three above studies is described in Section C, and the key differences between the studies are described in Section D. Additionally, Appendix A lists the major findings from the three studies, Appendix B contains detailed strategy descriptions, and Appendix C details the technical approach and documentation for each study. Each study quantified the potential greenhouse gas reductions from various on-road transportation projects, programs, and policies, often referred to as strategies. Depending on how the study is designed, a strategy could be a single project, program, or policy, or a few similar projects, programs, and policies combined for analysis purposes.

Strategies are often categorized based on how they reduce greenhouse gas emissions. Different studies have grouped strategies in different ways, but for the purpose of this report, these three categories will be used:

1. **Fuel efficiency, fuel content, and vehicle technology** – Greenhouse gas emissions from on-road transportation are the result of the combustion of fossil fuels (e.g. gasoline, diesel, natural gas).[15] Switching from carbon-intensive fossil fuel to less carbon-intensive fuels and reducing the amount of fossil fuel used (in the short term) by improving the fuel efficiency of conventional vehicles or developments in vehicle technology, such as electric vehicles, reduces greenhouse gas emissions.
2. **Automobile travel reduction** – Reducing vehicle-miles traveled (VMT) and vehicle trips reduces the amount of fossil fuels burned by conventional vehicles, thus reducing GHG

12 Final Report: What Would It Take? Transportation and Climate Change in the National Capital Region. Washington, D.C.: Metropolitan Washington Council of Governments. May 18, 2010. https://www.mwcog.org/documents/2010/05/18/what-would-it-take-scenario-land-use-projects/

13 Final Technical Report: Multi-Sector Approach to Reducing Greenhouse Gas Emissions in the Metropolitan Washington Region. Washington, D.C.: Metropolitan Washington Council of Governments (submitted by ICF International). January 31, 2016. https://www.mwcog.org/documents/2016/08/01/multi-sector-approach-to-reducing-greenhouse-gas-emissions-in-the-metropolitan-washington-region-final-technical-report/

14 An Assessment of Regional Initiatives for the National Capital Region: Technical Report on Phase II of the Long-Range Plan Task Force. Washington, D.C.: National Capital Region Transportation Planning Board (prepared by ICF International). December 20, 2017. https://www.mwcog.org/documents/2017/12/20/long-range-plan-task-force-reports-projects-regional-transportation-priorities-plan-scenario-planning-tpb/

15 US Environmental Protection Agency (EPA). "Greenhouse Gas Emissions from a Typical Passenger Vehicle." EPA Office of Transportation and Air Quality. EPA-420-F-18-008. March 2018. https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100U8YT.pdf

emissions. Travel reduction strategies can shorten trips, encourage shifts to less polluting modes, or eliminate a trip altogether.

3. **Operational efficiency** – Greenhouse gas emissions from conventional vehicles are highest during idling and at very low speeds,[16] thus reducing idling and highly congested conditions by improving transportation system operations can potentially reduce GHG emissions.

Each of the three studies looked at strategies to reduce automobile travel and improve operational efficiency. The WWIT and MSWG studies also looked at fuel efficiency and vehicle technology strategies.

16 See for, example Matthew Barth and Kanok Boriboonsomsin, "Traffic Congestion and Greenhouse Gases," ACCESS Magazine, Fall 2009, https://www.accessmagazine.org/fall-2009/traffic-congestion-greenhouse-gases/; OR Adriano Alessandrini et al., "Driving Style Influence on Car CO2 Emissions," in 2012 International Emission Inventory Conference Website (2012 International Emission Inventory Conference, Tampa, Florida, August 13-16, 2012, Tampa, Florida, 2012), https://www3.epa.gov/ttn/chief/conference/ei20/.

Section C. Summary Findings of Past Studies

Below is a summary of some of the findings, from all three studies, regarding individual on-road transportation strategies grouped under the above mentioned three categories. It is important to note that the three studies were conducted in different periods of time, using different sets of assumptions, methodologies and analysis tools. As such, comparing the effectiveness of a particular strategy among other strategies across studies, for example, is not advisable. The substantive differences between the three studies are listed later in this section.

1. Fuel efficiency, fuel content, and vehicle technology

    - **Fuel Efficiency:** The MSWG study showed a significant GHG emissions reduction from the light-duty CAFE standards that were phased in with model years 2012-2025 and the MHDV fuel efficiency standards that were phased in with model years 2014-2018. Compared with the business-as-usual (BAU) projections, in 2040, the analysis showed that the regional GHG emissions would decrease by 14% and emissions within the transportation sector by 53% with the "current policies" projection.

    - **Fuel Content**: The low-carbon fuel standard (TLU-6) was the most impactful transportation-only strategy studied by the MSWG. The low-carbon fuel standard contributed a 5% reduction in GHG emissions from the transportation sector total in 2040, but overall, less than a 1% reduction from the region's BAU forecast for 2040.

    - **Vehicle Technology:** Additional accelerated deployment of zero-emission vehicles examined in the MSWG (TLU-3) was the most impactful transportation-only strategy studied. TLU-3 contributed a 5% reduction in GHG emissions from the transportation sector's BAU forecast for 2040, but overall, it is only a 1% reduction from the region's BAU forecast for 2040. Electric vehicles do not have tailpipe GHG emissions that would be included in on-road vehicle emissions inventories; however, there are GHG emissions from the electric generation needed for charging the vehicles.[17] In the MSWG study and the CEAP 2030 analysis, the GHG emissions produced to generate the electricity needed to charge electric vehicles were accounted for, thus reducing the net GHG reduction benefit of electric vehicles.

2. Automobile travel reduction

    a. Shifting Land Use Patterns:
        - Both the MSWG (TLU-2) and LRPTF (Initiative 8) studies showed that shifting future projected growth to locate jobs and households closer together in regional Activity Centers and near high-capacity transit reduces automobile travel. The MSWG study specifically assumed bicycle and pedestrian enhancements.

        - The LRPTF study showed a 4% reduction in CO2 emissions, 18% reduction in daily vehicle hours of delay (VHD), 3% reduction in daily VMT, 6% reduction in daily VMT per capita, and a 29% increase in non-motorized trips compared to the Constrained Long-Range Plan (CLRP) in 2040. The MSWG study showed

17 US Environmental Protection Agency (EPA). "Greenhouse Gas Emissions from a Typical Passenger Vehicle." EPA Office of Transportation and Air Quality. EPA-420-F-18-008. March 2018. https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100U8YT.pdf

an 11.6% reduction in daily VMT compared to the "current policies" (CLRP) forecast in 2040.

- It should be noted that the land use strategies in the MSWG and LRPTF were evaluated using different assumptions and different modeling tools, which accounts for the difference in forecasted VMT and GHG reductions due to shifting future land use patterns. The MSWG analysis used a tool developed by the consultant while the LRPTF analysis used the TPB regional travel demand model and sketch planning tools.

b. **Travel Demand Management**: Both the MSWG (TLU-9) and LRPTF (Initiative 10) studies showed promising GHG reductions from employer-based travel demand management including transit subsidies and priced parking in Activity Centers. The LRPTF analysis also included a 40% office worker telework rate (i.e., an increase from the overall pre-Covid telework rate for all jobs from 10% to 20%). The LRPTF study showed a 7% reduction in CO2 emissions, 24% reduction in VHD, 6% reduction in daily VMT, 6% reduction in daily VMT per capita, and 20% reduction in single-occupant vehicle work trips compared to the CLRP in 2040. Because of the increase in teleworking, there was a 9% reduction in transit work trips.

c. Pricing

- Pricing strategies had mixed results depending on the assumptions. The most impactful was in the WWIT study and based on the 2009 Annual Energy Outlook's "High Price Case". That strategy included $7/gallon gasoline, which lead to a 6% reduction in VMT between 2010 and 2030 compared to the CLRP baseline. It should be noted that the 6% VMT reduction is a result from the national level models employed by the U.S. Department of Energy.

- The road pricing strategy (TLU-12) in the MSWG study included a cordon price of $5/trip into downtown DC in 2040 and the cordon price plus a VMT tax of 10 cents/per mile everywhere in 2050. The sketch planning analysis for this strategy showed significant VMT reductions (7.8% annually compared to the current policies forecast) in 2050 due to the VMT tax; however, it did not show significant GHG reductions due to the improved fuel efficiency of the fleet.

- A strategy that is more incentive-based, such as pay-as-you-drive insurance in the WWIT study, showed promise in reducing emissions among the automobile travel reduction strategies, although much less than fuel efficiency strategies.

d. Transit

- Each of the studies had multiple strategies that improved transit service, expanded transit service, or lowered the cost of transit service. Overall, these strategies tended to do fairly well among the project-focused strategies in their respective studies but could be expensive to implement. For example, the Metrorail regional core capacity improvements in the LRPTF study (Initiative 6) ranked a distant third behind TDM and land use for GHG reduction, but ahead of other project-focused initiatives. The Metrorail core capacity improvements reduced CO2 by 2%, daily VHD by 9%, daily VMT by 1%, daily VMT per capita by 1%, and increased transit commute mode share

by 2.8 percentage points compared to the CLRP in 2040 (i.e., transit mode share increased from 24.6% to 27.4%).

- Both the MSWG (TLU-11) and LRPTF (Initiative 9) studies examined policies that reduce transit fares. The transit fare policies examined in the LRPTF reduced CO2 by 1%, daily VHD by 2%, daily VMT by 1%, and daily VMT per capita by 1% compared to the CLRP in 2040.

e. Bicycle and Pedestrian

- The WWIT study showed benefits of an accelerated completion of the 2010 Bicycle and Pedestrian Plan compared to other local/state/regional strategies.

- The MSWG study did not analyze separate bicycle and pedestrian strategies. Instead, it simply assumed that safe and expanded bicycle and pedestrian infrastructure is essential to the success of the concentrated land use strategies.

- The LRPTF study assumed that transit investments will be supported by improvements in bike/walk infrastructure, facilitating access to those transit services.

3. Operational efficiency:

a. Operational Efficiency: The findings on operational efficiency strategies are mixed, likely due to the fact that, in the MSWG and LRPTF studies, all of the operational efficiency strategies under consideration are grouped into one strategy, unlike the transit strategies. Travel efficiency fared only a bit better in the MSWG study (TLU-7) than in the LRPTF study (Initiative 2), likely due to the inclusion of eco-driving, which promotes driving patterns to reduce rapid acceleration/deceleration and extended idling, and assumptions about system efficiency improvements though connected vehicles. Overall, though, operational efficiency improvements show only modest GHG reductions.

b. Express Highway (Toll) Network Expansion: The LRPTF study found that expanding the express highway network and express bus service (Initiative 1) did not lower GHG emissions, but did leave GHG emissions unchanged while increasing daily VMT and daily VMT per capita each by less than one percent and decreasing daily VHD by 11% compared to the CLRP in 2040. In addition to express buses, the express lanes can be available to carpool and vanpool users without charge, increasing options for reliable non-single-occupant vehicle travel. The revenue generated by the tolls charged to SOVs can be invested in high-quality regional bus service.

Section D. Key Differences Between Past Studies

These three studies were conducted over a period of almost a decade. When each study was conducted, the latest planning assumptions (long-range transportation plan and land use forecasts), modeling tools (travel demand model and emissions model), and federal policies (light-duty fuel economy standards and medium and heavy-duty fuel efficiency standards) were assumed.

