# What Would it Take?

## Transportation and Climate Change in the National Capital Region

# Final Report

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National Capital Region Transportation Planning Board

Metropolitan Washington Council of Governments

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The Metropolitan Washington Council of Governments (COG) is the regional organization of the Washington area's major local governments and their governing officials. COG works toward solutions to such regional problems as growth, transportation, the environment, economic development, and public safety. The National Capital Region Transportation Planning Board (TPB) conducts the continuing, comprehensive transportation planning process for the National Capital Region under the authority of the Federal-Aid Highway Act of 1962, as amended, in cooperation with the states and local governments.

**ABSTRACT:**
This document provides a summary of the development, analysis and results of the "What Would it Take?" scenario, which is one of two scenarios in the TPB Scenario Study. This scenario examines what it would take in the National Capital Region to meet aggressive regional climate change mitigation goals in the transportation sector. This report includes a baseline inventory and forecast of carbon dioxide emissions in the region, identification and analysis of potential mitigation strategies, and an analysis of whether any combination of these strategies meets long-term mitigation goals. The report also includes cost-effectiveness analysis of these measures and specifically identifies short-term measures that can be feasibly implemented by local governments in the region.

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# Executive Summary

The "What Would it Take?" (WWIT) scenario is the first step toward answering major questions about transportation and climate change mitigation in the Washington metropolitan region. This study was undertaken by the TPB and led by the TPB Scenario Study Task Force in 2007 in direct response to growing concern about climate change and a desire to position the region for early action. The WWIT study was developed as an important part of a comprehensive COG climate change effort, but provides transportation sector specificity to better understand what could work to reduce mobile carbon dioxide ($CO_2$) emissions in this region.

As one of two scenarios in the current TPB Scenario Study, this study examines what it would take in the transportation sector to meet aggressive regional climate change goals. These regional goals were created as part of the 2008 National Capital Regional Climate Change Report and include a short-term, intermediate and long-term target for reducing $CO_2$ emissions based on international scientific consensus. The scenario uses these goals to create a 20-year cumulative reduction goal from 2010 through 2030. With this goal in mind, the scenario includes analysis of transportation strategies, such as higher vehicle fuel efficiency, increased use of alternative fuels, and increased public transit usage and provision to determine their $CO_2$ emissions reduction potential, cost-effectiveness, and the timeframe for implementation.

The outcome of this analysis is the identification of effective and cost-effective transportation strategies for climate change mitigation that can be adopted by state and local jurisdictions in the region. The results will not only provide the region with an indication of what may be necessary to achieve climate change goals, but also with a menu of strategies that can be adopted in the short- and long-term. It is important to note that not all of the strategies examined in this study are necessarily feasible or desired by every jurisdiction. This study is intended to be a first step for local planners and officials to determine what types of strategies should be explored further as a response to climate change at the local level, and is thus not a replacement for case-by-case analysis.

As the first major climate change and transportation study for the Washington region, the WWIT study began by framing the problem and involved the following analytical steps:

1. Creating a baseline inventory of mobile source $CO_2$ emissions
2. Determining sources of reduction potential
3. Identifying potential reduction strategies

4. Analyzing individual strategies for effectiveness, cost-effectiveness, and timeframe for implementation
5. Combining additive strategies to determine different pathways toward approaching or meeting goals

This study includes the first mobile $CO_2$ emissions baseline inventory and forecast for the region. This baseline includes an analysis of the current long-range plan, recently adopted national CAFE standards, and transportation emission reduction measures implemented throughout the region for the purposes of reducing other types of air pollutants. The study found that the final baseline, particularly the new CAFE standards, fills part of the gap between business as usual and regional climate change goals.

The study also examined specific sources of emissions in the region, which enabled a more comprehensive determination of reduction opportunities. Three broad sources of emissions were examined: fleet composition, fuel used, and use of the fleet. The study found that heavy duty vehicles are forecast to account for a growing share of emissions over time as light duty vehicles become cleaner. Additionally, although recent energy legislation increases the forecast use of less carbon intensive alternative fuels in the future, gasoline is still forecast to be the dominant transportation fuel across the nation. Lastly, the study found that current travel behavior can benefit from efficiency improvements to reduce $CO_2$ emissions. For instance, it is forecast that many short trips (under three miles) are taken by automobile, a portion of which could be shifted to non-polluting modes. Traffic congestion or frequent stop-and-go driving is also a major source of emissions, since $CO_2$ is quite sensitive to vehicle speeds. Therefore, operational strategies to improve traffic flow could also deliver emissions benefits.

Over fifty individual strategies were identified and analyzed according to three categories of fuel efficiency, alternative fuels, and travel efficiency. The measures studied in this scenario do not represent the full universe of strategies that can be considered for the purposes of reducing $CO_2$ emissions, but instead are a first step. Following analysis of the effectiveness, cost-effectiveness and timeframe for implementation for each strategy, they were grouped in order to determine if they could meet the regional goals. Four groups were analyzed:

1. **No further federal/local action**: Legislation already adopted remains unchanged until 2030, including CAFE standards and alternative fuel standards.
2. **High federal role**: Current legislation is augmented with longer term policies, such as an extension and enhancement of CAFE standards, heavy duty vehicle CAFE standards and national gas price increases.
3. **Short-term regional actions**: Strategies that are implementable by state and local governments before 2020
4. **Long-term regional actions**: Strategies that are implementable by state and local governments between 2020 and 2030

Results of these four groups highlighted a few major issues and findings that can instruct future action in this region. The first grouping sets the maximum conceivable regional burden for action and shows that major reductions will still be necessary if aggressive federal action is not taken. The second grouping (high federal role) illustrates the effectiveness of aggressive federal measures, which are large in scope and therefore impact. However, while this grouping comes close to meeting the regional goals, it does not meet early targets and therefore does not achieve the region's 20-year reduction goal. The last two groupings (short and long-term regional actions) show the potential of state and local governments to make significant contributions to meeting regional goals. Although neither meets the goals, the short-term strategies position the region toward meeting early targets. These strategies, therefore, provide a menu for potential actions that can be done quickly across the region. It is also important to note that many of these strategies are very small-scale and can thus be implemented more quickly and easily than large infrastructure projects. Finally, an initial cost-effectiveness analysis was also provided in order to begin the discussion on prioritizing strategies and projects. The study found that many strategies can be done relatively cost-effectively; however, most, if not all, transportation strategies will have multiple benefits worth examining.

Major findings from the study include:

- Additional strategies would need to be analyzed and incorporated into the study groupings in order to meet the region's $CO_2$ reduction goals.
- The short-term regional actions grouping shows the ability of local governments to achieve important early targets if a wide range of early actions is taken immediately.
- It is unlikely that the goals can be achieved with any one of the categories of strategies; instead it will take a more aggressive approach across all three categories.
- Transportation strategies will have various other benefits from criteria pollutant reduction to increasing mobility and accessibility that should be factored into decision-making.

# Table of Contents

# List of References


1. Preliminary Analysis of Potential Transportation-related Greenhouse Gas Reduction Strategies for the Washington, DC Region, Transportation Planning Board draft, February 2010
2. Light-Duty Diesel Vehicles: Efficiency and Emissions Attributes and Market Issues, U.S. Energy Information Administration, February 2009, http://www.eia.doe.gov/oiaf/servicerpt/lightduty/execsummary.html
3. 2009 Constrained Long Range Plan, Performance Analysis, Transportation Planning Board, http://www.mwcog.org/clrp/performance/
4. Barth, Matthew et al. "Traffic Congestion and Greenhouse Gases." Access 35, University of California Transportation Center, Fall 2009
5. TERM Section-Appendix A and B of Call for Projects 2009 CLRP & FY 2010-2015 TIP, Appendix B TERM Reporting – TERM Tracking Sheet.
6. National Capital Region, Climate Change Report, Prepared by the Climate Change Steering Committee for the Metropolitan Washington Council of Governments Board of Directors Adopted November 12, 2008
7. Analysis of Potential Transportation Emissions Reductions Measures (TERMs) Under Consideration for the 2009 CLRP & FY2010-15 TIP
8. Global Climate Change Impacts in the United States, U.S. Global Change Research Program. Cambridge University Press, 2009
9. An,Feng and Sauer, Amanda. "Comparison of Passenger Vehicle Fuel Economy and Greenhouse Gas Emission Standards around the World." Pew Center on Global Climate Change, 2004.
10. The Kiplinger Letter, Volume 86, Number 47. Washington, DC: November 20, 2009.
11. Interagency Working Group on Social Cost of Carbon, United States Government, "Appendix 15A: Social Cost of Carbon for Regulatory Impact Analyses Under Executive Order 12866", 2010.
12. Summary of Carpool Trends, MIT Real-Time Rides Research, May 2009, http://ridesharechoices.scripts.mit.edu/home/histstats#post170

# What is the "What Would It Take" Scenario?

The issue of climate change is becoming increasingly well accepted as a major environmental threat to every place on the planet. As awareness has grown, so have the questions from policymakers, planners, and citizens. What can we do on each of these levels, from individual behavior changes to large-scale regulatory action, to reduce the impact of global climate change? How much do we have to do to prevent the most catastrophic climate change that is possible if we do nothing? How much action can we take without inflicting intolerable damage to the region's economy? Will we be able to adequately mitigate climate change impacts in this region?

When addressing these questions it becomes immediately evident that just as climate change affects every place on the planet, it also affects every sector—transportation, electricity, agriculture, and many others. And just as it does not affect every place equally, the contribution to the problem, burden of responsibility and ease of action are vastly different for each sector. So while an integrated approach to climate action will be necessary, the knowledge-building phase of planning will require detailed sector-specific analysis.

The "What Would it Take?" (WWIT) Scenario is the first step toward answering some major questions about climate change mitigation specifically in the transportation sector in the Washington metropolitan region. The transportation sector poses unique challenges, such as the infrastructural entrenchment across the nation of carbon intensive fuels, as well as mode choices and travel behavior that are inextricably linked to other sectors, such as housing and land use. Additionally, while there have been national level studies aimed at the carbon dioxide ($CO_2$) emissions of the transportation sector specifically, the travel patterns, energy sources, mode splits, and land use patterns are different in every state, region and local jurisdiction. These localized transportation characteristics play a major role in determining the extent to which a particular strategy can work at reducing $CO_2$ emissions.

The WWIT study provides this regional and sector specificity for a wide range of transportation strategies. As one of two scenarios in the current TPB Scenario Study, this study examines what it would take in the transportation sector to meet aggressive regional climate change goals. As part of this study, the TPB has undertaken $CO_2$ emissions analysis for individual transportation strategies, such as higher vehicle fuel efficiency, increased use of alternative fuels, and increased public transit usage and provision to determine their emissions reduction potential, cost-effectiveness, and the timeframe for implementation. The specific methodology and strategy-specific results are outlined in the study's technical report (Reference 1).

The goal of the study is to provide objective analysis of a wide variety of strategies to assist decision-makers with the transportation component of local and regional multi-sector sustainability plans. Not all of the strategies examined in this study are necessarily feasible or desired by every jurisdiction. This study is intended to be a first

step for local planners and officials to determine what types of strategies should be explored further as a response to climate change at the local level, and is thus not a replacement for case-by-case analysis.

# Why Ask the Question?

Transportation is one of the largest emitters of $CO_2$ emissions in the region, nation, and world, at between one quarter and one third of all emissions, depending on the geographic scale. It is clear that regardless of the eventual target set for transportation at the national level, the transportation sector will have to do *something*. It is thus important to find out what is possible—in terms of technological, financial and political feasibility.

In response to growing concern and a desire to position the region for early action, the WWIT study was developed by the TPB Scenario Study Task Force to specifically begin addressing climate change in the regional long-range transportation planning process. The Task Force was created in December 2007 to provide policy-level stewardship for the continuation of the Regional Mobility and Accessibility Study (RMAS)[1], and specifically to respond to emerging issues, such as climate change.

This study was developed as an important part of a comprehensive COG climate change effort, including the approval of the COG Climate Change Report in November 2008. Among the most important contributions of this regional report is the attempt to answer the primary question of: How much do we have to do to prevent the most catastrophic climate change that is possible if we do nothing? Based on international and national consensus around CO2 emissions targets regional leaders adopted similar, but voluntary regional carbon dioxide ($CO_2$) reduction targets. The report also began the discussion on tackling climate change in each sector and provided a comprehensive list of potential strategies for each sector, including transportation.

Building from the COG Climate Change Report, the WWIT scenario specifically examines what it would take in the transportation sector to meet the aforementioned CO2 targets. The outcome of this analysis is the identification of effective and cost-effective transportation strategies for climate change mitigation that can be adopted by state and local jurisdictions in the region. The results will not only provide the region with an indication of what may be necessary to achieve climate change goals, but also with a menu of strategies that can be adopted in the short-term and in the long-term.

This report provides an overview of the study development, methodology, and results. An appendix detailing the analysis for each strategy is provided at the end.