These are some of the key differences in the studies that should be kept in mind when reviewing the major findings below, and especially when reviewing the more detailed technical information in the appendices:

- The WWIT and LRPTF studies reported carbon dioxide (CO2) emissions which is the primary greenhouse gas. There are other greenhouse gases including methane and nitrous oxides. The MSWG study reported emissions from three GHG gases, CO2, methane, and nitrous oxide, and expressed these as an equivalent amount of CO2 (CO2e or CO2-equivalent) based on their global warming potential. For purposes of this report, emissions from all three studies are referred to as GHG emissions in the narrative in the discussion section.
- The WWIT study estimated cumulative reductions over a 20-year period; The MSWG and LRPTF studies estimated annual emissions for the specified analysis year(s).
- Each study assumes the light-duty corporate average fuel economy (CAFE) standards that were in place at the time of the study. The WWIT study assumes GHG emissions equivalent of 35.5 miles-per-gallon (mpg) by 2016; the MSWG and LRPTF studies assume GHG emissions equivalent of CAFE standards of 54.5 mpg by 2025. The current GHG emissions standards, promulgated in 2020 with the SAFE Vehicles Rule, call for GHG emissions equivalent of CAFE standards of 47.7 mpg for passenger cars by 2026.[18]
- The MSWG and LRPTF assume the medium and heavy-duty fuel efficiency standards that phase in between model years 2014 and 2018, after the WWIT study was completed.
- WWIT and LRPTF only examined on-road transportation strategies. The MSWG study considered non-road transportation existing policies and regional strategies and grouped those with energy and built environment. All of the "transportation/TLU" strategies in the MSWG were on-road.
- The LRPTF study calculates percentage reductions relative to a Constrained Long Range Plan (CLRP) forecast; the estimates in the WWIT and MSWG studies are compared to the 2005 "Business as Usual" (BAU) forecast from the 2008 National Capital Climate Change Report, which was updated with the current modeling tools for the MSWG study.
- Strategies chosen for analysis and the level of implementation for those strategies differs between studies.
- Each study used different planning tools to estimate GHG reductions for strategies. The WWIT and MSWG studies relied primarily on spreadsheet-based sketch planning tools. The LRPTF used both sketch planning and the regional travel demand model.
- The WWIT and MSWG studies reported primarily on GHG reductions; the LRPTF study focused on travel metrics with an emphasis on reducing congestion reported as vehicle-hours of delay (VHD).

As these planning assumptions and modeling tools change over time, the analysis of a strategy could have a slightly different outcome. Furthermore, each study was developed differently. Thus, **comparing the effectiveness of a particular strategy and comparing its exact ranking among other strategies across studies, for example, is not advisable**. However, despite these caveats, TPB staff maintain confidence in the major findings of the studies.

18 Srikanth, Kanti and Steve Walz. Memorandum to Kelly Russell, Chair, TPB. "Preliminary assessment of the Safer Affordable Fuel-Efficient (SAFE) Vehicles Final Rule for Model Years 2021-2026." Memorandum, May 12, 2020. https://www.mwcog.org/file.aspx?&A=duwNsxz2%2Fxd%2F2DXHZ14CUvhFvLvEezgHB%2BnzdnNpkvg%3D

Section E. Conclusion

Findings from the "What Would it Take" Scenario Study, the Multi-Sector Working Group Study, and the Long-Range Plan Task Force Study can assist the TPB in developing a scenario study to evaluate what the on-road transportation sector needs to do to work towards meeting the regional goal of reducing GHG emissions 50% below 2005 levels by 2030. Due to the substantial differences in the assumptions, analysis methodology, and metrics extracted, a new analysis of the most promising transportation strategies is needed. This new analysis should be based on assumptions reflecting the current travel and policy environment, and should also account for actions that have been taken since these previous studies were conducted.

All three studies show that it is possible to reduce GHG emissions from the transportation sector; however, the MSWG study and the 2030 scenario analysis conducted for the CEAP found that other sectors like the energy and buildings sectors, have more potential for GHG emissions reductions in part because on-road transportation is already anticipated to achieve high levels of GHG emissions reductions due to policies in place to improve fuel efficiency.

The MSWG study showed that phased-in CAFE standards from model years 2012-2025 light-duty vehicles and phased-in fuel efficiency standards for model year 2014-2018 medium- and heavy-duty vehicles significantly reduced future GHG emissions projections as those more fuel-efficient vehicles become a larger share of the vehicles on the region's roadways. Unfortunately, those future emissions reductions are not guaranteed. CAFE standards assumed in the current policies for the MSWG and LRPTF were rolled back when the Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule was finalized in 2020.

While national-level strategies such as fuel economy and fuel efficiency standards have the highest potential for GHG reductions, they are slow to implement as they require the region's vehicle fleet to turn over. Strategies that accelerate the deployment of zero-emission vehicles, such as electric vehicles, can help to bring about those reductions sooner, but will need supportive infrastructure, like charging stations, and the GHG reduction potential depends on the energy mix used to generate the electricity for the region.

At the regional and local levels, the studies show that land use policies that bring housing and jobs closer together and closer to transit reduce both GHG emissions and vehicle travel. Travel demand policies such as teleworking are also effective at reducing GHG emissions and vehicle travel and are also cost-effective. On the other side of the spectrum, the studies found that some of the ambitious projects, such as Initiative 1 (Regional Express Travel Network) and Initiative 7 (Transit Rail Extensions including all Metrorail lines) in the LRPTF study had very little impact on VMT and GHG emissions, with VMT actually increasing slightly in Initiative 1.

The region has already begun to implement some of the strategies that have been studied in past studies. TPB staff have conducted multiple site visits with member jurisdictions and led other efforts regarding the implementation of the Visualize 2045 Aspirational Initiatives.[19] Member jurisdictions and states have made progress toward transportation electrification.[20] [21] At the same time, staff

19 Visualize 2045: A Long-Range Transportation Plan for the National Capital Region. Washington, D.C.: National Capital Region Transportation Planning Board. October 17, 2018. https://www.mwcog.org/assets/1/28/Visualize_2045_Plan_2018_10_23_No_Crops_Single.pdf

20 Metropolitan Washington Council of Governments. "Metropolitan Washington 2030 Climate and Energy Action Plan". Washington, D.C. November 2020. https://www.mwcog.org/documents/2020/11/18/metropolitan-washington-2030-climate-and-energy-action-plan/

21 See, for example, Howard, B., S. Vaidyanathan, C. Cohn, N. Henner, and B. Jennings. 2021. The State Transportation Electrification Scorecard. Washington, DC: ACEEE.

recognize that some of the other potentially effective strategies that have been studied, such as $7 a gallon gasoline or a VMT tax, may be more politically challenging or may take longer time to implement (in part because these pricing measures are viewed as regressive, so they would need to be crafted in a way to make them as equitable as possible).

While different strategies and actions that will be studied in the scenario study envisioned for this year may yield a different outcome, the categories of strategies, in order of effectiveness and ability to provide GHG emissions reductions, are provided below:

1) Fuel efficiency, fuel content, and vehicle technology

These types of strategies and policies were found to have the greatest potential to reduce GHG emissions. For example, strategies could include new GHG emissions standards for light-duty vehicles, perhaps similar to (or more aggressive than) the standards promulgated in 2012, which called for the emissions equivalent to 54.5 miles per gallon CAFE Standards. The current GHG emissions standards, promulgated in 2020 with the SAFE Vehicles Rule, call for the emissions equivalent to 47.7 miles per gallon for passenger cars by 2026. Similarly, these strategies could also include higher rates of market penetration by electric vehicles and supportive actions to reduce the carbon emissions in the energy sector for charging those vehicles. While fuel efficiency strategies were shown in the studies to be the most effective in reducing GHG emissions, these strategies are dependent on, among other things, residents replacing their personal vehicles. This means that the reduction potential from these strategies may not be fully realized until the majority of the region's vehicle fleet is replaced. Prior studies have shown that equity implications of policies should be considered as well.[22]

Federal actions are largely responsible for the reduction in ozone emissions in this region and elsewhere.[23] For example, the 8-hour ozone design value for our region has decreased from 91 parts per billion to 72 parts per billion between 2005 and 2019. These design values represent averages based on the readings from air quality monitors that are located throughout our region. The decrease in ozone emissions occurred while VMT increased by nearly 10 million, or over 7%, during the same time period.[24]

2) Aggressive federal/local transportation and land use policy actions that could have a significant impact on travel behavior

The studies showed that there are aggressive transportation and land use policy actions that have not been implemented in this region in the past, but that have the potential to significantly reduce VMT and GHG emissions. These actions could include significant shifts in land use to activity centers and high-capacity transit station areas, large increases in the price of gasoline, cordon pricing, a VMT tax, travel demand management (e.g., increased telework), and a substantial increases in the cost of parking.

---

22 See, for example, p. 105 of ICF International, "Multi-Sector Approach to Reducing Greenhouse Gas Emissions in the Metropolitan Washington Region," Final Technical Report (Metropolitan Washington Council of Governments, January 31, 2016), https://www.mwcog.org/file.aspx?D=Uj%2fOvKporwCjlofmfR2gk7ay5EmBOb9a4UhR7cKKQig%3d&A=ITSIgZNdO1uWwMHJVzfUV1WlPhZ9IDhMGqWIEQSf9CM%3d.

23 Kumar, Sunil. "Ozone Season Summary 2020." Presented at the July meeting of the Technical Advisory Committee of the Metropolitan Washington Air Quality Committee (MWAQC-TAC), Washington, D.C., July 14, 2020.

24 Seifu, Meseret. Memorandum to Feng Xie. "Year 2019 Jurisdictional Weekday VMT Summaries." Memorandum, November 18, 2020.

None of the three studies analyzed carbon pricing, which a Brookings study found to be one of the most efficient ways to reduce GHG emissions.[25] Examples of carbon pricing include carbon taxes and cap-and-trade/cap-and-invest mechanisms. In December 2020, the Transportation and Climate Initiative (TCI) announced a multi-state cap-and-invest program to cap carbon dioxide emissions from transportation fuels and invest revenue from the program into programs and policies to further reduce greenhouse gas emissions from on-road vehicles. The District of Columbia, Massachusetts, Connecticut, and Rhode Island have already committed to participate in the program. Maryland and Virginia are in a group of eight states that have committed to continue collaboration with TCI and work to develop the model rule for the program.[26]

In contrast to most of the vehicle-related strategies, many of these policy actions can be implemented in a shorter timeframe contributing to critical near-term GHG reductions. The Transportation and Climate Initiative Program, for example, could begin as soon as January 2022. Prior studies have shown that equity implications of policies should be considered as well.[27] [28]

3) New transportation projects

Construction and implementation of new highway and transit projects has a lower potential to significantly impact VMT and GHG emissions. The LRPTF study analyzed ambitious packages of initiatives that grouped together managed lanes projects and extensive transit service extensions, all of which had a fairly low level of impact on VMT (mainly within 1%). It is important to note that although individual projects / groups of projects may not have a significant impact on GHG emission reductions, many of them would benefit the residents of equity emphasis areas by providing additional access to jobs and other activities (health care providers, grocery stores, etc.).[29]

The technical analyses for these studies have limitations that should be considered when reviewing the findings from these studies and designing future studies. The strategies were analyzed individually, not taking into account that, due to synergy, some strategies can amplify total benefits, whereas other strategies can counteract each other, resulting in reduced total benefits. The LRPTF study, for example, lists potential compatibilities and conflicts.

Each study noted that most strategies have numerous co-benefits. Most of the strategies analyzed are not cost-effective as GHG reduction strategies alone,[30] but should be evaluated as part of an equitable regional transportation network.

---

25 "Ten Facts about the Economics of Climate Change and Climate Policy." The Hamilton Project and the Stanford Institute for Economic Policy Research, October 2019. https://www.brookings.edu/research/ten-facts-about-the-economics-of-climate-change-and-climate-policy/

26 Morrow, E. Memorandum to the Transportation Planning Board. "Transportation and Climate Initiative (TCI): Memorandum of Understanding released." Memorandum, January 14, 2021. https://www.mwcog.org/file.aspx?&A=vJzRrjiQZi2WIeqwe80MmdahejC9TX0QKKBQJISRWX4%3d

27 See, for example, p. 85 of ICF et al., "An Assessment of Regional Initiatives for the National Capital Region: Technical Report on Phase II of the TPB Long-Range Plan Task Force" (Metropolitan Washington Council of Governments, National Capital Region Transportation Planning Board, December 20, 2017).

28 Note that while some groups of strategies, such as addressing the land use disparities inherent in the East-West Divide and transit fare subsidies, would have positive equity impacts, other strategies, such as those involving parking pricing, could result in out-of-pocket cost burdens on low-income residents, if the policies are not designed using an equity lens.

29 See, for example, ICF International, "Multi-Sector Approach to Reducing Greenhouse Gas Emissions in the Metropolitan Washington Region," 123.

30 See, for example, p. 33 of Monica Bansal and Erin Morrow, "What Would It Take? Transportation and Climate Change in the National Capital Region," Final Report (Washington, D.C.: National Capital Region Transportation Planning Board, Metropolitan Washington Council of Governments, May 18, 2010), http://www.mwcog.org/uploads/pub-documents/qF5eXVw20110617114503.pdf.

APPENDIX A: MAJOR FINDINGS FROM PAST TPB AND COG STUDIES

I. "What Would it Take?" Scenario Study (WWIT)

The WWIT study,[31] published in May 2010, is the oldest of the three studies and was one of the earlier MPO studies of its kind. The study asked what it would take if the newly adopted multi-sectorial greenhouse gas reduction goals had to be met within the transportation sector.

At the time of the study, the TPB long-range plan went out to 2030, so TPB staff did a straight-line interpolation to calculate a reduction goal of 40% below 2005 levels by 2030, which should be noted is less aggressive than the 50% reduction goal that was adopted by the COG Board in 2020.

The WWIT study examined strategies that could be taken at the local, state, and regional levels both in the short- and long-term including travel demand management, bicycle and pedestrian improvements, traffic signal optimization, and the purchase of more fuel-efficient transit vehicles. Note that if the WWIT study were conducted today, input assumptions made for many of the individual strategies, such as the eco-driving strategy, would likely be different.

Additionally, the study considered actions that would need to be taken at the federal level, which was dubbed the "high federal role." The actions included significant increases to light-duty vehicle fuel economy (CAFE) standards in place at the time and implementing heavy-duty fuel efficiency standards. It should be noted that after the WWIT study was completed, the National Highway Traffic Safety Administration (NHTSA) and the Environmental Protection Agency (EPA) took actions to improve CAFE standards and medium- and heavy-duty vehicle fuel efficiency, which were later included in the MSWG and LRPTF studies. The WWIT study also considered the impact of the "high price case" from the US Department of Energy's 2009 Annual Energy Outlook that contained $200/barrel oil, which translated to $7/gallon gasoline.

Due to technical limitations, the local/regional/state strategies were not combined with the high federal role strategies and are shown on Figure 3 and Figure 4, respectively.

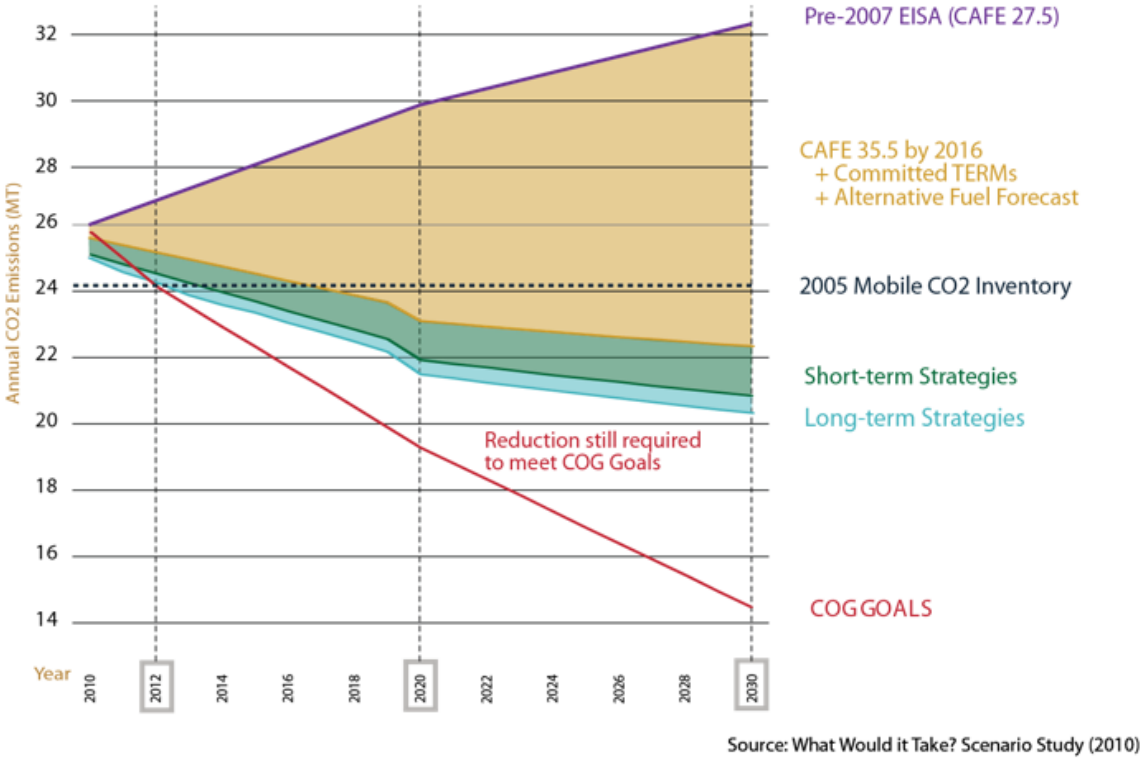
It is important to remember that the WWIT study was presented almost 11 years ago. The WWIT study is included in this report to illustrate the broader findings regarding the impacts of local/state/regional strategies versus national strategies and the impacts of strategies that can be implemented in the short-term versus the long-term, not to focus on the analysis of individual strategies.

The WWIT study found that neither grouping of strategies alone could achieve the 40% reduction goal by 2030. **Local/state/regional efforts (Figure 3) could help the region achieve short-term GHG reduction goals, but actions implemented at the federal level (Figure 4) would be required to meet long-term goals**. The federal strategies were found to be highly effective, due to the broadly impacted population in the region. Given that CO2 emissions are directly linked to fuel consumption, increasing the efficiency of vehicles showed to be "a clear strategy for reducing mobile CO2 emissions."

---

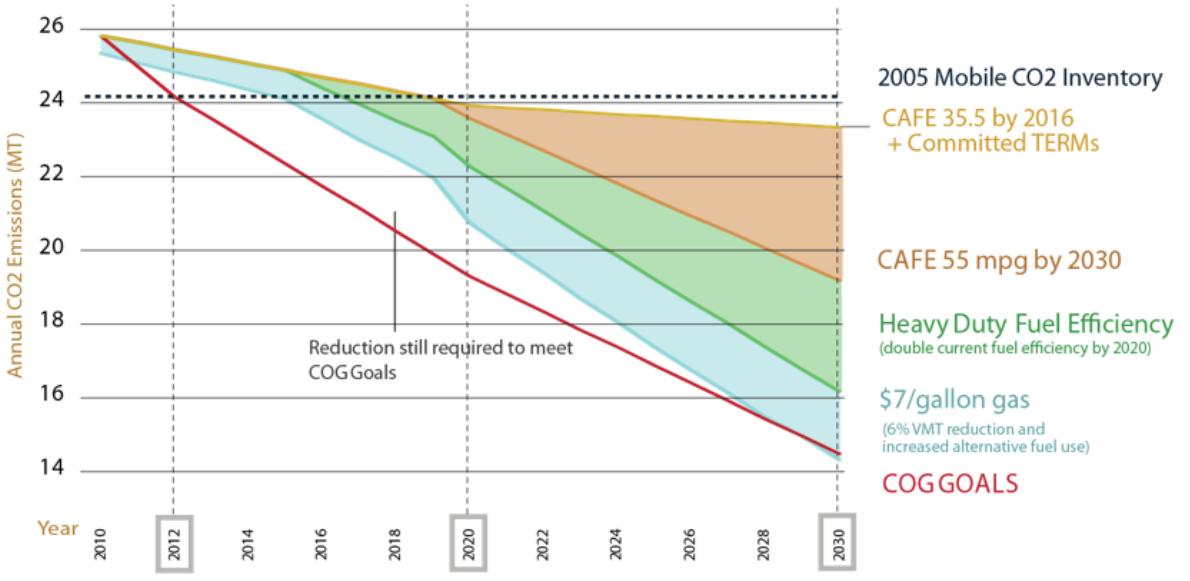
31 Final Report: What Would It Take? Transportation and Climate Change in the National Capital Region. Washington, D.C.: Metropolitan Washington Council of Governments. May 18, 2010. https://www.mwcog.org/documents/2010/05/18/what-would-it-take-scenario-land-use-projects/

Figure 3: GHG Reductions from Local/State/Regional Strategies (as defined in WWIT Study)



Source: What Would it Take? Scenario Study (2010)

Figure 4: GHG Reductions from "High Federal Role" Strategies (as defined in WWIT study)



Source: What Would it Take? Scenario Study (2010)

The cost-benefit analysis conducted for the WWIT study found that:

most measures demonstrated modest CO2 reduction potential and thus show high cost-per-ton values. Since CO2 emissions reductions are unlikely to be the sole justification for investing in transportation projects, other methods of weighing costs and benefits may be necessary. (p. 33)

II. Multi-Sector Working Group (MSWG)

The final technical report for the MSWG study was published in January 2016.[32] The technical analysis for the MSWG study was designed in a similar manner to the 2008 National Capital Region Climate Change Report, which used a 2005 "Business as Usual" (BAU) projection as baseline for analysis, i.e., the emissions projections if no new policies or programs to reduce GHG emissions were implemented after 2005. The BAU projection was updated for this study with the latest modeling tools and population projections. The analysis years for the study were 2020, 2040, and 2050. The assumptions for strategies in 2020 and 2040 were considered "viable." The assumptions for 2050 were considered to be more aggressive or a "stretch."

The analysis for the MSWG study was completed in three steps. First, the GHG emission reductions were estimated for policies and programs implemented between 2005 and 2015, the "current policies" at the time of the study. Second, the potential emissions reductions from regional strategies were estimated. Lastly, additional national-level strategies were considered to move the region towards its 2050 goal.

1. Policies implemented between 2005 and 2015 are making a difference.

The first step of the MSWG study was to examine the impact that the policies that were implemented between 2005 and 2015, when the study began, have on future emissions projected to 2050. For the transportation sector, this forecast is estimated with the same method as GHG emissions are estimated for the performance analysis of the long-range transportation plan, in this case the 2014 CLRP. At the time of this study, the horizon year for the long-range plan was 2040 and emissions for 2050 were estimated by growing emissions based on the rate of population growth. The study found that:

> *the most significant reductions are in emissions from on-road transportation combustion, due to higher federal corporate average fuel economy (CAFE) standards, including light-duty vehicle GHG regulations that phase in for model years 2017-2025 cars and light trucks and heavy-duty engine and vehicle GHG regulations that phase in during model years 2014-2018. In addition, regional land use patterns, transportation investments, and policies in the Constrained Long Range Plan (CLRP) also will reduce the rate of growth of vehicle travel… Based on significant improvements in vehicle fuel economy and local policies, GHG emissions from on-road transportation combustion are projected to be 17% lower in 2050 than 2005 levels based on currently implemented policies and plans. (p. 5)*

The analysis noted that there was a small uptick in emissions between 2040 and 2050, which is similar to the uptick between 2040 and 2045 forecasted for Visualize 2045 that was noted earlier.

2. Additional regional strategies can reduce GHG emissions considerably, but do not achieve the 80% reduction goal by 2050.

[32] Final Technical Report: Multi-Sector Approach to Reducing Greenhouse Gas Emissions in the Metropolitan Washington Region. Washington, D.C.: Metropolitan Washington Council of Governments (submitted by ICF International). January 31, 2016. https://www.mwcog.org/documents/2016/08/01/multi-sector-approach-to-reducing-greenhouse-gas-emissions-in-the-metropolitan-washington-region-final-technical-report/

The second step of the study analyzed the GHG emissions reduction potential for the strategies developed by the members of the MSWG. These strategies were divided into two groups - Transportation and Land Use (TLU) and Energy and Built Environment (EBE). The analysis found that potentially achievable and "stretch" reductions from the energy and built environment sector far surpassed the reductions that could be achieved by the transportation and land use sector.