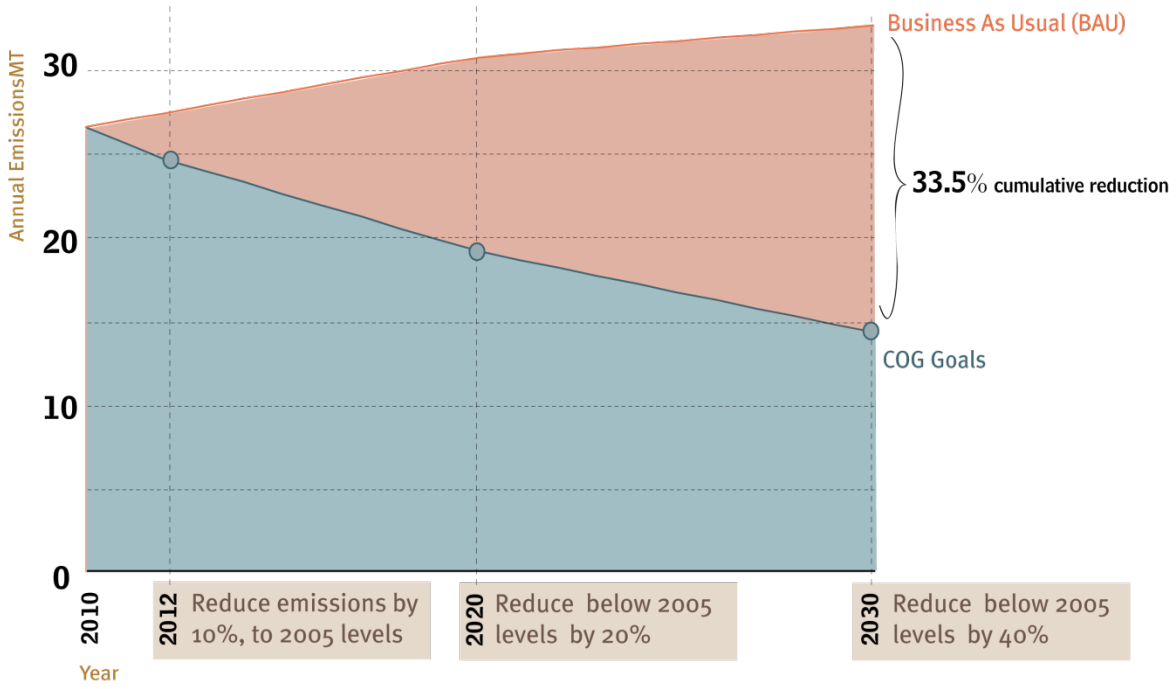
[1] RMAS is a transportation and land use scenario study begun by the TPB in 2001 and completed in 2007. The study examined five different land use scenarios with complimentary transit improvements. More information on this study is available here: http://www.mwcog.org/transportation/activities/regional/

# What are the Region's Climate Change Goals?

The COG Climate change report outlines short, medium and long-term regional emissions reduction targets. These targets are to reduce annual regional $CO_2$ emissions to 2005 levels by 2012, 20% below 2005 levels by 2020, and 80% below 2005 levels by 2050. The WWIT study uses these same reduction targets, but importantly only extends analysis out to 2030 due to travel demand modeling limitations. Therefore, the final target for this study is a 40% reduction below 2005 levels by 2030.

It should be noted that this study simplistically assumes an equal mitigation burden across sectors regardless of cost-effectiveness. The enormity of the transportation sector's emissions contribution will mean that at the very least, some reductions will need to come from this sector. However, as national-level studies have shown, the transportation sector presents greater difficulty in reducing emissions at a reasonable cost than other sectors, such as electricity generation. Therefore, it is unclear whether each sector will have equal reduction targets, or if transportation will be given a lesser climate change mitigation obligation. For the purposes of this study, transportation targets are assumed to be equal to the overall regional targets.

**Chart 1** COG $CO_2$ Reduction Goals



The chart above illustrates the chasm between the regional goals and business as usual projections, which represent forecast emissions with the current long-range plan, but no new federal CAFE standards or regional emission reduction measures. The reduction required to meet the COG goals is quite large, with a *cumulative* reduction of 33.5% over the twenty year period from 2010-2030, represented by the pink wedge. This wedge highlights the importance of each of the targets, which when applied internationally are intended to achieve the maximum acceptable atmospheric $CO_2$ concentration to prevent the most catastrophic effects of global warming. Analysis under this study was done on a cumulative basis, which is discussed in further detail in the next section. It should also be noted that this chart only displays $CO_2$ emissions. Although $CO_2$ is not the only greenhouse gas (GHG), only a few percentage points of regional mobile GHG emissions are from gases other than $CO_2$.

# Analytical Framework

In order to determine what may be necessary to meet these aggressive regional climate change mitigation targets, this study was conducted according to a simple set of steps:

1. Creating a baseline inventory of mobile source $CO_2$ emissions
2. Determining sources of reduction potential
3. Identifying potential reduction strategies
4. Analyzing individual strategies for effectiveness, cost-effectiveness, and timeframe for implementation
5. Combining additive strategies to determine different pathways toward approaching or meeting goals

This section details the above process; however, a more detailed technical report that provides the methodology and results for each strategy analyzed is available as a companion to this report. The technical report, "Preliminary Analysis of Potential Transportation-related Greenhouse Gas Reduction Strategies for the Washington, DC Region" (Reference 1) can be found here: http://www.mwcog.org/transportation/scenariostudy.

## 1. Developing the Baseline

In order to determine the emissions reductions that will be necessary in the future, the first step in the scenario analysis was to see what emissions levels are likely to look like in the future by developing the mobile GHG inventory and baseline forecast of emissions in the region. This analysis began in 2008 using the regional travel demand model outputs for the 2008 CLRP as the starting point. However, external factors over time required some re-benchmarking throughout 2008 and 2009. First, new CAFE standards were passed by Congress at the end of 2007 requiring 35 mpg by 2020. These CAFE standards were further strengthened in 2009 through GHG emissions standards that translate to 35.5 mpg by 2016. Lastly, new analysis of regional fleet characteristics in 2008 showed that with a troubled economy fleet turnover was not happening as rapidly as in the past. This translated into slightly higher than expected (though still declining) emissions rates over time. Final baseline inventories using the EPA MOBILE model version 6.2 were developed for 2005, 2010, 2020 and 2030. MOBILE6 is an emission factor model for predicting gram per mile emissions of Hydrocarbons (HC), Carbon Monoxide (CO), Nitrogen Oxides ($NO_x$), Carbon Dioxide ($CO_2$), Particulate Matter (PM), and toxics from cars, trucks, and motorcycles under various conditions. This model is EPA's official model for use in State Implementation Plans (SIP) and air quality conformity assessments and is thus the primary emissions model used by TPB.

### Step 1: Business as usual

In developing the $CO_2$ inventory, "business as usual" was first established. Under this scenario, business as usual (BAU) means that there would be no major changes to the forecast of travel management programs or vehicle fleet. The baseline uses the

modeling output for the 2009 CLRP and 2010-2015 TIP, which contain vehicle fleet forecasts based on 2008 vehicle fleet data and COG Cooperative Forecast Round 7.2 land use data. A detailed description of the Mobile 6.2 inventory development can be found in Appendix B of the technical report.

### Step 2: Account for new federal and regional developments

The second step was to determine the reductions in $CO_2$ emissions that would result from the improvement in vehicle fleet fuel economy as a result of the new federal CAFE requirement. Due to Mobile 6.2 constraints, this work was done using a spreadsheet tool developed by a consultant. Initially, the CAFE reductions were based on achieving 35 mpg by 2020 as specified in the 2007 Energy Independence and Security Act (EISA); however, the calculations were updated to reflect the proposed joint rulemaking between DOT and EPA which would improve the CAFE to 35.5 mpg by 2016. Calculations were also updated to use fuel efficiency forecasts based on the 2008 vehicle registration data.

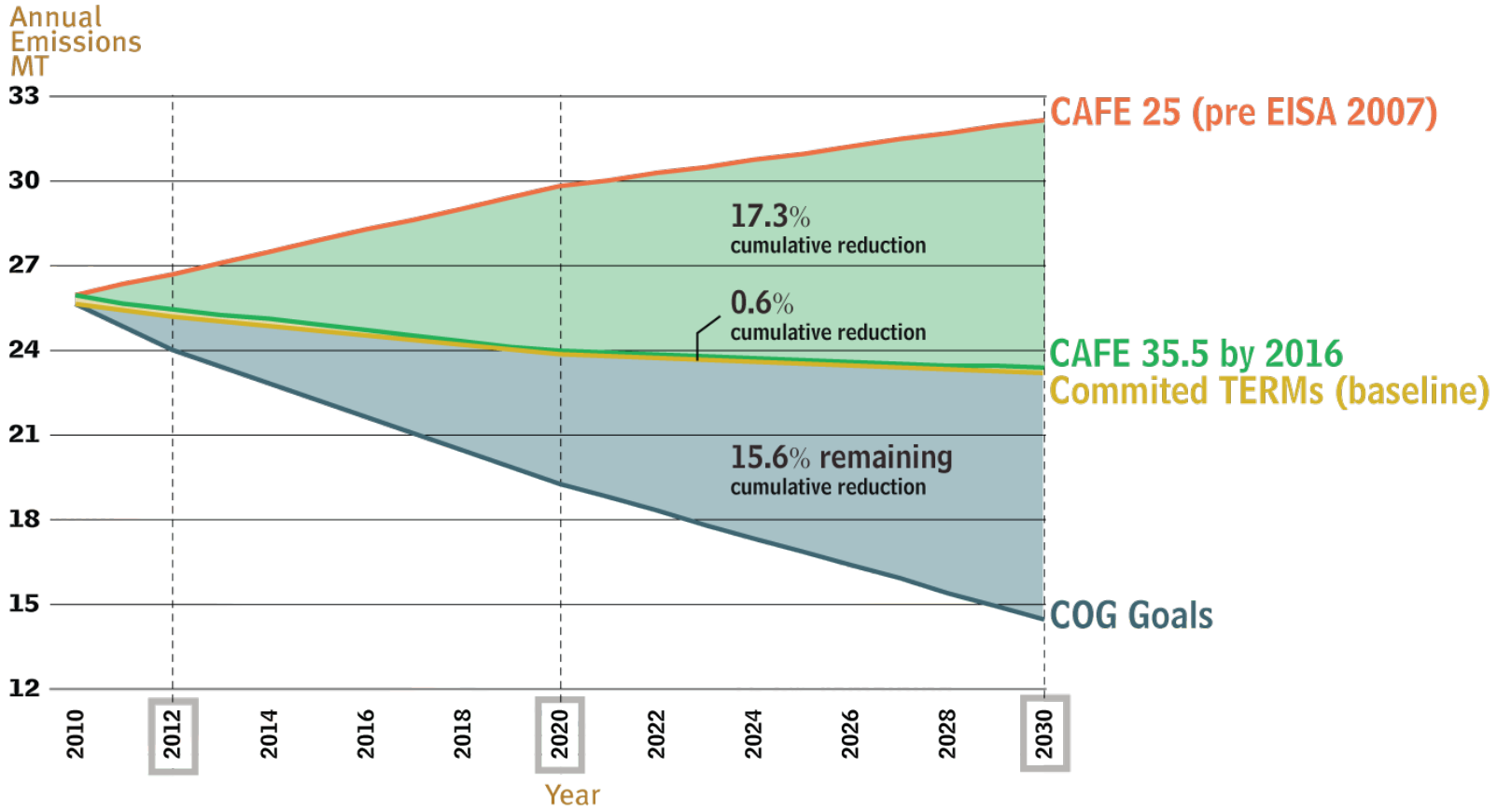
### Step 3: Add in regional air quality measures

The third step was to estimate the $CO_2$ reductions from the regionally committed Transportation Emission Reduction Measures (TERMs) as listed in the TERM Tracking Sheet. TERMs are measures implemented throughout the region for the purposes of reducing criteria pollutants, which are now being studied for their CO2 reduction potential. These TERMs were put into place after the last travel demand model calibration and thus are not reflected in the model and must be accounted for separately.

### The final baseline fills part of the gap between BAU and regional goals.

Chart 2 shows the results of each of the three steps for calculating the "Final Baseline" as well as the COG goals for 2020 and 2030 and the required reductions to meet those annual goals. After accounting for reduction commitments already made, both at the federal and local level, the region is left with a significantly lower reduction goal than it began with: instead of a 33.5% reduction in total 2010-2030 emissions from BAU levels to meet COG goals, 15.6% is now required. Recent strengthening of CAFE standards reduces BAU emissions by 17.3% over the twenty year period and the regionally committed TERMs reduce emissions further by 0.6%. While these two reduction sources make a significant contribution toward meeting regional climate change goals, they do not achieve the goals alone. In order to meet those goals, a further 15.6% total emissions reduction below BAU levels, from 2010-2030, would be required, as illustrated by the bottom wedge in the chart 2.

**Chart 2** Calculating the Final Baseline $CO_2$ Emissions Forecasts



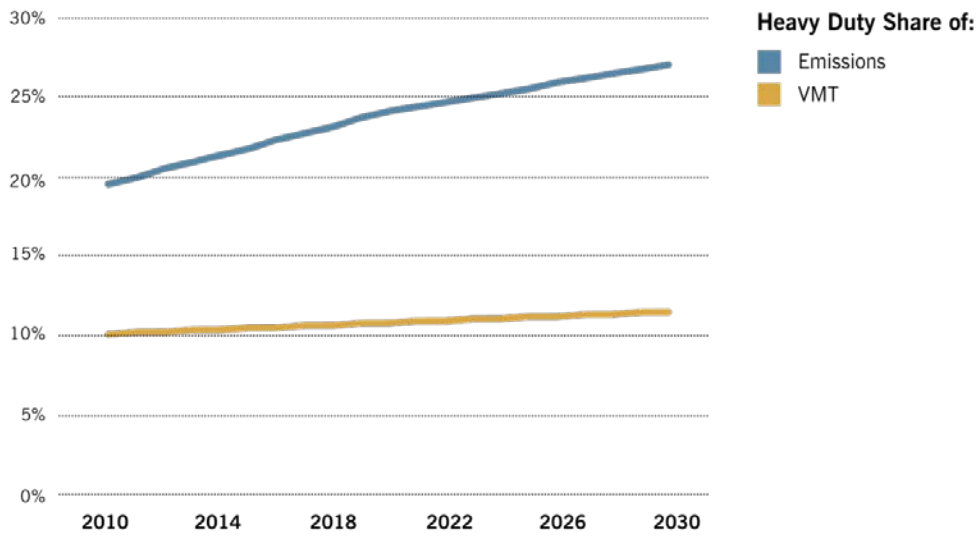
## 2. Identifying Sources of Potential Emissions Reductions

After identifying the $CO_2$ reduction necessary to meet regional climate goals, a thorough understanding of where emissions are coming from is essential to developing a comprehensive list of potential reduction strategies for analysis. Mobile $CO_2$ emissions are generally affected by fleet composition, fuel choice, and how the fleet is used.

### Fleet composition

The regional fleet is comprised of light duty vehicles, such as passenger cars and SUVs, and heavy duty vehicles, such as buses and trucks. As seen in the previous chart, a great deal of progress toward our climate goals can be achieved by making the light duty vehicles purchased and driven in this region more fuel efficient. While this accomplishes a great deal, it also ignores a growing source of emissions in the region and the nation as a whole. Light duty vehicles currently account for 90% of VMT, but only 80% of emissions. In 2030, absent fuel economy standards for heavy duty vehicles, trucks and buses are projected to remain at 10% of VMT, but will account for a growing share of $CO_2$ emissions at almost 30%. This signals a major opportunity for future $CO_2$ reductions.

**Chart 3** Heavy Duty Share of Total VMT and $CO_2$ Emissions

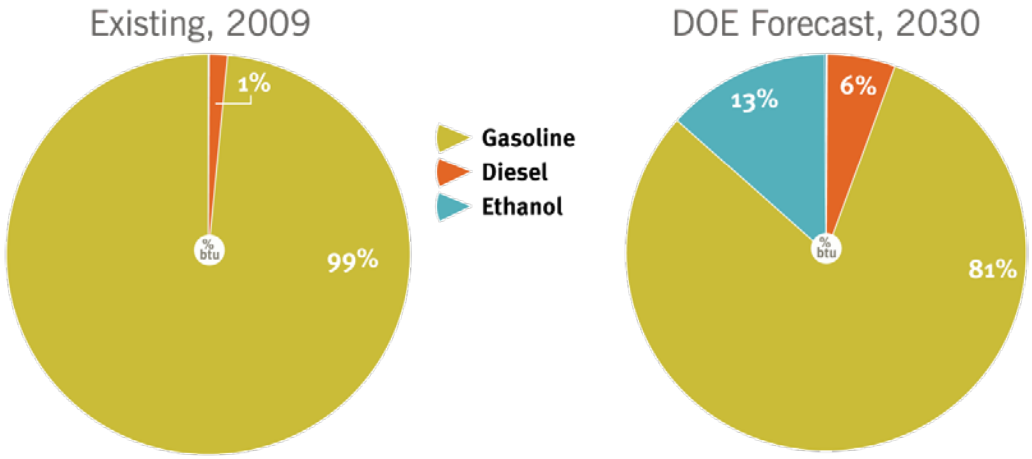


## Energy sources

Adding transportation energy sources that are less carbon intensive (such as some types of biofuel and electricity) to the region's transportation fuel portfolio can also offer major potential reductions. According to national data from the U.S. Department of Energy, in 2009 gasoline was the source of 99% of energy consumed in the light duty transportation sector. Even with significant alternative fuel mandates from the Energy Independence and Security Act of 2007, fuel use in 2030 is still projected to be dominated by gasoline at 81% of energy consumed in the light duty transportation sector. Chart 4 below shows significant penetration of ethanol and diesel in 2030 largely as a result of the federal Renewable Fuel Standard passed under the 2007 Energy Independence and Security Act (EISA). Higher penetration of diesel as a light duty fuel is also forecast for 2030. Diesel fuel has a higher energy density than gasoline and diesel engines are more fuel efficient than gasoline-powered engines, making diesel vehicles significantly more fuel efficient than gasoline vehicles. Greater sales of diesel vehicles in the U.S. are thus likely a result of higher CAFE standards as a method for auto-makers to meet these more stringent standards (Reference 2).

Even with higher ethanol and diesel percentages, there is still a great deal of room for increased alternative fuel use in this region. It must be noted that because this data is national level data, it does not reflect state mandates in this region to blend gasoline with 10% ethanol, which would likely result in a higher percentage of ethanol in 2009 than is reflected below.

**Chart 4** National Light Duty Fuel Mix

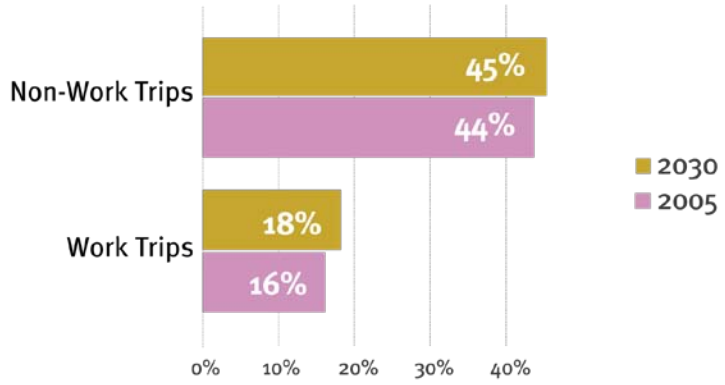


## Travel behavior

Lastly, *how* we travel can also have a significant impact on emissions. This includes many aspects of travel behavior and roadway operations, such as trip purposes, lengths, and mode, vehicle occupancy, congestion, and driving behavior.

Many of these aspects of travel behavior combine to illuminate potential planning strategies. For example, when examining trip lengths by mode it became clear that a large percentage of auto trips are less than three miles in length. Specifically, 45% of non-work trips and 18% of work trips are projected to be less than three miles in 2030. Given that the average bike trip length in the region, according to the 2007/2008 TPB Household Travel Survey, is around two miles, auto trips under three miles may have potential for mode shifts to non-polluting modes, including bicycling, walking, and low- or non-polluting vehicles if barriers to using these modes are overcome, such as urban design and land use issues.

**Chart 5** Percent of Auto Trips Under Three Miles in Length




Longer trips can also be targeted for shifts to less polluting modes, including not traveling at all, such as through teleworking. The performance analysis of the 2009 CLRP clearly shows the region heading for high levels of vehicular travel. In 2030, the region is still forecast to be dominated by SOV use, at around 87% of auto work trips and around 72% of all motorized work trips. While transit shares are forecast to grow, they still only represent a small share of trips, at 6% in 2008. Moreover, residential and commercial growth is forecast to be the fastest in the outer suburbs of the region where transit access is sparser than in the inner and core jurisdictions (Reference 3). Issues like transit access, commuter services, cycling and pedestrian infrastructure, and

financial signals or incentives to switch from SOV use to either HOV or transit are all potential sources of $CO_2$ emissions reduction.

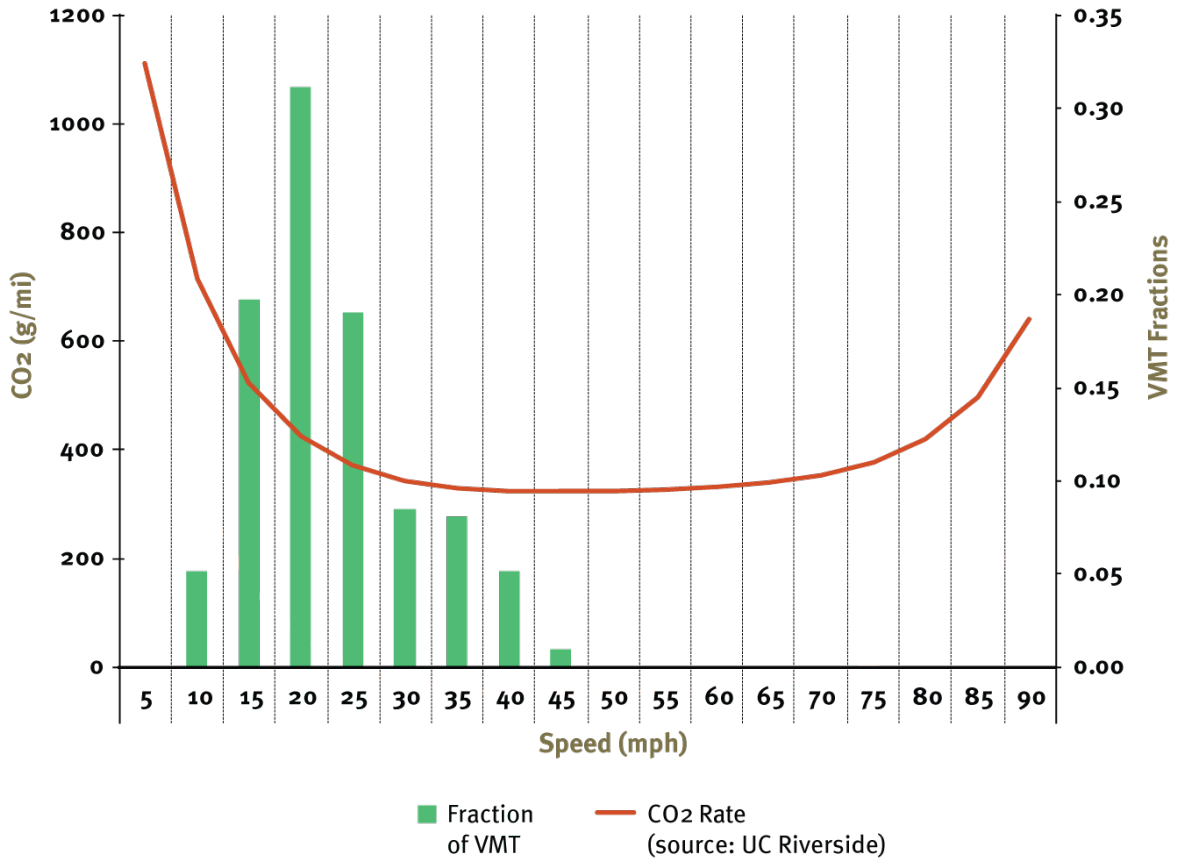
The number of auto trips taken in this region under less than optimal operating conditions, such as sitting in congestion, driving aggressively, or starting and stopping frequently at untimed signalized intersections also can have a significant impact on emissions. This is because since $CO_2$ emissions are a direct product of fuel combustion and vehicle fuel efficiency is sensitive to vehicle speed. Research from the University of California at Riverside shows that $CO_2$ emissions follow a U-curve, where, for a typical vehicle fleet, very slow vehicle speeds (less than 15 mph) can have up to twice the $CO_2$ emissions per mile of higher speeds (30-60 mph). Additionally, at speeds above around 60 mph, $CO_2$ rates begin to increase. This highlights three potential areas for $CO_2$ reduction by affecting vehicles speeds (Reference 4):

1. Congestion mitigation where speeds are very low, such as below 30 mph
2. Speed management where speeds are very high, such as above 60 mph
3. Traffic smoothing of stop-and-go traffic toward more even traffic flow

The first area of congestion mitigation is an important and obvious consideration for the Washington region, given the long history of being noted for long commutes and high congestion levels. Analysis of the 2009 CLRP includes forecast congestion for 2030, which shows congested conditions to be prevalent throughout the region. In chart 6, the 2030 forecast fraction of regional VMT by five-mile speed ranges for arterial roads is shown against the aforementioned U-curve of $CO_2$ rate by speed. It is clear that a large percentage of VMT on arterials is forecast at speeds between 10 and 25 mph, which corresponds with higher $CO_2$ rates than the in the 30-60 mph range. This highlights major opportunities in the future for congestion mitigation, particularly on the region's arterials.

In addition to congestion, other transportation supply issues and driver behavior can keep vehicles from driving at optimal fuel efficiency. If $CO_2$ rates are higher at very low and very high speeds, while congestion reduction addresses one extreme, is clear that measures addressing the other will also be necessary. The regional travel demand model assumes that 85% of vehicles travel above the speed limit under free flow conditions. Aggressive start and stop driving is also observed and probably practiced by many of the region's residents. National level studies on the potential for better vehicle maintenance, as well as more even, less aggressive driving behavior suggest this area as another potential source of reductions for the Washington region.

**Chart 6** $CO_2$ Emissions Rates by Speed and 2030 Fractions of VMT by Speed Range for Arterials (5pm-6pm)




## 3. Identifying Specific Reduction Strategies

Based on the above analysis and previous sources of transportation strategies, a list of strategies to be individually analyzed was developed. These strategies fall within three possible categories:

1. Vehicle Fuel Efficiency
2. Alternative Fuels
3. Travel Efficiency

The specific measures analyzed are the following:

### 1. Fuel Efficiency:

- **CAFE 55 mpg by 203o**: Assumes that after CAFE 35.5 mpg is achieved in 2016, CAFE standards are further strengthened to 55 mpg by 2030.
- **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
- **Local tax incentive for fuel efficient vehicle purchase:** Uses Arlington County as an example with their tax incentive program, where qualifying clean fuel vehicles receive substantial tax relief on the vehicle's assessed value

## 2. Alternative Fuels

- **High energy prices:** 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.

## 3. Travel Efficiency

*Increase transit use*

- **Metrorail feeder bus service:** At 2 underutilized park and ride lots and $0.50 morning 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:** 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:** Adds transit stores that provide traveler information and services using Arlington stores as the example

- **6 kiosks in MD**: Transportation information kiosks similar to ones in VA and DC
- **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.