> *Overall, EBE strategies show significant potential, particularly in the later years, as longer-term implementation measures go into effect. While looking relatively small in the context of total GHG emissions, regional TLU strategies support continued reductions in on-road transportation combustion emissions and have multiple co-benefits. TLU strategies are estimated to achieve significant GHG reductions in the near-term (approximately 1.2 MMTCO2e reduction in on-road transportation combustion emissions by 2020, or 5.5% of emissions from this source under the "current policies" scenario) and are forecast to have the potential for significant further reductions in GHGs over the 2040 to 2050 time-horizon (up to 6.8 MMTCO2e in 2050, or 36% of on-road transportation emissions under the "current policies" scenario). (p. 10)*

Table 1 shows the reductions from the BAU projects from the current policies and the analyzed EBE and TLU strategies along with the reductions still needed to achieve the 2050 goal. Figure 5 shows that same information in graphic form. Table 2 shows the GHG reductions from TLU and EBE strategies in descending order of GHG benefits in 2050. Appendix A contains a detailed listing of the strategy assumptions. For the transportation sector, each strategy was analyzed individually and it is "important to note that these strategies implemented in combination will cumulatively yield less than the sum of each individual strategy (e.g., a more fuel efficient and lower-carbon vehicle fleet will mean that each mile reduced yields less GHG reduction)." (p. 17).

Table 1: Estimated GHG Reductions from Current Policies and Potential Future Regional Strategies from MSWG Study

	GHG Emissions ($MMTCO_2e$)				
	2005	2012	2020	2040	2050
2005 BAU Projections	**74.5**	**82.3**	**91.3**	**103.3**	**106.3**
Revised 2005 BAU Projections	**74.5**	**82.2**	**91.0**	**106.9**	**113.3**
Impacts of Current EBE Policies	--	-5.9	-8.3	-15.2	-16.2
Impacts of Current TLU Policies		-2.5	-6.6	-15.3	-16.4
2015 Current Policies Projection	**74.5**	**73.7**	**76.1**	**76.4**	**80.8**
Impacts of additional regional EBE Strategies	--	--	-7.3	-26.1	-32.4
Impacts of additional regional Land Use Strategies^			-0.4	-1.5	-1.9
Impacts of additional regional Transportation Strategies^	--	--	-0.7	-2.4	-4.2
Total Impacts of New Regional Strategies	--	--	*-8.4*	*-29.8*	*-38.3*
Net Projected Emissions	**74.5**	**73.7**	**67.7**	**46.6**	**42.6**
Goal Emissions*	**74.5**	**74.0**	**59.6**	**29.8**	**14.9**
Further Reductions Needed to Meet Goal	--	-0.2	8.1	16.8	27.7
Projected Reductions from 2005 levels (%)			9%	37%	43%
Projected Reductions from 2005 BAU Projections (%)		10%	26%	56%	62%

Note: Results are presented by type of strategy (rather than emissions source).
^Land use strategies impact includes reductions in on-road transportation combustion and building energy emissions; transportation strategies impact includes net impact of reductions in on-road transportation combustion and increase in electricity emissions. Carbon sequestration is not included in these figures since not part of the baseline inventory.
*The goal emissions were determined by using the goal of reducing GHGs to 20% below 2005 levels by 2020 and to 80% below 2005 levels by 2050. The interim years were linearly interpolated based on these data points.

Source: Table 1, pp. 8-9 of ICF International. "Multi-Sector Approach to Reducing Greenhouse Gas Emissions in the Metropolitan Washington Region." Final Technical Report. Metropolitan Washington Council of Governments, January 31, 2016.

Figure 5: Estimated GHG Reductions from Current Policies and Potential Future Regional Strategies from MSWG Study

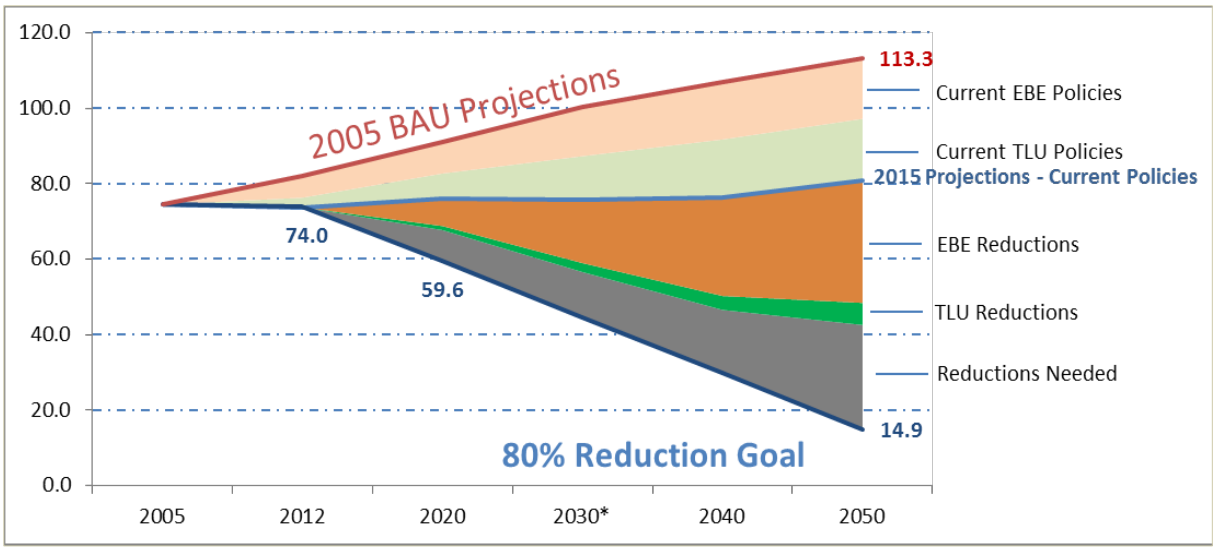


Table 2: Estimated GHG Reductions from Potential Future Regional Strategies (in Descending Order of GHG benefits in 2050) from MSWG Study

Strategy	Strategy Name	GHG Reductions ($MMTCO_2e$)		
		2020	2040	2050
EBE-6	Targeted reductions in power sector emissions	1.97	8.05	10.74
EBE-1	Reduce energy and water consumption in existing buildings	2.73	10.55	10.55
EBE-4	Improve new building energy and water efficiency performance	1.03	4.18	6.59
EBE-2	Support existing building-level renewable energy development	1.15	1.86	2.78
TLU-2	Sustainable development patterns & urban design (including enhancements for non-motorized modes)	0.34	1.32	1.67
TLU-6	Low carbon fuel standard	0	1.02	1.29
TLU-1	Increase tree canopy and reduce loss of vegetation through sustainable development patterns[2]	0.19	0.82	0.98
TLU-3	Improve fuel economy of light-duty vehicle fleet	0.09	0.50	0.88
TLU-7	Enhancing system operations	0.34	0.56	0.85
EBE-9	Reduce emissions from non-road engines	0.28	0.85	0.85
TLU-12	Road pricing	0	0.03	0.79
TLU-9	Travel demand management	0.13	0.24	0.54
EBE-3	Encourage development in activity centers	0.02	0.34	0.44
EBE-5	Achieve annual and cumulative reductions in fossil energy use by improving Infrastructure efficiency and increasing renewable energy use	0.05	0.23	0.32
EBE-8	Achieve targeted reduction in municipal solid waste	0.08	0.15	0.27
TLU-11	Transit incentives / fare reductions	0.12	0.10	0.19
EBE-7	Achieve targeted reductions in reduce natural gas pipeline leaks	0.02	0.11	0.11
TLU-4	Increase alternative fuels in public sector fleets	0.007	0.05	0.09
TLU-10	Transit enhancements	0.06	0.06	0.08
TLU-8	Reduce speeding on freeways	0.005	0.006	0.006
TLU-5	Truck stop electrification	<0.001	0.002	0.006

1 Note that the additive impact of individual strategies does not sum to the combined impact of implementing all strategies. Also note that EBE-10/TLU-0 (Educate and motivate the public through community engagement) has not been presented separately in this table because its effects are supportive of and are subsumed in other strategies.
2 Carbon sequestration benefits are not counted against the 80% GHG reduction target; over half of the benefit is the prevention of loss of tree coverage and vegetation due to more compact development.
3 Net GHG reduction accounts for increase in power sector emissions for electric vehicles; the increase is highly dependent upon other power sector strategies (not accounted for here when analyzing strategies independently). TLU-3 results in a reduction of on-road transportation combustion emissions of 0.22, 1.23, and 2.14 MMT CO2e in 2020, 2040, and 2050 respectively; however, this strategy results in increased electricity consumption from electric vehicles.

Source: Table 2, p. 11 of ICF International. "Multi-Sector Approach to Reducing Greenhouse Gas Emissions in the Metropolitan Washington Region." Final Technical Report. Metropolitan Washington Council of Governments, January 31, 2016.

Table 3 shows the projection of on-road transportation sector BAU emissions, 2015 current policies emissions, and estimated reductions from regional TLU strategies. In the five-year period from the beginning of the analysis period (2015) to 2020, VMT reduction strategies have the highest reduction potential among the transportation strategies as many of those strategies can be implemented relatively quickly and produce results, although the relative magnitude of impact of all

on-road strategies is still fairly low in the short-term. In the long-term, in 2040 and 2050, vehicle and fuel strategies are forecasted to have slightly higher reductions as the vehicle fleet turns over. VMT strategies provide GHG reductions close to that of the vehicles and fuels strategies due to aggressive assumptions such as a 10 cent/mile VMT tax and significant shifts in land use projections; however, the lower emissions rates forecasted for the future vehicle fleet reduces the emissions savings for each mile of travel reduced.

Table 3: Estimated GHG Reductions from Current Transportation and Land Use Policies and Potential Future Regional Transportation and Land Use Sector Strategies from MSWG Study

On-Road Transportation Combustion Emissions	GHGs ($MMTCO_2e$)				
	2005	2012	2020	2040	2050
2005 BAU Projections	**22.58**	**25.17**	**28.14**	**33.13**	**35.00**
2015 Current Policies Projections	**22.58**	**22.63**	**21.54**	**17.80**	**18.64**
VMT Strategies (including Land Use)	-	-	-0.64	-1.75	-3.27
Vehicle/Fuels Strategies*	-	-	-0.23	-2.30	-3.53
Operational Efficiency Strategies	-	-	-0.34	-0.57	-0.86
Total On-Road GHG Reductions+	-	-	-1.19	-4.30	-6.77
Net Projected Emissions	**22.58**	**22.63**	**20.35**	**13.50**	**11.86**
Projected Reductions from 2005 levels (%)			10%	40%	47%
Projected Reductions from 2005 BAU Projections (%)			28%	59%	66%
Impacts to Other GHG Source Categories					
*Increased emissions from electricity consumption**			*0.13*	*0.72*	*1.26*
Carbon sequestration benefits			*0.19*	*0.82*	*0.98*

*Note that an increase in electric vehicles reduces on-road transportation combustion emissions but increases electric utility emissions; the level of increase in electric utility emissions will depend on many factors, including the implementation of EBE strategies. Also note that the total does not equal the sum of the individual types of strategies due to off-setting effects.

The MSWG study examined aggressive strategies to reduce VMT. According to the final technical report:

> *the aggressive land use strategies analyzed reduce VMT by 11.6% in 2040 and 14.1% in the 2050 stretch scenario, but have relatively modest effects in the near term due to the time-frame for development to occur. Other VMT reduction strategies generally reduce VMT by 2 to 4% from 2020 to 2040, but have a much more significant impact in the 2050 stretch scenario (a 13.5% reduction in VMT) due to assumptions of wide-scale implementation of pricing mechanisms, including VMT-based road pricing, parking pricing, and mandated employer-provided commute subsidies. In combination with land use, the analysis suggests nearly a 28% reduction in VMT compared to the "current policies" baseline.*
>
> *… Viewed comprehensively, these levels of VMT reduction reduce the rate of growth in regional VMT over the analysis period through 2040; the 2050 stretch scenario actually reduces total VMT within the region below 2012 levels, as shown in Table 5*

[Table 4 in this report]. The significant VMT reductions highlight how aggressive the stretch scenario is, given the expected growth in regional population over this timeframe. While per capita daily VMT is already forecast to decline, the additional TLU strategies reduce average per capita daily VMT by nearly one-third across the entire region by 2050. (pp. 18-19)

Table 4: VMT Reductions and Average Daily VMT for the Land Use and the VMT reduction strategies Compared to "Current Policies" (2014 CLRP) from MSWG Study

	2012	2020	2040	2050 stretch
VMT Reductions due to Strategies Compared to Baseline with Current Policies (2014 CLRP)				
LU Strategies	-	2.2%	11.6%	14.1%
LU + Other VMT Reduction Strategies	-	4.2%	15.4%	27.6%
Average Daily VMT by Passenger Vehicles (millions)				
VMT with Current Policies	100.81	108.59	126.01	131.91
With LU Strategies		106.18	111.39	113.31
With LU + Other VMT Reduction Strategies		104.00	106.59	95.57
Daily VMT per Capita by Passenger Vehicles				
With Current Policies	19.49	19.13	18.86	18.86
With LU Strategies		18.71	16.67	16.20
With LU + Other VMT Reduction Strategies		18.33	15.95	13.66

3. Additional Strategies are Needed to Achieve the 2050 Goal

In the final part of the analysis, the Final Technical Report discusses a "combination of aggressive national and regional level actions additional strategies" (p. 22) that could make the 80% reduction goal achievable by 2050. Please refer to the Final Technical Report for more information on that discussion.