*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.
- **Completion of 2030 Bike/Ped plan by 2020:** Accelerated completion of the TPB Bicycle and Pedestrian Plan by 2020 instead of 2030.

*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).
- **TPB Value Pricing Study:** 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.

*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.

*Reduce Travel*

- **Expanded Telecommuting:** 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:** Incentive program designed to increase number of vanpools in the region by offering $25/van/day.
- **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
- **CLRP Aspirations Scenario:** TPB land use and transportation scenario examining concentrated land use around a network of BRT and congestion pricing. Also includes a scenario of concentrated, transit-oriented land use without the new pricing, road capacity or transit services. This strategy also has a significant effect on transit and non-motorized mode share.

The measures studied in this scenario do not represent the full universe of strategies that can be considered for the purposes of reducing $CO_2$ emissions. This list above is an amalgam of strategies studied by TPB in the past for air quality conformity purposes and from ideas generated at other TPB and COG committees. Other strategies can and should be explored through the ongoing analytical process that this study initiated. Specifically, the strategies chosen for this first major study were derived from four primary sources. They include previously committed TERMs, a subset of potential TERMs, transportation strategies listed in the National Capital Region Climate Change Report, and strategies from local, regional and federal initiatives such as the CLRP Aspirations Scenario, TPB TIGER application, federal and local fuel efficiency policies, and alternative fuel use.

A detailed description of these four primary sources of strategies is below:

1. **TERM Tracking Sheet**

   Transportation Emission Reduction Measures (TERMs) are strategies or actions that the TPB has identified to specifically offset increases in nitrogen oxide ($NO_x$) and volatile organic compound (VOC) emissions from mobile sources. The TERM Tracking Sheet is the document used by the region to document all emissions reduction projects committed throughout the region (Reference 5). The most current evaluation of TERMs, completed in June 2009, can be found at: http://www.mwcog.org/transportation/activities/quality/terms.asp. Additional

information about the TERM tracking sheet can be found in the technical report (Reference 1).

**2. Analysis of Potential TERMs Under Consideration for the Conformity of the 2009 CLRP and FY 2010-2015 TIP**

This document contains the analysis of potential TERMs for the 2009 Constrained Long range Plan (CLRP) and FY 2010-2015 Transportation Improvement Program (TIP). The TPB has been adopting TERMs since FY1995 as a method for reducing ozone precursor emissions NOx and VOC. The Travel Management Subcommittee provides technical oversight of the TERMs analysis process and makes recommendations to the TPB Technical Committee. The Technical Committee then makes recommendations or endorsements of TERMs to the TPB for adoption. The TERMs in this document are potential measures, but have not been adopted. Additional information about the potential TERMs can be found in the technical report (Reference 1).

**3. National Capital Region Climate Change Report**

With the rapid growth in population, housing, employment, and energy use in Washington metropolitan region, COG forecasts that the total $CO_2$ emissions in the region will increase by 33 percent by 2030 and 43 percent by 2050 based on current "business as usual"(BAU) projections. The National Capital Region Climate Change Report (Reference 6) states that the resulting changes in the climate will have significant effects on the region's natural and built environments, all sectors of its economy, and its residents and families, communities, and workplaces. The full report can be found at: http://www.mwcog.org/uploads/pub-documents/zldXXg20081203113034.pdf

In addition to setting regional $CO_2$ reduction goals, the report contains fourteen recommendations for the transportation sector under the categories of Increase Fuel Efficiency and use of Clean Vehicles, Reduce Vehicle Miles Traveled (VMT) and Increase Travel Efficiency, a majority of which were analyzed by staff under this study. Additional information about the potential TERMs can be found in the technical report (Reference 1).

**4. Recent, Proposed, and Potential Regional Initiatives**

This fourth source of potential reduction strategies includes other TPB studies and initiatives, particularly those that included extensive modeling or analysis that could be readily translated into $CO_2$ emissions impacts. This list includes strategies such as TPB's recent TIGER Grant proposal submission, TPB's Value Pricing study, eco-driving, and federal forecasts such as the Alternative Energy Outlook.

A full list of strategies analyzed (excluding the full TERM tracking sheet) is provided in Appendix A.

## 4. Analysis Methodology: Individual Analysis of Strategies

Each individual strategy listed in the previous section was analyzed along three lines:

1. $CO_2$ emissions reduction potential
2. Cost-effectiveness per ton of $CO_2$ abated
3. Timeframe for implementation

Each measure was analyzed using sketch planning methods and existing programs as a model whenever possible according to a foundational set of assumptions regarding emission rates, travel patterns, and cost-effectiveness.

### 1. $CO_2$ Emissions Reduction Potential:

Strategies were first analyzed for their emissions reduction potential using sketch planning techniques. The strategy-specific methodology and assumptions are outlined for each strategy in Appendix A of the technical report. Additional information on overarching assumptions used across all of the emission reduction analyses, such as $CO_2$ emission rates can also be found in the technical report. All strategies were analyzed across a twenty-year time period from 2010-2030. Analysis beyond this point was not possible within this study because the regional travel demand model, which provides the basis for assumptions used in the sketch planning analysis, is currently only coded up to 2030. In 2010, the TPB travel demand model will extend forecasting another ten years to 2040 enabling a longer timeframe for future analysis.

### 2. Cost-effectiveness Assessment:

Measures were also assessed for their cost-effectiveness in terms of dollars of program or project cost per ton of $CO_2$ abated as a method of prioritizing the variety of possible interventions. Some strategies can serve as "low-hanging fruit" and provide relatively inexpensive benefits in the short term, such as telecommuting programs, as opposed to more complex, expensive, and longer-term measures, such as major infrastructure projects.

In most cases, the costs for the project were considered to be only the cost for the government or program administrator such as capital or operating costs. The user costs (or cost savings) were not factored in. The cost-effectiveness for each of the strategies was calculated for year 2020 in current year dollars, except for the examples from the TERM Tracking Sheet which have cost-effectiveness for 2010. The methodology for calculating cost-effectiveness can be found on page A-19 of the "Potential TERMs" document (Reference 7).

### 3. Implementation Timeframe and Cumulative Emissions Analysis:

Lastly, measures were analyzed over a twenty-year time period to determine the timeframe for implementation and also their cumulative reduction impacts. Experts have stated that the most prevalent GHGs, such as $CO_2$ and methane, behave differently than criteria pollutants, such as PM and $NO_x$, and thus require a different analytical framework. According to a report released by U.S. Global Change Research Program in 2009, "after emission, the atmospheric concentration of carbon dioxide remains elevated for thousands of years, and that of methane for decades" (Reference 8). Therefore, GHG emissions cannot be looked at on an annual basis as is the case with criteria pollutants, but rather should be considered cumulatively over much longer periods of time than is traditional in current planning processes.

Cumulative analysis highlights issues with the overall effectiveness of strategies that may not be apparent with simple point-in-time analysis. For example, when emissions are examined over time in a cumulative manner, early emissions reductions have a compounding effect upon future emissions levels. The early emissions reduction targets therefore assume greater importance in not only building political momentum but also in building the region's ability to practically meet the later 2020, 2030 and 2050 targets. The study thus emphasizes strategies across the study timeframe—both short and longer-term.

**Review of Strategy Analysis:**

All analysis of strategies was presented to the TPB Travel Management Subcommittee (TMS), the TPB Technical Committee, and the TPB Scenario Study Task Force (SSTF) for review as measures were analyzed. Measures from the TERM Tracking Sheet and the Potential TERM document underwent detailed review from the Travel Management Subcommittee prior to being adopted as TERMs or gaining approval as potential TERMs. Measures from the COG Climate Change Report were similarly reviewed by TMS. Other measures were reviewed by the TPB Technical Committee.

## 5. Grouping Strategies for Final Analysis:

The problem of climate change is large enough and the goals aggressive enough that it is inconceivable that any one strategy alone will solve the problem. Therefore, looking at only individual results is somewhat meaningless. The region will no doubt need to implement a suite of strategies.

Following individual analysis of strategies, combinations of strategies were constructed in order to determine the potential suites of strategies that meet the regional $CO_2$ reduction targets. Strategies were grouped along two different lines: level of government able to implement the strategy and timeframe for implementation. There are two sets of two different groupings, one examining the impacts of current and

potential federal actions and one examining short and long term regional/state/local actions. The four groups are as follows:

6. **No further federal/local action**: Legislation already adopted remains unchanged until 2030. This includes 2016 CAFE standards and the renewable fuel standard under the 2007 EISA.
7. **High federal role**: Current legislation is augmented with longer term policies, such as an extension and enhancement of CAFE standards, heavy duty vehicle CAFE standards and national gas price increases.
8. **Short-term regional actions**: Strategies that are implementable by state and local governments before 2020
9. **Long-term regional actions**: Strategies that are implementable by state and local governments between 2020 and 2030

A full list of the measures included in each grouping is provided in Appendix A. It is important to note that the groupings combine additive strategies to the extent possible at this time. It is possible that further combinations can be made to move closer to achieving regional goals, though careful analysis will be needed in order to avoid double-counting or overstating benefits. It should also be noted that each grouping represents only the additive impacts of strategies, rather than a true "bundling" of strategies, which would account for interactions, both positive and negative, between multiple strategies. Further explanation of both issues is included in the following "Results" section.

# Results

The four groupings outlined in the previous section were all analyzed to determine whether their cumulative reduction over the twenty-year study period would achieve the 15.6% remaining emissions reduction necessary to meet the COG goals.

## 1. No further federal/local action

Although it's (hopefully) unlikely that in the next twenty years the federal government would do nothing to further climate-related goals, this first grouping examines what the regional burden would be if federal action were to stand still. It includes strategies and legislation already adopted by the federal government and local governments to date. It assumes no additional action by state/local/regional agencies and no additional climate, energy or transportation legislation that would reduce $CO_2$ emissions. Chart 8 illustrates reductions associated with current federal and regional action.

The starting point for this analysis is the new CAFE and GHG emissions standard of 35.5 mpg by 2016 and the regionally committed TERMs, which are assumed in the study baseline and have already been discussed. Added to this analysis is an estimation of $CO_2$ reduction from increased alternative fuel use in the region resulting largely from the Renewable Fuel Standard (RFS) as part of the 2007 EISA. Among the largest RFS mandates is the increase in production of ethanol from 9 billion gallons in 2008 to 36 billion gallons in 2022. The basis for the forecast estimation is the national level forecast done by the U.S. Department of Energy (DOE) in its 2009 Annual Energy Outlook. A detailed explanation of this analysis is provided in Appendix A of the Technical Report.

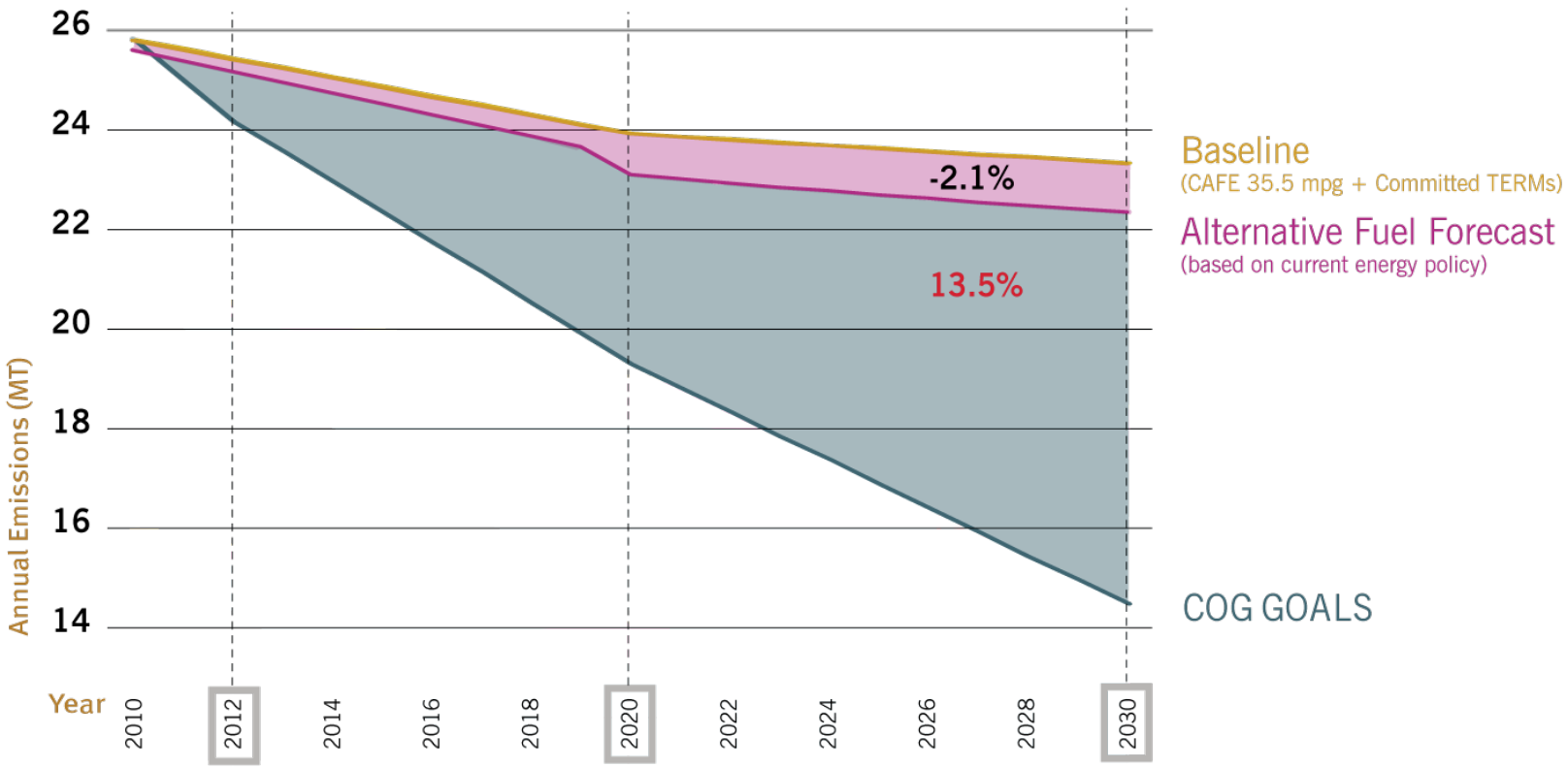
The U.S. DOE national-level results in a significant increase in alternative fuel/hybrid vehicle technology from less than 4% in 2010 to 25% in 2030 when applied to the Washington region. The forecast also includes an increase in diesel-fueled light duty vehicles from 2% in 2010 to 4% in 2030. Specifically, it is estimated that gasoline-hybrid vehicles, plug-in hybrid electric vehicles (PHEVs), ethanol-powered vehicles, and biodiesel-powered vehicles will increase significantly between now and 2030. It should be noted that these estimations are based on national-level data and therefore do not reflect regionally specific alternative fuel characteristics, such as the ethanol blending mandate currently in place throughout the region. As regional data becomes available, this analysis can be refined to better estimate regional conditions.

This alternative fuel forecast as applied to the region results in an additional 2.1% total emissions reduction from 2010-2030. It should be noted that several alternative fuel/hybrid vehicle types will be produced and sold by manufacturers as a method of meeting federal CAFE standards and thus were not included in the calculation of additional emissions reduction from alternative fuel vehicle usage.

These vehicles include (in addition to gasoline powered vehicles) gasoline-electric hybrids, PHEVs, and diesel vehicles.

The contribution of the U.S. DOE forecast leaves the region with 13.5% reduction left to meet the regional goal, which is down from the initial 15.6% reduction. Although this reduction is substantial, it is clear from chart 7 that none of the major regional targets are met and there is still a significant portion of the reduction goal left to achieve. As would be expected, significant additional action from both the federal and local/state/regional levels of government will be necessary if the region sets the study's goals for the transportation sector.

**Chart 7** "No Further Federal/Local Action" Grouping $CO_2$ Emissions from 2010-2030



## 2. High federal role

The "high federal role" grouping examines the impact of large-scale, aggressive action taken by the federal government. With strategies in each of the three categories of fuel efficiency, alternative fuels and travel efficiency, this grouping illustrates the opposite extreme from the first grouping, which showed the maximum regional burden than can be expected. This group shows what would probably amount to the smallest regional burden that can be expected. It includes three aggressive federal actions.

The first action is extending CAFE standards from the current 35.5 mpg by 2016 to 55 mpg by 2030. It was determined that this could be at least technologically, if not politically, feasible given similar vehicle standards in the European Union and in other countries, such as Japan and China. According to a 2005 study by the Pew Center for Climate Change (Reference 9), strict vehicle GHG emissions standards in the EU roughly translate to a fuel economy standard of over 50 mpg by 2012. Chart 10 illustrates the significant emissions reduction that could be expected with this aggressive CAFE standard. Beginning in 2020, this strategy reduces emissions by another 4% below BAU levels from 2010-2030.

The second action is the creation of an average fuel economy standard for heavy duty vehicles, which includes trucks and buses. As previously stated, heavy duty vehicles are projected to be the source of an increasing share of $CO_2$ emissions in the absence of federal regulation. The strategy examined in this study creates a CAFE standard for heavy duty vehicles similar to the current light duty standards. The standard is assumed to double current heavy duty fuel economy by 2020. This was assumed to be feasible based on language in the 2007 EISA requiring the National Academy of Sciences (NAS) to study and recommend heavy duty CAFE standards for adoption by Congress. Recent reports have indicated the likelihood that NAS will recommend a near doubling of current heavy duty fuel economy (Reference 10). The results of this strategy are illustrated in the second wedge in Chart 10, which shows a 4.2% reduction in projected $CO_2$ emissions below BAU levels from 2010-2030.

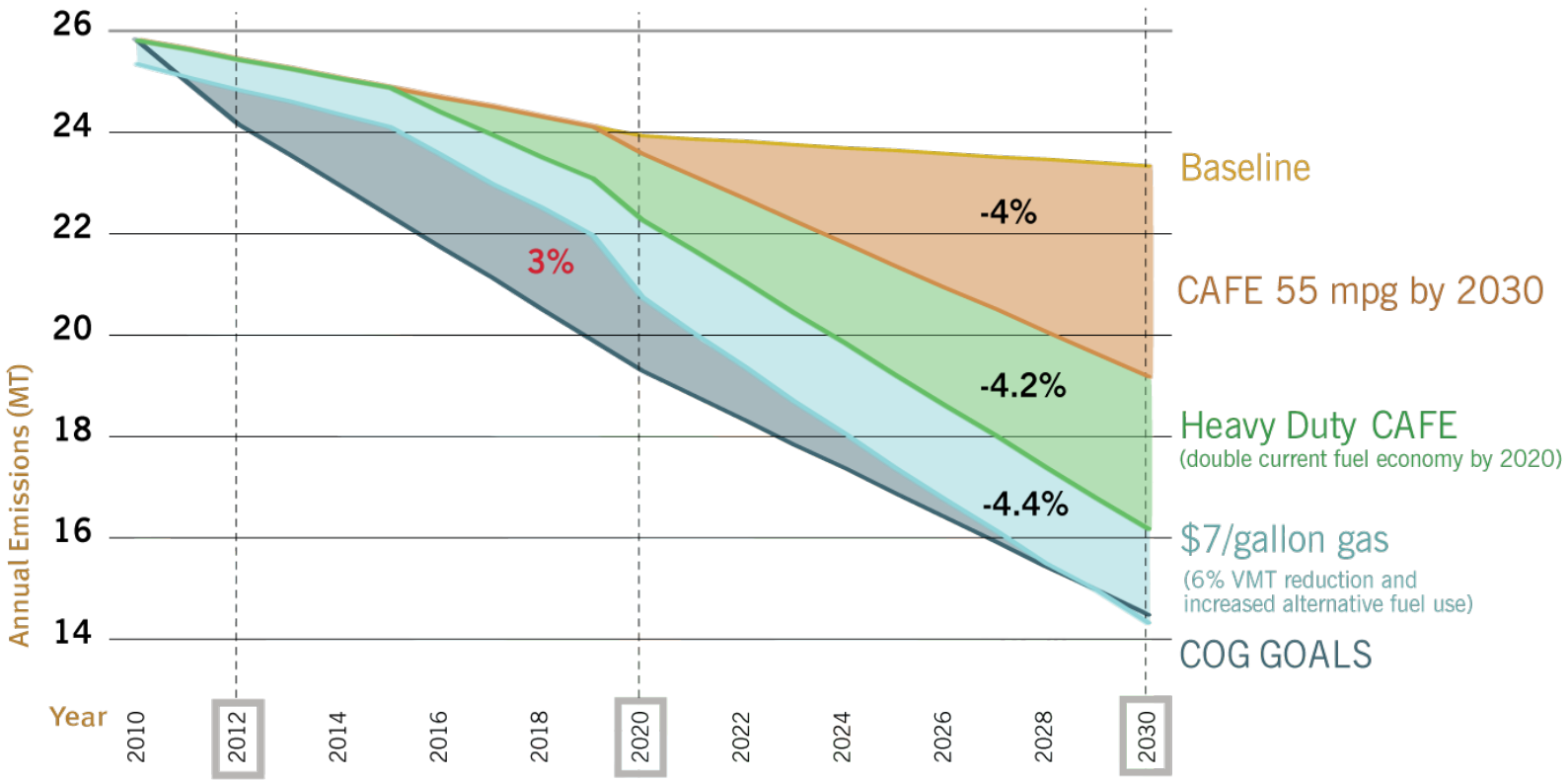
The third and final action in this grouping is the aggressive increase of oil prices to $200 per barrel, which roughly translates to increased gas prices of $7 per gallon. This analysis relies on national modeling of this scenario by the U.S. Department of Energy in their 2009 Annual Energy Outlook and therefore is similar in methodology to the alternative fuel analysis described in the first grouping and further detailed in the technical report (Reference 1). As may be expected of a national increase in gas prices, the results are two-fold: a 6% reduction in VMT and a significant increase in use of alternative fuel/hybrid vehicle technology. Specifically, gasoline-hybrid vehicles, PHEVs, ethanol-powered vehicles and diesel vehicles increase in use beyond what was forecast under normal conditions by U.S. DOE.

It should be noted that the 6% VMT reduction is a result of the national level models employed by U.S. DOE. This VMT reduction assumes less travel as a result of high gas prices. It does not assume specific regional travel demand strategies to offset

this VMT reduction with increased demand on other modes, such as increased transit, compact land use, or bike and pedestrian infrastructure. Therefore, it is assumed that the price increase will decrease VMT without assuming increased travel options to maintain the baseline level of mobility. The overall reduction from this increase in gas prices is 4.4% below BAU levels from 2010-2030, shown in Chart 8.

Chart 8 shows that these three actions combined significantly reduce $CO_2$ emissions to almost meet the overall regional emissions reduction goal. Together the actions achieve reductions in excess of the 2030 target; however, they do not ramp up fast enough to meet the 2012 or 2020 targets. Overall they reduce $CO_2$ emissions by 12.6%, 3% short of the regional reduction goal.

**Chart 8** "High Federal Role" Grouping $CO_2$ Emissions from 2010-2030



## 3. Short-term regional actions

The "short-term regional actions" grouping employs a different approach by focusing on actions that can be taken by local, state, or regional governments, rather than at the federal level. As a result, this grouping includes smaller scale strategies, rather than the very aggressive and sweeping changes possible at the federal level.

Strategies in this group are short-term, which is defined as projects and programs that are likely to be implementable in the next ten years (2010-2020). This group includes twenty-seven different strategies across five categories of:

1. Increase transit use
2. Increase bike/ped use
3. Pricing
4. Improve operation efficiency
5. Reducing travel

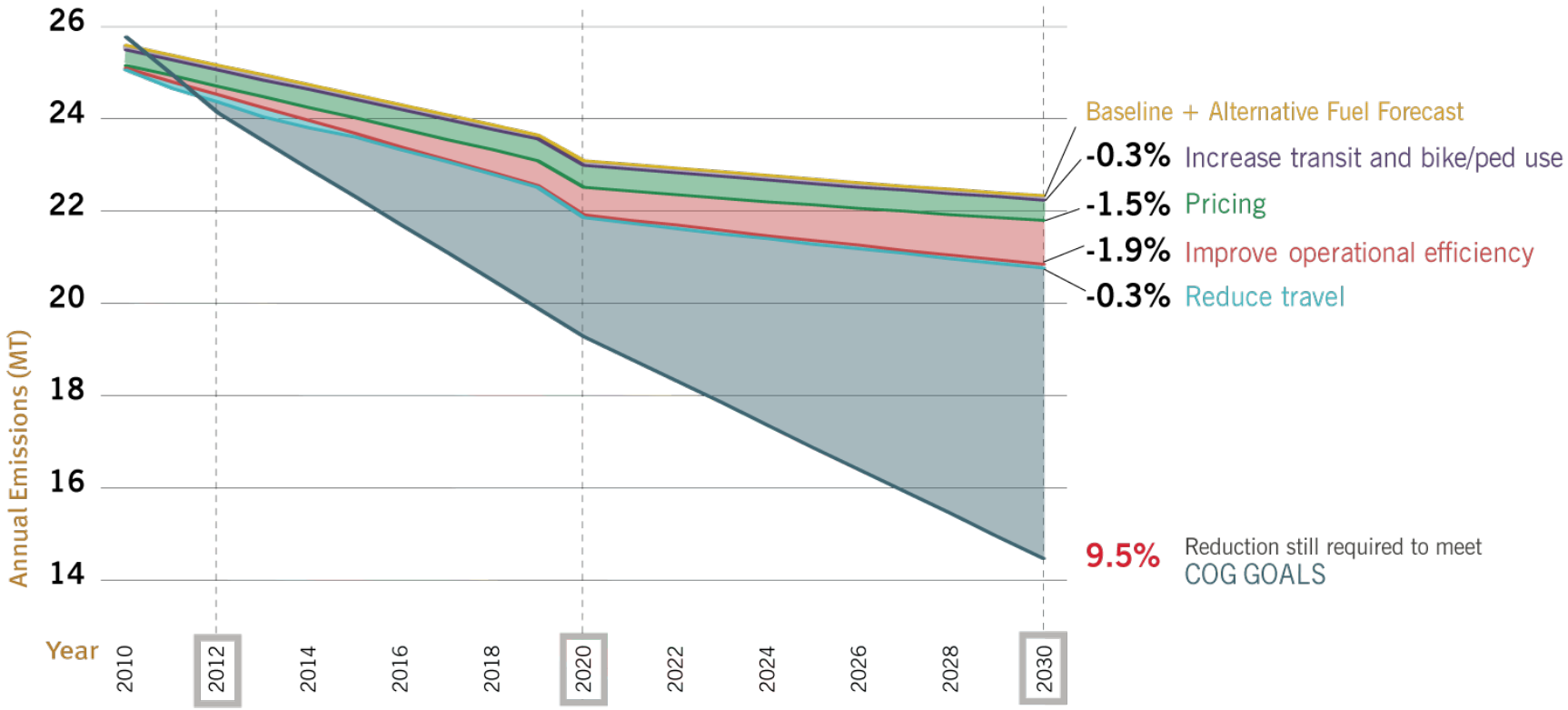
The first category includes many strategies intended to increase transit use, particularly on existing services, such as Metrorail feeder service, new cleaner-fueled WMATA buses, free bus service, priority bus treatments, among others. The second category (later grouped together with the first) includes measures that improve pedestrian and bicycle infrastructure, such as improved pedestrian access to transit, bike stations, bike sharing, among others. The third category includes various pricing strategies, such as parking cash-out subsidies, parking impact fees, and pay-as-you-drive insurance. The fourth category includes strategies intended to improve traffic flow to ensure more steady operating speeds, such as eco-driving incentives and promotion, idling reduction, regional incident management, and traffic signal optimization. The fifth category includes strategies that specifically reduce travel, such as carpool and vanpool incentives, telecommuting, and car-sharing. The full list of strategies and their descriptions can be found in Appendix A and in more detail in the technical report.