III. Long Range Plan Task Force (LRPTF)

After a review of planning information and establishing regional challenges and performance metrics, the LRPTF developed ten initiatives to analyze their potential to improve the performance of the long-range transportation plan. The analysis in the Phase II Detailed Technical Report[33] showed that **policies that optimize the regional land-use balance and increase employer-based travel demand management (such as teleworking policies) can improve the performance of the transportation network as well as have a noticeable impact on GHG emissions**. This is similar to the findings of the MSWG study.

Table 5 shows Initiatives 1-10 listed in descending order by the change in annual CO2 reductions

Table 5: Percent change in GHG, VHD, VMT, and VMT per Capita versus 2040 (2016 CLRP) from LRPTF Study

	Change in 2040 CO2 Emissions (annual)	Change in 2040 Daily VHD	Change in 2040 Daily VMT	Change in 2040 Daily VMT per Capita
10. Amplified Employer-Based Travel Demand Management	-7%	-24%	-6%	-6%
8. Optimize Regional Land-Use Balance	-4%	-18%	-3%	-6%
6. Metrorail Regional Core Capacity Improvements	-2%	-9%	-1%	-1%
7. Transit Rail Extensions	-1%	-3%	-1%	-1%
9. Transit Fare Policy Changes	-1%	-2%	-1%	-1%
4. Regionwide Bus Rapid Transit and Transitways	-1%	-2%	<-1%	<-1%
2. Operational Improvements and Hotspot Relief	-1%	-8%	2%	2%
5. Regional Commuter Rail Enhancements	0%	-2%	<-1%	<-1%
1. Regional Express Travel Network	0%	-11%	<1%	<1%
3. Additional Northern Bridge Crossing/Corridor	1%	-3%	1%	1%

[33] An Assessment of Regional Initiatives for the National Capital Region: Technical Report on Phase II of the Long-Range Plan Task Force. Washington, D.C.: National Capital Region Transportation Planning Board (prepared by ICF International). December 20, 2017. https://www.mwcog.org/documents/2017/12/20/long-range-plan-task-force-reports-projects-regional-transportation-priorities-plan-scenario-planning-tpb/

APPENDIX B: DETAILED STRATEGY DESCRIPTIONS

I. "What Would it Take?" Scenario Study (WWIT)

1. Federal Actions:

a. No Further Federal or Local Action

Strategies:	Description
Fuel Efficiency: CAFE 35.5 mpg by 2016	CAFE standards adopted in 2007 and later strengthened in 2009 moving from 25 mpg corporate average fuel economy to 35.5 mpg by 2016
Alternative Fuels: DOE Annual Energy Outlook, based on current energy legislation	Uses national forecasts of energy usage in the transportation sector completed annually by the U.S. Department of Energy. Forecasts are conducted according to current legislation and market assumptions.
Travel Efficiency: Committed TERMs	Committed TERMs include strategies already adopted by state and local jurisdictions in the region to address criteria air pollutants.

b. High Federal Role

Strategies:	Description
Fuel Efficiency: CAFE 55 mpg by 2030	Assumes that after CAFE 35.5 mpg is achieved in 2016, CAFE standards are further strengthened to 55 mpg by 2030.
Fuel Efficiency: Doubling heavy duty vehicle CAFE by 2020	Assumes institution of heavy-duty CAFE standards, which would double current heavy duty vehicle fuel economy by 2020
Alternative Fuels and Travel Efficiency: High energy prices ($7/gallon gas)	Uses DOE forecasts for a national high energy price scenario, which assumes $7/gallon gasoline. This causes higher alternative fuel usage and a 6% reduction in VMT.

2. State/Regional/Local Actions

a. Shorter term Strategies

Strategies:	Description
(1) Increase transit use	
Metrorail feeder bus service	At 2 underutilized park and ride lots and $.50 am fare buy-down program
Implement neighborhood circulator buses	Expanded circulator bus service to/from Metrorail in 10 neighborhoods
Real-time bus schedule information	Internet and bus shelter display units, with satellite technology tracking 596 buses.
Purchase 185 WMATA buses	CNG buses on 36 crowded routes in DC
WMATA bus information displays with maps (2000 cases)	Increased and improved bus service information at 2000 stops.

Enhanced commuter services	Bus service from Metrorail to Potomac Mills and Arundel Mills shopping centers; bus service from Reston/Herndon, Centreville, and Springfield to Pentagon and downtown DC.; and bus service on HOV facilities such as US 50, I-270, and US 29.
Free bus-rail transfers	Free bus to rail transfers similar to the reduced fare rail to bus transfers.
Free off-peak bus service	Free bus service mid-day and on weekends.
K Street Transitway	Implementation of the K Street Transitway project on K Street in NW DC between 10th St and 23rd St.
TIGER smart hubs	Implementation of the technology component of the TPB TIGER grant submission: regional website of comprehensive transportation information and digital displays at 20 intermodal hubs.
TIGER bus priority	Implementation of the bus priority component of the TPB TIGER grant submission: transit signal priority, queue jump lanes, etc on 10 bus corridors.
10 transit stores in MD	Arlington stores used as the example
6 kiosks in MD	Transportation information kiosks similar to ones in VA and DC
(2) Increase non-motorized mode share	
Bike stations at rail stations	Assumes construction of 9 bike stations similar to the Union Station BikeStation.
TIGER bike-sharing	Implementation of the bike-sharing component of the TPB TIGER grant submission: regional expansion of DC's bike-sharing program from 500 bikes to 3000.
Improve pedestrian facilities near rail stations	Improved sidewalks, curb ramps, crosswalks, and lighting at 11 MARC stations and 12 Metrorail stations in Montgomery County.
(3) Pricing	
Volunteer employer parking cash-out subsidy	Equal compensation for free parking to those not driving to work
Parking impact fees	Administered by local governments to recoup costs associated with maintaining roadways and mitigating negative impacts of auto use. Fees are charged per parking space to land owners.
Pay-as-you-drive insurance	Assumes 30% of light duty drivers will switch to PAYD insurance within 6 years (insurance premiums are on a per-mile driven basis).
(4) Improve operational efficiency	
Eco-driving incentives and promotion	Based on study done in Denver, assuming 50% of drivers adopt eco-driving practices.
Idling reduction	Enforcement of existing idling regulations. Many states have state-wide anti-idling laws and several counties and cities have their own anti-idling rules.
MATOC	Regional coordination of incident management. Assumes current MATOC commitments.
Traffic signal optimization	Optimization of almost 2000 signals throughout the region.

(5) Reduce travel	
Expanded Telecommuting (conversion of all potential telecommuters)	Based on State of the Commute Report, all commuters stating that they are able and willing to begin telecommuting do so within 5 years.
Carpool incentive program	Based on Commuter Connections Carpool Incentive Demonstration Project Study where participants received $1 per carpool trip taken.
Vanpool incentive program ($25/van/day)	Incentive program designed to increase number of vanpools in the region.
Expand car-sharing program	Funds incentives for 1000 new car-sharing customers.
Employer outreach, public and private (Metrochecks and carpooling)	Marketing and implementing employer-based TDM programs

b. Longer term Strategies

Strategies:	Description
(1) Increase transit use	
Construction of 1000 parking spaces at Metrorail stations	WMATA adding 1000 parking spaces at different Metrorail stations.
Incremental increase in transit (heavy rail)	Example used is the Dulles rail project to indicate the order of magnitude of CO_2 reduction for a major Metrorail expansion.
(2) Increase non-motorized mode share	
Completion of 2030 Bike/Ped plan by 2020	Accelerated completion of the TPB Bicycle and Pedestrian Plan by 2020 instead of 2030.
(3) Pricing	
TPB Value Pricing Study, with transit	2008 TPB Value Pricing Study, including new priced lanes on major freeways, pricing of existing arterials in DC and pricing of national parkways. Also includes enhances bus transit operating on priced lanes.
(4) Reduce travel	
CLRP Aspirations Scenario	TPB land use and transportation scenario examining concentrated land use around a network of BRT and pricing. Also includes a scenario of just concentrated, transit-oriented land use.

II. Multi-Sector Working Group (MSWG)

TLU-2: Sustainable development patterns and urban design, including bicycle/pedestrian enhancements	• 2040: Major reallocations of growth, but attempted to retain overall CLRP control totals within the host jurisdiction, focusing instead on allocating as much of that growth as possible into activity centers. Top priority was given to locating in activity centers that include premium transit service. Second priority was given to premium transit station areas that were not formerly designated as activity centers, and third priority was given to those remaining activity centers that were not served with premium transit. • 2050: Relaxed the constraint on moving jobs or households across jurisdictional lines, and sought to achieve a better regional distribution of employment opportunity and a better balance between jobs and housing.
TLU-3: Improve fuel economy of light-duty vehicle fleet	• 2020: Increase light-duty zero emission vehicles (ZEVs) to 2% of total vehicle population in region (beyond those anticipated with existing policies) • 2040: Increase light-duty ZEVs to 15% of total vehicle population in region (beyond those anticipated with existing policies) • 2050 (stretch): Increase light-duty ZEVs to 25% of total vehicle population in region (beyond those anticipated with existing policies)
TLU-4: Increase alternative fuels in public sector fleets	• 2020: Add 200 zero emission vehicle (ZEV) buses to public transit fleet in the study region (replacements). • 2040: Increase ZEVs in municipal light-duty fleets to 15% of total fleet population; require B5 in all municipal fleets and school buses; require 15% of public transit fleet to be ZEVs. • 2050 (stretch): Increase ZEVs in municipal light-duty fleets to 25% of total fleet population; require B20 in all municipal fleets and school buses; require 25% of public transit fleets to be ZEVs.
TLU-5: Truck stop electrification (TSE)	• 2020: One TSE location with 20 bays/site in the region. • 2040: Six (6) TSE locations with 20 bays/site in the region. • 2050 (stretch): Fourteen (14) TSE locations with 20 bays/site in the region.
TLU-6: Low carbon fuel standard	• 2020: No reductions (assume measure will not be implemented by this date). • 2040: Reduction in total on-road fuel emissions in region by 10%. • 2050 (stretch): Reduction in total on-road fuel emissions in region by 15%.

TLU-7: Enhancing system operations	• 2020: 20% of drivers adopt eco-driving practices (based on public campaigns); region wide operational improvements reduce vehicle operating emissions by additional 1.65% (based on best available regional simulation study). • 2040: 80% of drivers adopt eco-driving practices (based in part via connected vehicle/automated vehicle technologies); regionwide operational improvements reduce vehicle operating emissions by additional 1.65% (based on best available regional simulation study). • 2050 (stretch): 100% of drivers utilize eco-driving practices (via connected vehicle/automated vehicle technologies); regionwide operational improvements reduce vehicle operating emissions by additional 1.65% (based on best available regional simulation study).
TLU-8: Reduce speeding on freeways	• 2020: One-third of freeway speeding eliminated (above 57.5 mph) • 2040: All freeway speeding eliminated (through automated enforcement/autonomous vehicles) • 2050: All freeway speeding eliminated (through automated enforcement/autonomous vehicles)
TLU-9: Travel Demand Management	• 2020: Expand employer-based incentives (subsidies of $50 per month for 40% of employers); 50% of parking in activity centers is priced at an average of $8 per day for work trips. • 2040: Expand employer-based incentives (subsidies of $50 per month for 80% of employers); 90% of parking in activity centers is priced at an average of $8 per day for work trips. • 2050 (stretch): Expand employer-based incentives (subsidies of $80 per month for 100% of employers); 100% of parking in activity centers is priced at an average of $8 per day for work trips.
TLU-10: Transit enhancements	• 2020: Reduce transit travel times by 10% and reduce headways (wait time) by 10%. • 2040: Reduce transit travel times by 15% and reduce headways (wait time) by 15%. • 2050 (stretch): Reduce transit travel time by 20% and reduce headways (wait time) by 20%.
TLU-11: Transit incentives/ Fare reductions	• 2020: Reduce transit fares regionally by 20%. • 2040: Reduce transit fares regionally by 25%. • 2050: Reduce transit fares regionally by 40% partially funded through pricing strategies.
TLU-12: Road pricing	• 2020: None – long term scenario only • 2040: Cordon pricing into downtown DC at $5/trip • 2050 (stretch): Full VMT-based pricing on road network at $0.10 per mile peak. Cordon pricing into downtown DC at $5/trip.

III. Long-Range Plan Task Force (LRPTF)

Multimodal Initiatives	
1. Regional Express Travel Network	• Express toll lanes network (free to HOV and transit vehicles) with added lanes where feasible on existing limited access highways (including remaining portion of the Capital Beltway, I-270, Dulles Toll Road, U.S. 50); includes expanded American Legion Bridge. • New express bus services on network (paid in part through tolls) connecting major Activity Centers.
2. Operational Improvements and Hotspot Relief	• Application of technology and enhanced system operations strategies, such as ramp metering, active traffic management, and integrated corridor management (including transit signal priority and enhanced multimodal travel information), plus targeted capacity enhancements where feasible to address top regional congestion hotspots and adjoining connections. • Improved roadway design (such as treatments of turning movements) and reversible lanes on major roadways, as appropriate (to be identified based on strong directional flows). • Expanded regional incident management where appropriate. • Technological integration of demand-responsive services for persons with disabilities and others with limited mobility to create efficiencies of scale and improve mobility of traditionally underserved populations.
3. Additional Northern Bridge Crossing/Corridor	• New northern bridge crossing of Potomac River, as a multimodal corridor between the Intercounty Connector and Northern Virginia. • New express bus services connecting existing Activity Centers in this new multimodal corridor.
Transit-Focused Initiatives	
4. Regionwide Bus Rapid Transit and Transitways	• Bus rapid transit (BRT)/transitway networks in Montgomery County, Prince George's County, Northern Virginia (TransAction 2040), Washington D.C., and transitway from Branch Ave to Waldorf; specifications according to jurisdiction plans. • Additional D.C. streetcar line (north-south) as complement to network. • Improved bicycle and pedestrian connections and access improvements to transit stations.
5. Regional Commuter Rail Enhancements	• VRE System Plan 2040, MARC Growth and Investment Plan (including run-thru and two-way service on selected lines, increased frequency and hours of service).[1] • Long Bridge corridor improvements including at least four tracks and bicycle-pedestrian facilities. • Improved bicycle and pedestrian connections and access improvements to rail stations.

Transit-Focused Initiatives (Continued)	
6. Metrorail Regional Core Capacity Improvements	• 100% 8-car trains. • Metrorail station improvements at high-volume stations in system core. • Second Rosslyn station to reduce interlining and increase frequency. • New Metrorail core line to add capacity across Potomac River (new Rosslyn tunnel) between Virginia and D.C. through Georgetown to Union Station toward Waterfront. • Improved bicycle and pedestrian connections and access improvements to rail stations.
7. Transit Rail Extensions	• Metrorail extensions to Centreville/Gainesville, Hybla Valley /Potomac Mills. • Can consider an extension(s) in MD, such as to National Harbor or north of Shady Grove (to be defined later). • Purple line extension to Tysons (west) and Eisenhower Avenue (east). • Improved bicycle and pedestrian connections and access improvements to rail stations.
Policy-Focused Initiatives	
8. Optimize Regional Land-Use Balance	• Optimize jobs/housing balance regionwide. • Increase jobs and housing around underutilized rail stations and Activity Centers with high-capacity transit. • Build more housing in the region to match employment (about 130,000 more households) and reduce the number of long distance commuters outside of the region.
9. Transit Fare Policy Changes	• Reduced price Metrorail fare for off-peak direction during peak period and on underutilized segments. • Free transit for low-income residents.
10. Amplified Employer-Based Travel Demand Management	New policies (e.g., employer trip reduction requirements) and programs (e.g., financial incentives) implemented at the local and regional scale to significantly reduce single-occupancy vehicle commute trip making, including: • Employer-based parking cash-out • Expanded employer-based transit/vanpool benefits • Expanded telework and flexible schedule adoption • Substantial increase in priced commuter parking in major Activity Centers

APPENDIX C: TECHNICAL APPROACH AND DOCUMENTATION

I. "What Would it Take?" Scenario Study (WWIT)

Date Completed: May 18, 2010

Oversight: TPB

Documentation: Final Report: What Would It Take? Transportation and Climate Change in the National Capital Region[34]

Final Technical Report: What Would It Take? Transportation and Climate Change in the National Capital Region[35]

Study Purpose

The "What Would it Take?" Scenario Study was one of two scenario studies that were undertaken under the purview of the Scenario Study Task Force that the TPB established in September 2007. The WWIT Scenario Study was the TPB's first step toward answering some major questions about climate change mitigation, specifically in the transportation sector in the Washington metropolitan region. The study examined what types of projects, programs, and policies it would take in the transportation sector to meet the regional aspirational GHG reductions targets established in the National Capital Region Climate Change report and adopted by the COG Board in November 2008. The study developed the baseline GHG emissions in the transportation sector and tested the potential reductions in GHG emissions from various projects/programs/policies would generate in the transportation sector. The intent was to determine the nature and scope of actions that would be necessary to reduce GHG in the transportation sector in the target amounts noted below.

- By 2012, 10% below "business as usual" (of the transportation sector)
- By 2020, 20% below 2005 levels (of the transportation sector)
- By 2050, 80% below 2005 levels (of the transportation sector)

Study Design

The technical analysis for this study was conducted by TPB staff. The WWIT study reported cumulative CO2 emissions reductions from 2010-2030 as compared to a CLRP baseline. Because the horizon year for the long-range plan was 2030, a straight-line interpolation goal of 40% below 2005 levels by 2030 was used as the benchmark for the study. The study was reported in two separate groupings (Systemwide and State/Regional/Local) to avoid double-counting emissions reductions benefits from strategies. Emissions for strategies were estimated using spreadsheet-based sketch planning techniques developed for Transportation Emissions Reduction Measure (TERMs) analyses.

---

[34] Final Report: What Would It Take? Transportation and Climate Change in the National Capital Region. Washington, D.C.: National Capital Region Transportation Planning Board. May 18, 2010. https://www.mwcog.org/documents/2010/05/18/what-would-it-take-scenario-land-use-projects/

[35] Preliminary Analysis of Potential Transportation-related Greenhouse Gas Reduction Strategies for the Washington, DC Region. National Capital Region Transportation Planning Board. May 13, 2010.

Technical Approach

CLRP:	2009
Emissions Model:	Mobile6.2 + offline spreadsheet for fuel economy standards
Travel Demand Model:	Version 2.2
Demographic Data:	Round 7.2
Vehicle Registration Data:	2008
Analysis Years:	2010, 2020, 2030
Geography:	8-hour Ozone Non-Attainment Area

II. Multi-Sector Working Group (MSWG)

Date Completed: January 18, 2017

Oversight: TPB/MWAQC/CEEPC

Documentation: Final Technical Report: Multi-Sector Approach to Reducing Greenhouse Gas Emissions in the Metropolitan Washington Region[36]

Recommendation of the Multi-Sector Working Group[37]

Study Purpose

In December 2014, the TPB and the Metropolitan Washington Air Quality Committee (MWAQC) affirmed COG's adopted voluntary greenhouse gas reduction goal of 80% below 2005 levels by 2050,[38] and committed staff and resources to support a multi-sector, multi-disciplinary professional working group to be convened by COG to:

- Identify viable, implementable local, regional, and state actions to reduce GHG emissions in four sectors (Energy, the Built Environment, Land Use, and Transportation) in accordance with the voluntarily adopted goals
- Quantify the benefits, costs and implementation timeframes of these actions
- Explore specific GHG emission reduction targets in each of the four sectors
- Jointly develop an action plan for the region

Study Design

[36] Final Technical Report: Multi-Sector Approach to Reducing Greenhouse Gas Emissions in the Metropolitan Washington Region. Washington, D.C.: Metropolitan Washington Council of Governments (submitted by ICF International). January 31, 2016. https://www.mwcog.org/documents/2016/08/01/multi-sector-approach-to-reducing-greenhouse-gas-emissions-in-the-metropolitan-washington-region-final-technical-report/

[37] Recommendation of the Multi-Sector Working. Washington D.C.: Metropolitan Washington Council of Governments. January 18, 2017. https://www.mwcog.org/documents/2017/01/18/multi-sector-working-group-greenhouse-gas-emission-reducing-strategies-air-quality-climate-mitigation-greenhouse-gas-multi-sector-working-group/

[38] TPB R10- 2015: Resolution on the Metropolitan Washington Council of Governments' Regional Multi-Sector Goals for Reducing Greenhouse Gases. Washington, D.C.: National Capital Region Transportation Planning Board. December 17, 2014. https://www.mwcog.org/file.aspx?&A=NQRpyfkLR1A9O4KiCx0%2bhAVEs%2fYo7kI1bNCWYEltoHU%3d

The MSWG work was directly tied to the greenhouse gas reduction targets laid out in the National Capital Region Climate Change Report. Baseline for comparison is the 2005 "Business as Usual" (BAU) forecasts from the Climate Change Report, which were updated with the latest planning tools to be consistent. The analysis MOVES2014, TRIMMs, analysis conducted by consultant team lead by ICF International.

Technical Approach

CLRP:	2014
Emissions Model:	MOVES2014
Travel Demand Model:	Version 2.3
Demographic Data:	Round 8.3
Vehicle Registration Data:	2014
Analysis Years:	2020, 2040, 2050**
Geography:	TPB Planning Area

**Emissions for analysis years 2012, 2020, and 2040 were estimated by TPB staff using MOVES2014. Emissions for analysis year 2050 were estimated by the consultant team.

III. Long-Range Plan Task Force (LRPTF)

Date Completed: December 20, 2017

Oversight: TPB

Documentation: An Assessment of Regional Initiatives for the National Capital Region: Technical Report on Phase II of the Long-Range Plan Task Force[39]

R-8 2018: TPB Resolution endorsing initiatives recommended by the LRPTF[40]

Study Purpose

TPB Resolution R16-2017, adopted on March 15, 2017, directed the Long-Range Plan Task Force to identify a limited set (6-10) of projects, policies, or programs that would have the potential to improve the performance of the region's transportation system and to make substantive progress towards achieving the goals laid out in TPB's and the Metropolitan Washington Council of Government's (COG's) governing documents. As a part of this study, among other measures, GHG impacts of each initiative were analyzed in relationship to the Planned Build.

Study Design

[39] An Assessment of Regional Initiatives for the National Capital Region: Technical Report on Phase II of the Long-Range Plan Task Force. Washington, D.C.: National Capital Region Transportation Planning Board (prepared by ICF International). December 20, 2017. https://www.mwcog.org/documents/2017/12/20/long-range-plan-task-force-reports-projects-regional-transportation-priorities-plan-scenario-planning-tpb/

[40] TPB R-8 2018; TPB Resolution endorsing initiatives recommended by the LRPTF. Washington, D.C.: National Capital Region Transportation Planning Board (prepared by ICF International). December 20, 2017. https://www.mwcog.org/documents/2017/12/20/r8-2018---resolution-endorsing-initiatives-recommended-by-the-long-range-plan-task-force/

The analysis looked at 10 initiatives, which were groupings of individual strategies. The initiatives were compared to horizon year 2040 from 2016 CLRP. Sketch planning methods, including simple VMT-based factoring, were used for the analysis. The analysis was conducted by a consultant team lead by ICF International and assisted by TPB staff.