As seen in Table 1, the many short-term strategies combine to have a significant reduction in emissions, by 3.9% below BAU levels. While the strategies alone do not achieve the overall goal, they do meet the earliest, 2012 target, putting the region on the right track toward meeting the later targets. This is further illustrated in Chart 9.

**Table 1** $CO_2$ Emissions Reductions from Short-term Strategies

| | **$CO_2$ Emissions Reductions** (millions of tons) | | | | |
|---|---|---|---|---|---|
| | **2010** | **2020** | **2030** | **Cumulative Total, 2010-2030** | **% Reduction off of BAU levels** |
| Short-term Strategies: | | | | | |
| (1) Increase Transit use (13 measures) | -0.10 | -0.10 | -0.09 | -1.95 | -0.3% |
| (2) Increase Bike/ped use (3 measures) | -0.003 | -0.005 | -0.008 | -0.12 | -0.02% |
| (3) Pricing (3 measures) | -0.32 | -0.48 | -0.44 | -8.99 | -1.45% |
| (4) Improve Operational Efficiency (4 measures) | -0.07 | -0.59 | -0.95 | -11.61 | -1.87% |
| (5) Reduce Travel | -0.03 | -0.07 | -0.08 | -1.78 | -0.29% |
| | | | | | |
| TOTAL (all Short-term Strategies) | -0.52 | -1.24 | -1.57 | -24.45 | -3.9% |
| | | | | | |
| Reduction still required to meet goal | | 2.58 | 6.31 | 59.23 | 9.6% |

**Chart 9** "Short-term Regional Actions" Grouping $CO_2$ Emissions from 2010-2030



## 6. Long-term regional actions

The "long-term regional actions" grouping provides the complement to the above short-term strategies. These strategies are those that most likely would be implementable after 2020. Three categories of long-term strategies were examined:

1. Increasing non auto mode share
2. Pricing
3. Reducing travel

The first category includes major transit and bicycle/pedestrian infrastructure projects, such as a Metrorail expansion project and the accelerated completion of the TPB Bicycle and Pedestrian Plan. The second category includes the TPB Value Pricing Study, which studied the variable pricing of new and existing freeway and select arterial lanes throughout the region. The last category examines compact transit-oriented land use changes combined with major transit service improvements, increased road capacity, and region-wide variable road pricing through the TPB CLRP Aspirations Scenario.

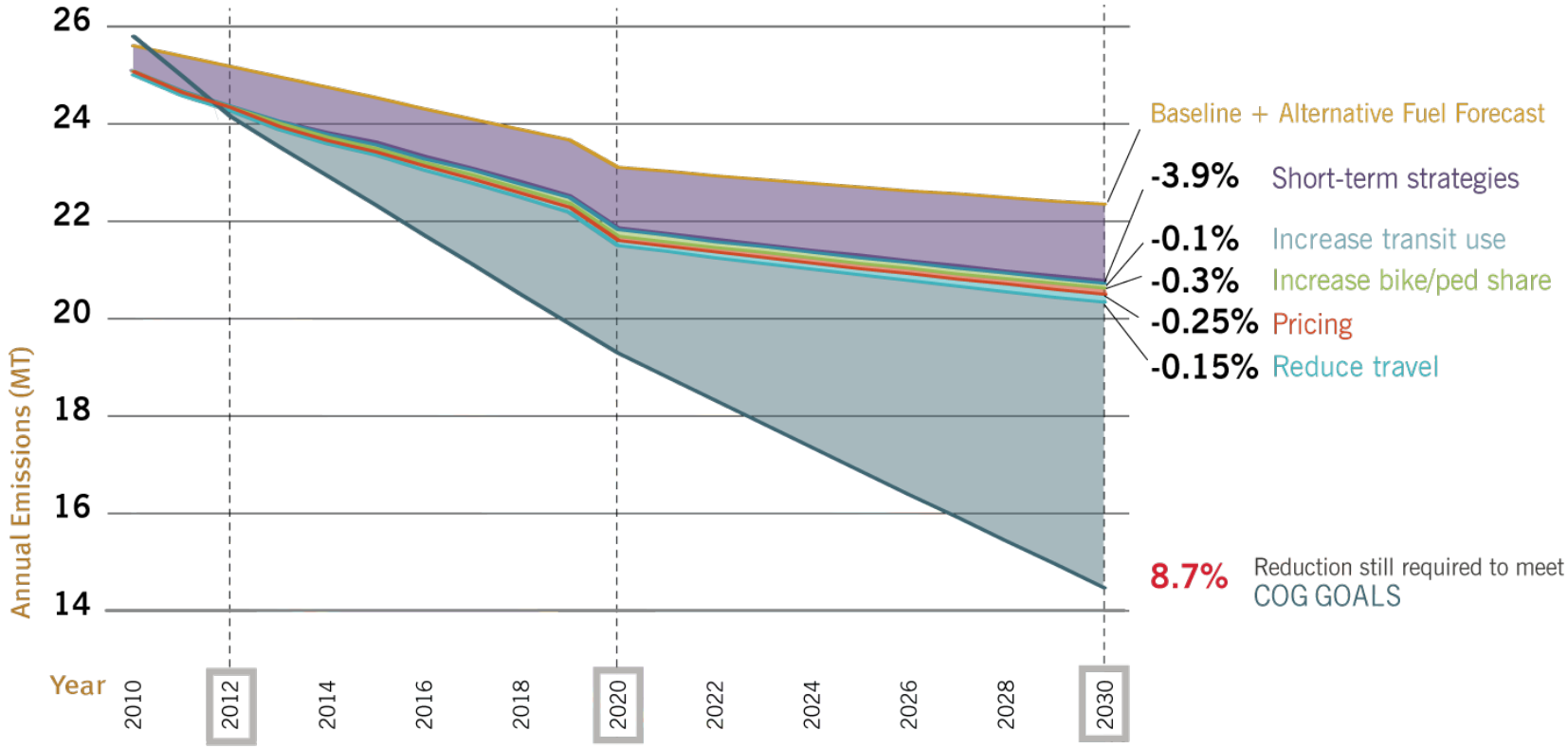
As seen in Table 2 and Chart 10, these strategies combine to achieve a 0.5% reduction below BAU levels. While this may seem low, significantly fewer longer-term strategies were studied than the almost thirty shorter-term strategies. Moreover, a few of the strategies studied were assumed to be completed in 2030, which is the upper limit of the study analysis time period. A ramp-up period leading up to 2030 was assumed for these measures; however, the full reduction potential is still only incorporated for one year, which does not adequately convey the long-term benefits. Beginning with the 2010 CLRP, plan modeling and analysis will also extend out for a full thirty years to 2040, which give future climate change analysis a longer and more appropriate timeframe.

Individual $CO_2$ reduction analysis and a more detailed description of each measure are also included in Appendix A and in the technical report. Additionally, more detailed discussion on how these types of strategies performed is included in the next section.

**Table 2** $CO_2$ Emissions Reductions from Long-term Strategies

| | **$CO_2$ Emissions Reductions (millions of tons)** | | | | |
|---|---|---|---|---|---|
| | **2010** | **2020** | **2030** | **Cumulative Total, 2010-2030** | **% Reduction off of BAU levels** |
| Long-term Strategies: | | | | | |
| (1) Increase Transit use (2 measures) | 0.00 | -0.05 | -0.05 | -0.81 | -0.13% |
| (2) Increase Bike/ped mode share (1 measure) | 0.00 | -0.12 | -0.11 | -1.85 | -0.30% |
| (3) Pricing (1 measure) | 0.00 | -0.08 | -0.11 | -1.48 | -0.24% |
| (4) Reduce Travel (1 measure) | 0.00 | -0.04 | -0.10 | -0.91 | -0.15% |
| | | | | | |
| TOTAL (all Long-term Strategies) | 0.00 | -0.29 | -0.36 | -5.04 | -0.8% |
| | | | | | |
| Reduction still required to meet goal | | 2.30 | 5.95 | 54.18 | 8.7% |

**Chart 10** "Long-term Regional Actions" Grouping $CO_2$ Emissions from 2010-2030



## Cost-Effectiveness Analysis

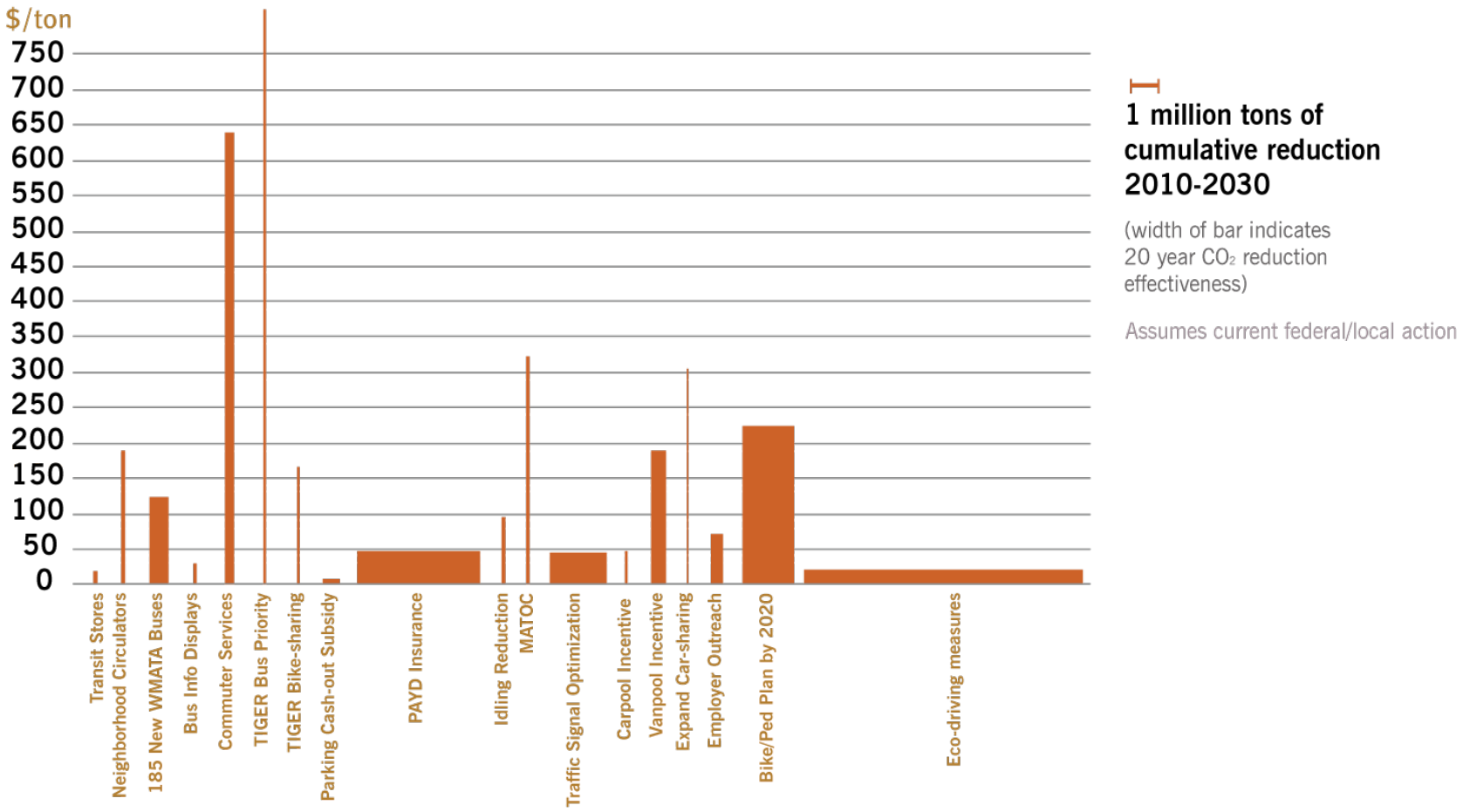
In addition to $CO_2$ reduction potential, strategies were also analyzed for their cost-effectiveness as a useful prioritization metric. In Chart 11, a subset of the strategies analyzed is shown in terms of cost-effectiveness (the length of the bars) and effectiveness at reducing $CO_2$ (the width of the bar). The shortest and widest bars represent strategies that could offer the greatest bang for the buck in terms of $CO_2$ reduction and could be considered low-hanging fruit for implementation.