Technical Approach

CLRP:	2016
Emissions Model:	MOVES2014a
Travel Demand Model:	Version 2.3.66
Demographic Data:	Round 9.0
Vehicle Registration Data:	2014 for baseline scenario
Analysis Year:	2040
Geography:	TPB Planning Area

TPB CLIMATE CHANGE MITIGATION STUDY OF 2021

Findings from Past TPB and COG Studies

Erin Morrow
TPB Transportation Engineer

Transportation Planning Board
May 19, 2021

Agenda Item #9

National Capital Region
Transportation Planning Board

Findings from Past Studies

- "What Would it Take?" Scenario Study (WWIT) *(TPB, May 2010)*
- Multi-Sector Working Group (MSWG) *(TPB/MWAQC/CEEPC, Jan. 2017)*
- Long Range Plan Task Force (LRPTF) Study *(TPB, Dec. 2017)*
- Metropolitan Washington 2030 Climate and Energy Action Plan (CEAP) *(CEEPC, Nov. 2020)*

Background: Climate Change Reduction Goals

- The Metropolitan Washington Council of Governments (COG) Board of Directors adopted, and National Capital Region Transportation Planning Board (TPB) affirmed, the following GHG reduction goals for the region:
  - By 2012, GHG levels will be 10% below "business as usual" forecasts
  - By 2020, GHG levels will be 20% below 2005 levels
  - By 2030, GHG levels will be 50% below 2005 levels
  - By 2050, GHG levels will be 80% below 2005 levels

On-road Greenhouse Gas Emissions

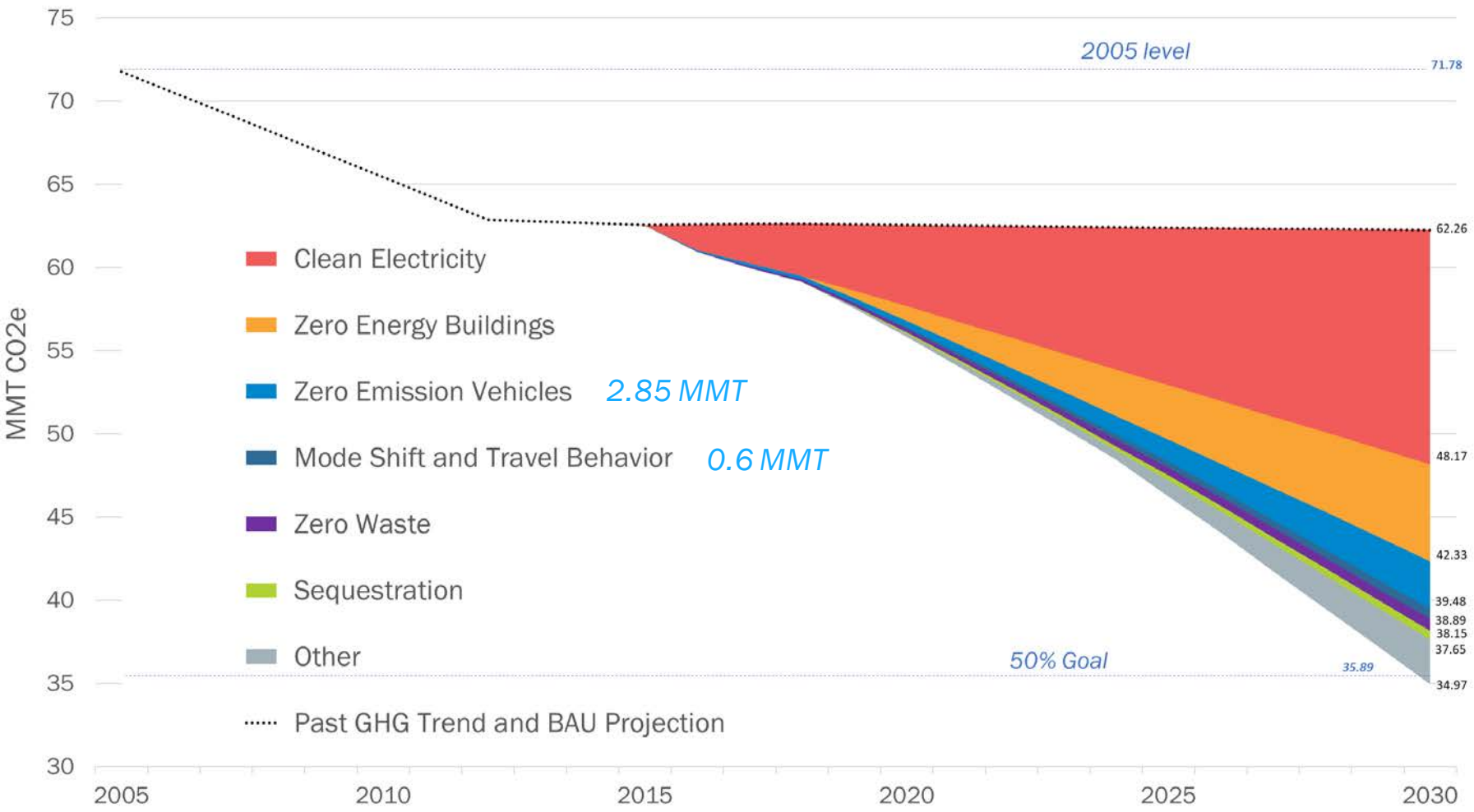
Visualize 2045 (2018):

- 1.3M more people and 1M more jobs (2019-2045)
- Percent growth in walk/bike and transit trips greater than auto trips
- Percent growth in VMT less than in previous LRPs
- VMT per capita reduced (Region Forward Target)
- GHG emissions 23% below 2005 levels in 2045

2030 Climate Energy Action Plan (CEAP)

- Plan is fully compliant with Global Covenant of Mayors for Climate and Energy (GCoM) global standards of best practices for climate planning
- 2030 scenario for the plan analyzes the technical potential for metropolitan Washington to reach a 50% reduction in GHG emissions from 2005 levels by 2030
- On-road transportation strategies include Zero Emission Vehicle (ZEV) and Mode Shift and Travel Behavior (MSTB) actions
  - ZEV strategies are based on the "high electric vehicle (EV) adoptions rates from the National Renewable Energy Laboratory's 'Electrification Futures Study'" i.e., adoption rates of greater than 20% for light-duty cars, 9% for light-duty trucks, 4% for medium/heavy-duty trucks, and 30% for transit buses
  - MSTB strategies are from the MSWG study and include increasing transit, carpooling, and non-motorized travel; bringing jobs and housing closer together; and travel demand management (teleworking, transit benefits)

CEAP 2030 Scenario Analysis: Findings



Reducing GHG Emissions from On-Road Transportation

1. Reduce fossil fuels consumed by vehicles
   - Improve vehicle fuel efficiency
   - Convert fleet to less-carbon intense fuel
2. Reduce vehicle travel (VT or VMT)
   - Provide alternatives to single-occupant vehicle (SOV) travel (new transportation projects or service)
   - Disincentivize SOV travel or incentivize non-SOV travel (policies or programs)
   - Locate housing, employment, and other activities closer together
3. Reduce inefficiencies in vehicle travel
   - Invest in programs to reduce non-recurring congestion
   - Target capital improvements to reduce recurring congestion

Major Findings from Past Studies

- Reducing GHG from on-road transportation in a growing region is difficult
- There is not a single strategy or category of strategies that, if implemented, would achieve the region's GHG reduction goals
- Actions will be required at all levels of government – federal, state, and local
- The effectiveness of a strategy is affected by the scale and timeframe of its implementation
- Benefits from multiple strategies are not always additive and at times are counteractive

Findings: Most Effective Strategies (In Descending Order of Effectiveness)

1. Fuel efficiency, fuel content, and vehicle technology
   - Greatest potential to reduce GHG emissions (e.g., stricter fuel economy and GHG vehicle emissions standards, higher rates of electric vehicle market penetration)
   - GHG reduction potential takes years to be fully realized
   - Equity implications of policies should be considered
   - Actions can be implemented outside the Long-Range Plan

Findings: Most Effective Strategies (In Descending Order of Effectiveness)

2. Aggressive federal/local transportation and land use policy actions that could have a significant impact on travel behavior **(i.e., VMT)**
    - Significant potential, but have not been implemented in the region at levels needed to achieve significant GHG reductions (e.g., large increases in price of gasoline, VMT tax, cordon and parking pricing, significant land use shifts, travel demand management, including telework)
    - Could be implemented in a shorter timeframe contributing to critical near-term GHG reductions
    - Equity implications of policies should be considered
    - Actions can be implemented outside the Long-Range Plan

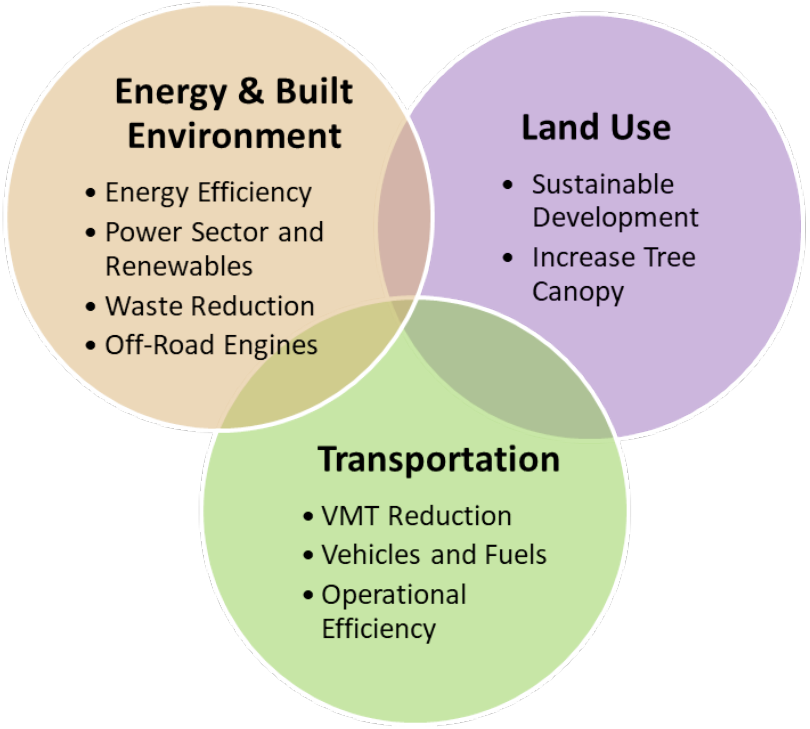
Findings: Most Effective Strategies (In Descending Order of Effectiveness)

3. Operational efficiency and new transportation projects
    - Operational Efficiency
        - The findings on operational efficiency strategies are mixed, likely due to different assumptions in MSWG and LRPTF; plan to further examine in Phase 2 of Climate Change Mitigation Study of 2021
    - New Transportation Projects (e.g., Long-Range Plan)
        - Have the least significant potential for GHG emissions reductions (even some ambitious packages of projects show low potential for GHG emissions reductions based on past studies)
        - Important projects to implement from equity and livability perspective

Sample of Findings

- Results from two studies shown for illustration
  - Multi-Sector Working Group (MSWG) Transportation Sector Analysis
  - Long Range Plan Task Force (LRPTF) Study

2017: Multi-Sector Work Group (MSWG)



- Existing policies/plans analyzed for potential 2040/2050 reductions
- Additional strategies analyzed at "viable" and "stretch" levels for 2040/2050 reductions

MSWG: Transportation and Land Use Results

On-Road Transportation Combustion Emissions	GHGs ($MMTCO_2e$)			
	2005	2020	2040	2050
2005 "Business as Usual" Projections	**22.58**	**28.14**	**33.13**	**35.00**
2015 Current Policies Projections *(includes 2011 CAFE standards, 2012 medium- and heavy-duty fuel efficiency standards)*	**22.58**	**21.54**	**17.80**	**18.64**
Projected Reductions from 2005 Levels (%) (2015 Current Policies)	*-*	*5%*	*21%*	*17%*
VMT Strategies (including Land Use)	-	-0.64	-1.75	-3.27
Vehicle/Fuels Strategies*	-	-0.23	-2.30	-3.53
Operational Efficiency Strategies	-	-0.34	-0.57	-0.86
Total On-Road GHG Reductions+	-	-1.19	-4.30	-6.77
Projected Reductions from 2005 Levels (%) (MSWG Strategies)	*-*	*5%*	*19%*	*30%*
Net Projected Emissions (2015 Current Policies + MSWG Strategies)	**22.58**	**20.35**	**13.50**	**11.86**
Projected Reductions from 2005 levels (%) (2015 Current Policies + MSWG Strategies)		*10%*	*40%*	*47%*
Impacts to Other GHG Source Categories				
*Increased emissions from electricity consumption**		*0.13*	*0.72*	*1.26*
Carbon sequestration benefits		*0.19*	*0.82*	*0.98*

*Note that an increase in electric vehicles reduces on-road transportation combustion emissions but increases electric utility emissions; the level of increase in electric utility emissions will depend on many factors, including the implementation of Energy and Built Environment strategies. Also note that the total does not equal the sum of the individual types of strategies due to off-setting effects

MSWG Actions: Vehicles and Fuel

2040

- 15% zero emissions vehicles (e.g., EVs) in on-road light-duty fleet (LDV) and public sector heavy-duty fleet (PSHD)
- Reduce on-road fuel emissions by 10% by reducing carbon content of fuel

2050

- 25% zero emissions vehicles in on-road LDV fleet and PSHD
- Reduce on-road fuel emissions by 15% by reducing carbon content of fuel

MSWG Actions: Travel Efficiency

2040

- Regionwide operational improvements; 80% of drivers adopt "eco-driving" practices

2050

- Regionwide operational improvements; 100% of drivers adopt "eco-driving" practices

MSWG Actions: Reduce Vehicle Travel

2040

- Reallocate future growth within jurisdictions to maximize concentration within Activity Centers and near premium transit (i.e., Metrorail, commuter rail, LRT, or BRT)
- $50/month transit subsidy for 80% of employers
- Reduce transit fares by 25% regionally
- Reduce transit travel times by 15% and reduce headways (wait time) by 15%
- Increased parking charges in 90% of Activity Centers
- $5 cordon pricing entering downtown DC

2050

- Reallocate future growth across jurisdictions to maximize concentration within Activity Centers and near premium transit
- $80/month transit subsidy for 100% of employers
- Reduce transit fares by 40% regionally
- Reduce transit travel time by 20% and reduce headways (wait time) by 20%
- Increased parking charges in 100% of Activity Centers
- $5 cordon pricing entering downtown DC
- $0.10/mile VMT charge

2017: Long Range Plan Task Force (LRP-TF)

Multimodal	Transit	Policy-Focused
1. Regional Express Travel Network	4. Regionwide High-Capacity Transitways	8. Optimize Regional Land Use Balance
2. Operational Improvements & Hotspot Relief	5. Regional Commuter Rail Enhancements	9. Transit Fare Policy Changes
3. Additional Northern Bridge Crossing/Corridor	6. Metrorail Regional Core Capacity Improvements	10. Amplified Travel Demand Management (for commute trips)
	7. Transit Rail Extensions	

- 10 Alternative scenarios of land use and transportation projects/programs/policies evaluated
- To identify potential long-term improvements in the multi-modal system performance outcomes *(not Climate Change focused)*
- Scenario evaluation metrics included changes in VMT, VHD, and GHG emissions

2017: LRP-TF Study Findings

	Change in 2040 CO2 Emissions (annual)	Change in 2040 Daily VHD	Change in 2040 Daily VMT	Change in 2040 Daily VMT per Capita
10. Amplified Employer-Based Travel Demand Management	-7%	-24%	-6%	-6%
8. Optimize Regional Land-Use Balance	-4%	-18%	-3%	-6%
6. Metrorail Regional Core Capacity Improvements	-2%	-9%	-1%	-1%
7. Transit Rail Extensions	-1%	-3%	-1%	-1%
9. Transit Fare Policy Changes	-1%	-2%	-1%	-1%
4. Regionwide Bus Rapid Transit and Transitways	-1%	-2%	<-1%	<-1%
2. Operational Improvements and Hotspot Relief	-1%	-8%	2%	2%
5. Regional Commuter Rail Enhancements	0%	-2%	<-1%	<-1%
1. Regional Express Travel Network	0%	-11%	<1%	<1%
3. Additional Northern Bridge Crossing/Corridor	1%	-3%	1%	1%

LRPTF Case Study 1: Amplified Employer-Based Travel Demand Mgmt

Transit/Vanpool Subsidy: Transit subsidies averaging $50 per month for 80% of employees

Parking Pricing Increase: Charge for 90% of parking for work-trips in Activity Centers with average parking costs of $6 per day (higher in the core and lower in areas not currently charging for parking)

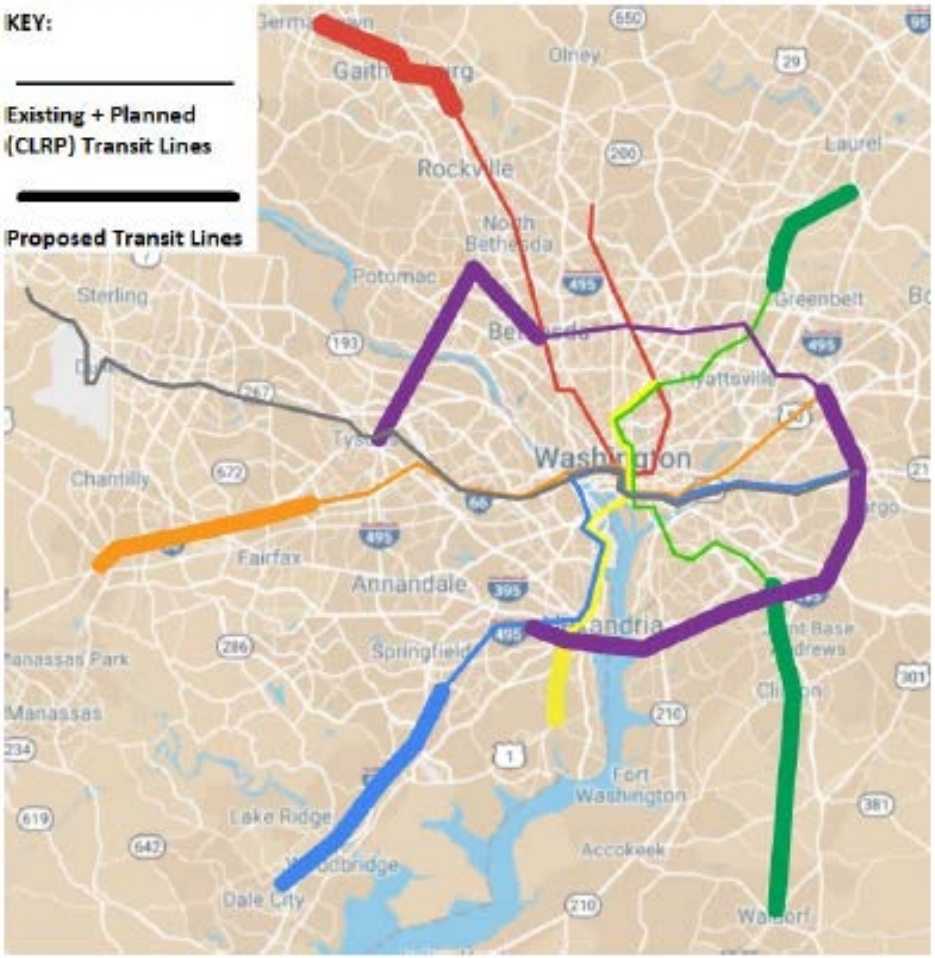
Land-Use Assumptions: 2040 CLRP Round 9.0 Cooperative Land-Use Forecasts were used without any change

Increase in telework: Regional reduction in the number of commute trips for all modes to achieve a 20% telecommute rate

This initiative resulted in a VMT decrease of 6%, VHD decrease of 24%, and GHG decrease of 7% relative to the 2040 Baseline

LRPTF Case Study 2: Transit Rail Extensions

Figure 12: Existing Metrorail and Proposed Extensions



Source: ICF

LRPTF Case Study 2: Transit Rail Extensions

Transit Rail Extensions:

Metrorail: Centreville/Gainesville, Hybla Valley/Potomac Mills, Germantown, and Laurel

Purple Line: Tysons (west) and Eisenhower Avenue (east)

Southern Maryland Rapid Transit: between Branch Avenue and Charles County

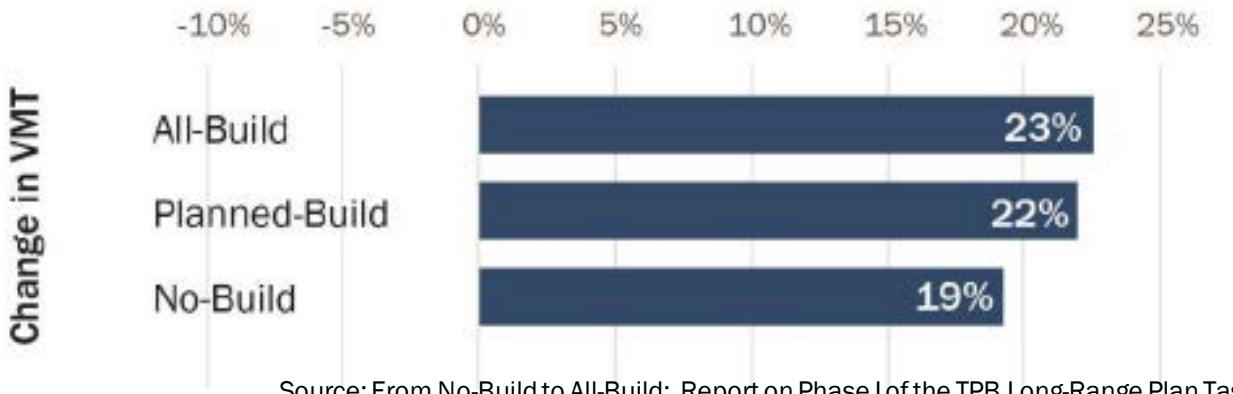
Land-use Assumptions: Jobs and households were shifted to Activity Centers in the corridor

This initiative, which included an expansion of the transit system with 62 new stations, resulted in a VMT decrease of 1%, VHD decrease of 3%, and GHG decrease of 1% relative to the 2040 Baseline

Challenges of Regional Growth on Mobility and Emissions

VMT Growth: Population vs. Projects

VMT Growth (2015 – 2040) based on the 2015 CLRP Amendment



Source: From No-Build to All-Build: Report on Phase I of the TPB Long-Range Plan Task Force (December 2016)

- Population growth 24% and employment growth 36% in all scenarios
- No Build adds no new transportation projects from 2015-2040; Planned-Build adds 372 new projects; All-Build adds an additional 550 new projects
- How the region approaches growth will have impact on VMT and GHG emissions

Next Steps

- **Phase 2: Pathways to Greenhouse Gas (GHG) Reductions**
  - Literature review
    - State and local climate planning
    - Climate planning in other regions
    - National policies
  - Technical Analysis
    - Mode Shift and Travel Behavior (VMT and Trip Reduction)
    - Vehicle Fuel, Fuel Efficiency, and Vehicle Technology
    - Operational Efficiency

Erin Morrow

TPB Transportation Engineer
(202) 962-3793
emorrow@mwcog.org

Dusan Vuksan

TPB Transportation Engineer
(202) 962-3279
dvuksan@mwcog.org

Mark Moran

TPB Travel Forecasting and Emissions Analysis Program Director
(202) 962-3392
mmoran@mwcog.org

mwcog.org/tpb

Metropolitan Washington Council of Governments
777 North Capitol Street NE, Suite 300
Washington, DC 20002

National Capital Region
Transportation Planning Board