Although it is unclear what the reduction expectation will be for the transportation sector, the ultimate decision on the federal level will likely be informed largely by some type of cost-effectiveness or cost-benefit analysis to limit unnecessary negative economic burden and impacts. Currently federal guidelines provide general direction on how to value carbon dioxide by setting values for the "social cost of carbon," which is an estimate of the monetized damages associated with an incremental increase in carbon dioxide emissions in a given year that factors in a wide range of impacts, such as agricultural productivity and human health (Reference 11). An interagency working group dedicated to this issue has set this value at around $21 in 2010, rising steadily to $45 in 2050 (discounted at 3%). This valuation provides a point of comparison for strategies across sectors and also a potential threshold for projects done for $CO_2$ reduction only; however, it does necessarily provide the appropriate guideline for transportation projects where multiple benefits will be realized. In the absence of a clear guideline as to where the cost threshold should be for such transportation projects, some strategies do emerge as attractive options relative to each other.

Pay-as-you-drive insurance is shown to be highly effective and with relatively low associated administration costs. Similarly, because traffic signal optimization improves roadway efficiency for the entire fleet, both light and heavy duty, the emissions reduction payoff is high, making the cost per ton relatively low. Other cost-effective measures include the parking cash-out subsidy measure and purchase of new compressed natural gas (CNG) WMATA buses. The accelerated completion of the TPB Bicycle and Pedestrian Plan also stands out as an effective strategy in the middle of the cost-effectiveness range.

Most measures demonstrated modest $CO_2$ reduction potential and thus show high cost-per-ton values. Since $CO_2$ emissions reductions are unlikely to be the sole justification for investing in transportation projects, other methods of weighing costs and benefits may be necessary. This issue is discussed in more detail in the next section.

**Chart 11** Cost-effectiveness Analysis for Subset of Individual Strategies (Cost per ton of $CO_2$ Abated)



# Discussion: What Would it Take?

Although none of the four groups of strategies meet the regional reduction goal, many strategies emerged as highly effective, and in many cases cost-effective. These strategies are clear potential starting points for regional action.

The study examined many different strategies that can be grouped according to the ultimate goal of the strategy, such as to reduce travel or increase transit use. Strategies performed differently as a result of their scope and scale, but each category provides overarching lessons that can be useful in evaluating strategies for adoption. Below follows a discussion of the performance of the major groups of strategies analyzed:

1. Fuel efficiency at the federal level
2. Alternative fuel use
3. Increasing transit use
4. Increasing non-motorized mode share
5. Pricing
6. Improving operational efficiency
7. Reducing travel

## 1. Fuel efficiency at the federal level

Given that $CO_2$ emissions are linearly linked to fuel consumption, increasing the efficiency of vehicles is a clear strategy for reducing mobile $CO_2$ emissions. For obvious reasons, the regulatory control of fuel efficiency standards rests with the federal government, leaving only smaller scale strategies for local governments to incentivize fuel efficient car purchase and use above and beyond federal standards. Under this study, several federal strategies and one local incentive strategy were analyzed.

The federal strategies were clearly found to be highly effective, simply due to the broad impacted population in the region. All new light duty vehicles added to the region's fleet between 2016 and 2030 are affected by the passed CAFE standards. Additionally, all heavy duty vehicles in the region are similarly affected by the potential heavy duty CAFE standards. The issue of scale is particularly evident when compared to the local incentive measure for fuel efficient vehicle purchase, which has the potential to affect a much smaller pool of residents. However, even at a smaller scale, fuel efficiency improvements at the local level were shown to have significant reduction impacts.

## 2. Alternative fuel use

As described in previous sections, the analysis of alternative fuel use impacts is taken from the U.S. DOE Annual Energy Outlook 2009. Increases in alternative fuel use and the $CO_2$ emissions reductions that are forecast by DOE result mostly from the Renewable Fuel Standard (RFS) passed within the 2007 EISA, which mandates

substantial increases in biofuel production. DOE's projections therefore include likely production and market penetration limits according to federal mandates for various alternative fuels, primarily corn-based and cellulosic ethanol and biodiesel. This analysis forecasts biofuel production and uptake of other technologies only according to currently passed legislation and market analysis; therefore, even 2030 projections include high gasoline usage for the national light duty fleet.

The high price case analysis, which assumes $200/barrel oil prices, illustrates the potential of increased adoption of higher priced, but less carbon intensive transportation fuel technologies, such as cellulosic ethanol and plug-in hybrid electric vehicles.

The analysis assumes life-cycle emissions rates for all fuels when comparing the DOE forecasts, both reference and high price cases, with a continuation of current fuel use ratios. When using life-cycle analysis, the tangential emissions originating from, for example, electricity production or agricultural practices become increasingly important. Therefore, the analysis highlights the alternative fuels that perform the best on a life-cycle basis, such as cellulosic ethanol over more energy intensive biofuels like corn-based ethanol. Since many advanced biofuels and other environmentally friendly technologies are still produced at higher costs than fossil fuels, the high price case illustrates how effective price signals that encourage alternative fuel use can be.

## 3. Increasing transit use

A wide range of transit strategies were examined in this study from a Metrorail expansion to increased service information at bus stops, all with the direct goal of increasing transit ridership by making transit more reliable, convenient, and faster. Although the many livability and sustainability benefits of transit are widely known, virtually all of the transit strategies exhibited modest $CO_2$ reductions, particularly relative to cost. This is a function of not only the scale of the strategies that were studied, but also the fact that, particularly for transit strategies, $CO_2$ emissions reductions are often ancillary to more primary benefits of access, mobility, social equity, and transportation affordability, among others.

All the short-term transit strategies in this study were relatively small-scale improvements with limited geographies and thus affecting only a small portion of the Washington region. Many of the strategies analyzed are simple methods of making existing transit services more attractive and reliable from a user perspective, such as increased bus information and real-time transit arrival information. These strategies are aimed at getting the most out of the existing system, and thus do not include major transit service expansions.

Yet even with relatively small levels of investment achieving multiple benefits, these strategies combined to reduce almost two million tons over the twenty year study period, which is two percent of the regional reduction goal. Moreover, these strategies can be implemented quickly by local governments and can achieve long-held transportation goals of virtually all of the region's local jurisdictions, such as increasing

transportation choice, while also making a small, but significant contribution to climate change mitigation.

One major long-term transit strategy was examined, which is the expansion of the transit system using the Dulles rail as an indicator of the order of magnitude that could be expected with a major Metrorail expansion. This example looked specifically at expanding rapid transit into areas of the region that are currently largely auto-dependent. Based on the Dulles Corridor Rapid Transit Project Final Environmental Impact statement, just over half of the projected opening year Metrorail ridership is estimated to be new riders. Due to the auto dependency of the area under current conditions, it is assumed that over two-thirds of these riders will have shifted from SOV and ten percent from carpooling. This high mode shift from SOV translates into relatively significant $CO_2$ emissions reductions—particularly when examined at the local level.

It should be noted that when examined at the regional level, the emissions reductions are modest. Although the system expansion will have network effects, the project impacts are limited to certain corridors and populations. Another limitation of this strategy (and all transit strategies) is in how $CO_2$ emissions can be reduced: benefits are only accrued from new trips that were previously taken by a low occupancy vehicle. Additional considerations also limit the benefits, such as the percent of potential new riders that will have access to transit via non-polluting modes, such as bike and walk.

The impacts of transit strategies thus appear limited because of the limited number and type of trips that can be affected. Without accompanying changes to make transit more viable and attractive compared to other modes, such as considerable land use changes, it is unlikely that transit would serve as a primary method of achieving $CO_2$ reduction goals in the region. However, it clear that significant progress can still be made in attracting more people to the existing transit system at a low cost and in the near future.

A vast increase in transit service was also studied through a concurrent transportation and land use scenario study, which is discussed in detail below under the “reducing travel” sub-section.

## 4. Increasing non-motorized mode share

Several strategies were considered to make increased bicycling and walking more convenient and safe as an alternative mode. These include expanding physical infrastructure, such as paths, sidewalks, dedicated lanes, bicycle racks and full service bike stations. They also include services for bicyclists and pedestrians, such as a bike-sharing system.

All of the strategies examined under this category are similar in benefits and limits as the short-term transit strategies. They can be done quickly with relatively low costs. They can be successful in shifting current and forecast short trips made by polluting forms of transportation. However, the efficacy of these strategies, like transit, is tied very closely to the land use of the surrounding local areas. Higher densities of

destinations make short trips, such as those most likely to be taken by bike or walk, more frequent and possible.

Nevertheless, in addition to a multitude of other benefits, the bike and pedestrian strategies did result in significant $CO_2$ emissions. The most successful was also the most ambitious strategy, which assumed an accelerated completion of the 2030 TPB Bicycle and Pedestrian Plan in 2020. The extensive reach of the plan and connections to existing and planned facilities resulted in a higher estimated ridership and a corresponding high shift from polluting modes. It is likely that the bundling of bicycle and pedestrian strategies, such as physical infrastructure like the TPB plan and service improvements like a bike-sharing system would result in positive feedback between the two strategies and thus even higher reduction potential.

## 5. Pricing

Various pricing strategies were examined, such as extensive variably priced lane networks, parking impact fees, an employer parking cash-out subsidy for non-driving employees, and pay-as-you-drive insurance. The parking impact fees, which are fees charged by the local government to land owners per parking space, and the pay-as-you-drive insurance, which provides motorists with the option to purchase auto insurance at a per mile rate, were the most effective of the pricing measures and were among the most effective measures overall. Both measures were able to affect a large portion of transportation users: everyone that drives must park somewhere and everyone that drives must purchase some kind of insurance in order to comply with the law. Therefore, the scale of impact for these two measures alone was found to be correspondingly large, achieving 10% of the reduction required to meet the regional goals.

The analysis for the parking impact fees did not include analysis of ancillary services that may be necessary to offset the increased parking costs borne by the private citizen, such as increased transit service; however, there are likely major costs and benefits that could be linked with such an analysis.

Variable pricing, or congestion pricing, was also examined under this study. It shows a relatively small reduction in $CO_2$ emissions, which is largely a reflection of several practical and study limitations. First, the scope of the study only allowed for emissions analysis of an existing pricing study, which included extensive regional variable pricing on roughly 600 miles of new lanes on the region's freeways. A small portion of the variable priced lane network included pricing of existing lanes on freeways and arterials in the District of Columbia and national parkways only. Therefore the emissions reductions were almost entirely due to the reduction in vehicle delay, rather than to reduced VMT, which is often a touted goal for congestion pricing programs. Additionally, the same analysis issues that were discussed for all long-term measures were problems for this measure. The original study only examined implementation in 2030. For this study, implementation was assumed to be phased over time, beginning with the completion of the high occupancy toll (HOT) lanes projects on I-495 and I-

395/95 in Virginia that are currently in the CLRP. Nevertheless, full construction of the value priced network is only assumed to be complete in 2030. Therefore, this measure only factors in only one year of emissions reduction assuming full completion.

## 6. Improving operational efficiency

In order to begin testing the relationship between operational improvements and $CO_2$ reduction, four region-wide strategies were analyzed: signal optimization, eco-driving, idling reduction, and incident management. The best performing measures in this category are signal optimization and eco-driving, the latter being the most effective possible regional strategy overall.

The signal optimization strategy examines a region-wide program of optimizing signal timing to ensure the most efficient vehicle flow. Since very low speeds generate the highest $CO_2$ emissions rates, this measure was very successful in reducing emissions. Another factor was its potential to affect the whole fleet—both light and heavy duty. Given the growing share of emissions that heavy duty vehicles will be accounting for in regional emissions forecasts, the ability to squeeze even a little efficiency out of this vehicle type can generate major savings. Additionally, regional application of signal optimization has the potential to affect a large portion of the light duty fleet. All vehicles driving within or through the region, both light and heavy duty, are affected by signal timing or lack thereof.

Eco-driving is a relatively new concept that employs a variety of methods to increase public awareness on how driving behavior and vehicle maintenance can improve fuel efficiency markedly. Based on national studies and pilot programs in the U.S., it has been found that eco-driving practices can improve vehicle fuel efficiency by 10-15%. This measure therefore has the potential of affecting every single driver in the region, which can have extremely high reduction potential. Moreover, many measures, many of which center on the education of all drivers, are within the purview of local jurisdictions and can be done at relatively low costs. Analytically, the Commuter Connections program was looked at as a model for how an eco-driving campaign could be structured. This could be a workable model for practical purposes as well.

Other measures studied in this category are incident management and idling reduction, both of which had modest $CO_2$ reductions, but, like transit, serve as examples of strategies that have multiple benefits worth exploring. A currently employed program of regional incident management coordination (Metropolitan Area Transportation Operations Coordination) was analyzed and found to have modest $CO_2$ reduction benefits. MATOC is a prime example of a strategy that was not initially done for climate change mitigation. In fact, it is not likely that this strategy or similar strategies would ever be done for the primary purpose of reducing emissions of any kind. Modest $CO_2$ emissions reductions contribute to a suite of benefits that should be examined together.

For all operational efficiency measures, the potential for induced demand as speeds increase was not factored into the analysis as the impacts are not yet widely understood. It is likely that such feedback issues would be very case specific and thus require

detailed analysis for specific locations and projects. Nevertheless, unintended impacts and possible degradation of reduction benefits should be studied further.

## 7. Reducing travel

Lastly, strategies were analyzed with the sole aim of reducing travel in general, such as telecommuting, carpooling and vanpooling, and compact, mixed use land use development.

Among the more effective strategies is telecommuting, which was examined as an extension of the already robust Commuter Connections program. The measure assumes increased telecommuting rates, consistent with the 2007 State of the Commute report, which highlighted that 24% of people in the region were not yet telecommuting, but "could and would." Given the high percentage of people affected, the reduction benefit for this measure is not insignificant.

This measure could have even higher potential for climate change mitigation given several factors that were not taken into account. First, only workers who "could and would" telecommute were assumed to begin telecommuting. However, over 50% of commuters in the region have job responsibilities that would not comport with telecommuting. The report states that between 2004 and 2007, the percentage of these commuters dropped, indicating a likely shift in the perception of a worker's ability to telecommute, such as through new technologies or even greater employer flexibility. Therefore, there are a large portion of the region's commuters that could potentially still be captured as telecommuters beyond what this measure assumed. Second, the increased removal of commuters during peak hours from congested roads could mean a measurable reduction in congestion, which could result in some level of $CO_2$ reduction.

Measures examining the use of incentives to encourage greater carpooling and vanpooling were also studied and found to be fairly effective at reducing $CO_2$ emissions. The carpool incentive studied the potential impact of paying SOV commuters $1 per trip shifted to carpooling. The resulting emissions reductions were somewhat modest, largely because of the limited scope studied, including implementation on only five of the region's corridors. These corridors were chosen based on high congestion levels with regard for availability of alternative commute options and directional congestion. While the corridors were chosen as focused areas of the region where the highest benefits were likely to be achieved, it is possible that the program could be expanded further. It should be noted that this measure has recently begun implementation and therefore will have the future advantage of empirical data to determine its effectiveness as a climate change mitigation strategy.

Lastly, land use (specifically smart growth policy) was studied as a potential vehicle for VMT reduction. Concurrent with this study, the TPB also completed an aspirational land use and transportation scenario. The "CLRP Aspirations" Scenario, so named because of its potential role as a de facto regional unconstrained long-range transportation plan, examines the potential travel demand and air quality impacts of concentrated future residential and commercial growth, congestion pricing and new

road capacity connecting these targeted growth areas, and extensive new transit service, including bus rapid transit running on priced lanes. The full scenario was found to increase VMT by 2.9% and $CO_2$ emissions by 2.6% despite significant reductions in vehicle delay of 12.5% throughout the region. However, when the land use component of the scenario, which includes an increase in jobs of 0.5% and households of 2% above the baseline projection, was isolated and modeled without the pricing, new road capacity, and new transit, a very modest decrease in $CO_2$ of 0.3% was estimated. The decrease in $CO_2$ can be wholly attributed to the reduced VMT of 0.5%, which results from higher bike/walk percentages and higher transit percentages. The $CO_2$ reduction, however, is somewhat diminished by a small increase in vehicle delay of 1% region-wide. This measure is another long-term strategy where the full benefits are only accrued and examined for the year 2030. Similar to the Value Pricing Study, a phased in approach was used to estimate partial benefits as the full plan ramps up toward completion. Based on scenario assumptions, benefits are assumed to begin accruing in part in 2015, with full completion in 2030. In order to fully understand the long-term implications of this type of a measure, a longer time frame will be necessary for analysis.

## What Worked the Best?

Overall, there were clear characteristics that emerged as major drivers of success in reducing $CO_2$ emissions. These characteristics can be used to better understand what it will take to reduce transportation $CO_2$ emissions, regardless of the ultimate targets that are applied to the transportation sector. The observations below do not necessarily reflect the individual strategies that performed the best, as discussed above, but rather highlight the potential of strategies that could be realized with geographic or programmatic expansions.

First, given the growing share of emissions by heavy duty vehicles, among the most successful strategies were those that affected the whole fleet, both light and heavy duty. The most effective example of this is signal optimization, which can improve traffic flow for any vehicle passing through a signalized intersection, both heavy and light duty.

Second, strategies that can affect the whole light duty fleet were shown to be more effective than those that target small portions of the whole fleet, like signal optimization. Since light duty vehicles represent around 90% of VMT in the region, targeting light duty drivers can have a significant impact on $CO_2$ emissions. Although the eco-driving measure has the potential to affect every single driver, including heavy duty vehicle drivers, in this study only light duty vehicle drivers were assumed to increase their vehicle fuel efficiency by 10% through eco-driving practices. Even with this limitation the reductions still were the greatest of any other regional measure analyzed. A similar effect was noted from the pay-as-you-drive insurance measure, which also has the potential to affect a significant portion of the drivers in the region. As might be expected, a larger affected population will lead to greater reduction, assuming the measure is a robust application of increased fuel efficiency, reduced carbon intensity of fuels, or increased travel efficiency.

Third, given the growing proportion of emissions from heavy duty vehicles, even a small-scale application of a measure that targets the highest polluting vehicles, such as buses, can be a highly effective strategy. In this study the purchase of 185 new CNG buses for 36 crowded routes was studied and found to be among the highest performing measures. The low fuel efficiencies and slow speeds of buses leave significant room for improvement on the operations and technology side, such as heavy duty fuel efficiency, transit signal priority, and alternative fueled vehicles.

Fourth, if done on a large enough scale, providing wide-spread non-polluting transportation options can be a very effective method of reducing $CO_2$ emissions. If SOV trips can be replaced with a zero-polluting mode, such as a bicycle or walk trip, the net emissions benefit has the potential of being quite large. For instance, in the study of the accelerated completion of the 2030 TPB Bicycle and Pedestrian Plan by 2020, the extensiveness of the network translated into one of the best performing strategies over the twenty year study period.

Lastly, since roughly 20% of all trips are work trips it is no surprise that there is significant potential in targeting commute trips. Despite many commuter services already offered throughout the region, there is still potential in offering additional services aimed at lowering the SOV rate and reducing VMT from commuting. For instance, enhancing commuter transit services, incentivizing carpooling/vanpooling, and encouraging public and private employers to offer increased telecommuting support have great potential for reducing $CO_2$ emissions.

## Overall Lessons Learned

It is clear that the strategies analyzed in this study do not combine to meet the Washington region's $CO_2$ reduction goals. While aggressive federal actions come close, they do not completely close the gap between forecast emissions and the region's emissions goals. It appears that if the "short term strategies" grouping is combined with the "high federal role" grouping that the region would able to meet its climate targets. The groupings were assembled to carefully and conservatively avoid potential double-counting of benefits. In this case, because a 6% VMT decrease is assumed in the "high federal role" grouping, it is unclear that the adoption of the short-term strategies under this scenario would result in the same VMT reduction as under the baseline conditions. It is possible that those strategies would simply restore some of the lost mobility associated with the 6% VMT reduction and therefore would create new trips rather resulting in additional mode shifts. It is also possible that with the adoption of the short-term strategies early on, higher gas prices in the long term would not result in the same level of VMT reduction as was found under baseline conditions. The combination of these strategies would require further study in order to most accurately estimate their cumulative effect. Therefore, **additional strategies would need to be analyzed and incorporated into the study groupings in order to potentially meet the region's $CO_2$ reduction goals.**

It is also clear that in order to meet the region's goals strategies will need to be adopted across all levels of government and across the three categories of fuel efficiency, alternative fuels and travel efficiency. The "high federal role" grouping illustrated clearly that while aggressive measures can be ramped up over time to achieve the later targets, the overall reduction goal cannot be met without meeting the earlier targets as well—which will likely require local, state, and regional actions. The **"short-term regional actions" grouping showed the ability of local governments to achieve these important early targets if a wide range of early actions are taken immediately**.

For instance, the eco-driving measure showed significant $CO_2$ emissions reduction potential with relatively low investment. Local governments and state agencies could quickly adopt driver education programs, incorporate eco-driving messaging into existing inspection reminder mailings, incentivize free air at service stations, and develop roadside eco-driving signage. Based on the strategies analyzed, the following were identified as potential actions state and local governments could implement in the near term:

1. Expand telecommuting and compressed work week options through public and private employer outreach and potential incentives for providing telework infrastructure
2. Incentivize increased carpooling and vanpooling through direct monetary reward for carpool/vanpool trips taken
3. Increase bicycle and pedestrian mode share through bike-sharing systems, bicycle racks and other facilities, bicycle lanes, pedestrian trails, and improved pedestrian access to bus stops and rail stations
4. Increase transit use through bus priority treatments, real-time arrival information, lowering fares, and parking cash-out subsidies for employees who do not drive to work but receive free parking at their workplace
5. Promote compact, mixed use development around current and planned transit through incentives and zoning changes if necessary
6. Incentivize eco-driving
7. Increased incident management and regional coordination through such programs as TPB's Metropolitan Area Transportation Operations Coordination (MATOC) Program
8. Signal optimization throughout the region to ensure efficient vehicle movement
9. Incentivize the purchase of fuel efficient vehicles by offering, for example, tax breaks and HOV usage allowances

It is also clear that one category of strategies alone will not achieve the reductions necessary to achieve the region's climate change goals. Although the new, stronger CAFE standards significantly reduce emissions over time, fuel efficiency alone is not likely going to produce the necessary emissions reductions. Similarly, while the 2007 Renewable Fuel Standard significantly boosts ethanol production and thus achieves major $CO_2$ emissions reductions, likely levels of future alternative fuel use still do not prove to be enough to reach regional targets. Regionally feasible travel efficiency strategies also are unlikely to be able to meet the goals on their own. It is clear that even with a combination of strategies the goals are difficult to meet; however, **it is unlikely**

**that the silver bullet rests with any one of the categories of strategies and instead will take a more aggressive approach across all three categories**.

It is also unlikely that strategies adopted throughout this region in the transportation sector will have the sole benefit of $CO_2$ reduction, as may be the case in other sectors such as electricity generation and delivery. While this analysis only examines the cost-effectiveness of these strategies for $CO_2$ reduction, it is more likely that **transportation strategies will have various other benefits from criteria pollutant reduction to increasing mobility and accessibility that should be factored into decision-making**. For instance, improving transit, increasing telecommuting options, expanding regional incident management, and implementing road and/or parking pricing options have benefits beyond climate change mitigation, such as congestion reduction, greater access to employment and services, time savings, and safety benefits.

# Next Steps

Climate change will continue to be a pressing issue on the international, national and local stages for many years to come and, therefore, will be an ongoing TPB focus. The outcomes of this study have not only uncovered the potential of many strategies to bring the region closer to its emission reduction goals, but have also highlighted several possible directions for the region's climate change work to progress.

The first is to **further analyze the strategies included in this study within a comprehensive cost-benefit framework** in order to account for multiple benefits. Some strategies may not have major $CO_2$ reduction potential, but have multiple benefits worth exploring through cost-benefit analysis, which would provide a more complete context for prioritization of strategies in the transportation sector specifically.

The second next step is to conduct an analysis of bundling strategies. In this study the strategies within each grouping were simply added together. It is likely that combining certain strategies may have effects on the emissions reduction efficacy of those strategies. For instance, it is possible that for many strategy combinations multiplier effects may result in higher emissions reductions than were calculated. With the combination of bicycle-sharing and increased bicycle facilities and infrastructure, it is likely that bicycle ridership would be higher than was assumed. Conversely, it is also possible that in some cases the combination of strategies would result in lower than expected emissions reductions. For instance, it is yet unclear whether mass transit services and carpooling are complimentary or substitutes. Therefore, in combining carpooling incentives with increased rapid bus services, it is possible that both services would be competing for the same users, resulting in an overall lower mode shift than the sum of the individual measures (Reference 12). **These possibilities should be studied further to determine potential effects, both positive and negative, of combining multiple strategies.**

In the same vein as the previous points, it will also be necessary to more closely examine each strategy for potential unintended impacts. For instance, operational improvements that improve travel times and reduce congestion must be studied on a case-by-case basis to determine potential loss of benefit from induced travel demand. The possibility that as speeds increase, trip lengths may increase and/or more trips may be generated to increase VMT must be studied. **Unintended impacts must be considered for all strategies.**

It is a natural next step that **in ongoing climate change work staff should analyze additional strategies, or the expansion of already analyzed strategies**, in order to eventually put together a combination of strategies that meet the regional $CO_2$ reduction goals. Additional strategies could include an examination of the local role in promoting alternative fuel use, such as through provision of public fueling or charging infrastructure and regional green fleets. Another potential source of additional analysis could be more analysis of transit-oriented and compact land use strategies. A major area requiring greater attention is the "long-term actions" grouping, which would benefit from a more refined analysis technique and a broader set of

strategies to analyze. For instance, many of the strategies analyzed in this grouping were sourced from previous TPB studies, which often included impacts analysis for the year 2030 only. It is likely that these strategies will develop and ramp up over time and thus result in greater $CO_2$ emissions reductions. Therefore a more nuanced analysis may be appropriate in subsequent studies. Additional strategies could also be studied, including different types of transit alternatives, such as bus rapid transit and light rail, broader exploration of pricing, such as pricing of existing lanes and cordon pricing, and major freight improvements.

Finally, this study focused entirely on climate change mitigation, which was appropriate for this initial effort. In ongoing work, the **TPB may consider developing a broader response to studying climate change that includes building regional resilience to climate change impacts** that will be felt regardless of mitigation success. Adaptation to higher temperatures and sea level rise is a major issue particularly within the transportation sector where major infrastructure will be impacted negatively. The linkage between building adaptive capacity and achieving mitigation goals should also be studied to ensure that strategies employed for the purposes of one do not negatively impact the other, but rather are complementary.

# Appendix A

## List of WWIT Groupings and Individual Strategies

1. **Federal Actions:**

   a. No Further Federal or Local Action

| **Strategies:** | **Description** |
|---|---|
| *Fuel Efficiency:*<br><br>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:*<br><br>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:*<br><br>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:*<br><br>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:*<br><br>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:*<br><br>High energy prices ($7/gallon | Uses DOE forecasts for a national high energy price scenario, which assumes $7/gallon gasoline. This causes higher alternative fuel usage and a 6% |

| | |
|---|---|
| gas) | 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. |