Governor's Executive Order 09-05

Washington's Leadership on Climate Change

Report on Section 2(a)

December 29, 2010

Washington State
Department of Transportation

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Executive Summary

This report summarizes the recent work of the Washington State Department of Transportation (WSDOT) to analyze vehicle miles traveled (VMT) in the state and to develop strategies to reduce greenhouse gas (GHG) emissions from the transportation sector.

On May 21, 2009, Governor Gregoire signed Executive Order 09-05: Washington's Leadership on Climate Change. Section 2(a) of the Executive Order directed WSDOT to

- Estimate current and future statewide levels of VMT,
- Evaluate potential changes to the VMT benchmarks established in RCW 47.01.440 as appropriate to address low- or no-emission vehicles, and
- Develop additional strategies to reduce GHG emissions from the transportation sector.

WSDOT worked collaboratively with an Executive Order Working Group to complete this work. Members of the group included representatives from the Departments of Ecology and Commerce, the state's four largest regional transportation planning organizations, local government, environmental organizations and businesses. The group contributed to the work by providing input into the analysis process and discussing its findings, and reviewing draft documents. However, the findings, conclusions, and recommendations presented in this report are those of WSDOT.

What is WSDOT's current estimate of statewide levels of vehicle miles traveled?

WSDOT estimates that the annual statewide VMT in 2009 was 56 billion or 8,400 VMT per capita (including both light and heavy duty vehicles). This estimate comes from the Highway Performance Monitoring System (HPMS). WSDOT uses this established and consistent methodology for tracking and reporting VMT at the state level.

Findings

- HPMS is an appropriate tool to monitor VMT statewide.
- HPMS may also be an appropriate tool for monitoring VMT at the local and regional levels.

Recommendation

WSDOT recommends the use of HPMS as the appropriate tool to monitor statewide VMT. WSDOT should continue the discussion with the Regional Transportation Planning Organizations (RTPOs) in 2011 to determine the most appropriate tool for monitoring VMT at the local and regional level.

What is WSDOT's current estimate of future statewide levels of vehicle miles traveled?

The statutory VMT benchmarks in RCW 47.01.440 used a baseline of 75 billion VMT for 2020. This baseline for 2020 was established by the February 2008 VMT forecast and serves as the basis for the VMT per capita reductions benchmarks in 2020, 2035, and 2050.

Based on a new methodology developed specifically for forecasting VMT, the June 2010 forecast projects total statewide VMT in 2020 to be 66 billion. WSDOT will update the VMT forecast annually each June.

Findings

- The June 2010 VMT forecasting model uses a new methodology that more accurately forecasts VMT.
- The June 2010 VMT forecast for 2020 is 66 billion, 12 percent lower than the 75 billion VMT baseline set by the February 2008 model.
- Basing reduction target percentages on a forecast is problematic because the forecasts are adjusted annually and create unnecessary confusion.
- Regional transportation planning organizations forecast VMT using very different methodologies than the state. Some regional organizations do not use models and do not have the capability to forecast VMT.
- VMT forecast models are most accurate in predicting VMT in the near-term (within two to four years) and less accurate beyond four years.

Recommendation

WSDOT recommends that the legislature use historical, measured VMT (e.g., 2000, 2005, or 2010 levels), rather than forecasted VMT, to set the VMT baseline.

Do the VMT benchmarks need to be changed to address low- or no-emission vehicles?

If very low-emission or no-emission vehicles become a large share of the vehicle fleet, or low carbon fuels become more prevalent, there may be less need to reduce VMT to reduce GHG emissions from the transportation sector. The Department of Ecology, with assistance from WSDOT, assessed the practicality of low carbon fuels and the feasibility of a low carbon fuel standard for Washington. WSDOT, Ecology, and Commerce examined the market penetration of alternative vehicles and fuels to complement WSDOT's VMT benchmark analysis.

Findings

- Ecology's research showed that projected vehicle technology and fuel changes will occur relatively slowly.
- The rate at which significant vehicle and fuel technology advances and regulatory changes are likely to happen over the next 40 years is highly uncertain.

Recommendation

WSDOT recommends that the VMT benchmarks should not be changed at this time to address low- or no-emission vehicles. In the coming years, the VMT benchmarks may need to be reassessed for numerous reasons. Some potential reasons for further assessment in the future may include more rapid market penetration of low- or no- emission vehicles than expected, better VMT estimates and data, advancements in technology, and the implementation of regional or national policies to reduce GHG emissions.

What additional strategies are available to reduce emissions from the transportation sector?

In 2008, the Climate Action Team's Transportation Implementation Working Group and the Land Use and Climate Change Advisory Committee identified a number of transportation and land use strategies to reduce GHG emissions from the transportation sector. Building on this work, WSDOT reviewed national research that identified additional strategies and evaluated their effectiveness in reducing emissions. WSDOT then applied this information in a scenario analysis to evaluate the possible reductions from different combinations of strategies.

Findings

- Greenhouse gas reduction strategies from the transportation sector fit into four broad categories:
  - Operating the system more efficiently
  - Advancing vehicle technology
  - Improving fuels
  - Reducing VMT
- WSDOT's analysis suggests that there is no silver bullet and major contributions from each of the strategies will be needed to reduce GHG emissions.
- Many of the identified transportation sector strategies would require changes in policy, funding, and authority.
- The state cannot significantly reduce emissions from the transportation sector without collaborative and comprehensive actions by private citizens, businesses, and regional and local governments.
- WSDOT's analysis suggests that implementing combinations of aggressive transportation emission reduction strategies can achieve roughly a ten percent reduction in total statewide GHG emissions compared to the 2050 baseline. Implementing many of these strategies would require changes in policy, funding, and authority, and also assumes ambitious improvements in vehicles and fuels. WSDOT did not assess the political or financial feasibility of implementing the strategies.

Recommendation

WSDOT recommends that the state consider the most viable ways to reduce statewide GHG emissions across all sectors. In 2011, WSDOT will continue to work with the four largest RTPOs identified in the Executive Order as part of the Section 2(b) work, which would further inform practical approaches for reducing GHG emissions at the regional level.

What are the next steps?

Section 2(b) of Executive Order 09-05 directs WSDOT to take the next steps to apply the information developed for this report and work with the Puget Sound Regional Council, Spokane Regional Transportation Council, Southwest Washington Regional Transportation Council, and Thurston Regional Planning Council to "cooperatively develop and adopt regional transportation plans that will, when implemented, provide people with additional transportation alternatives and choices, reduce GHG and achieve the statutory benchmarks to reduce annual per capita vehicle miles traveled in those counties with populations greater than 245,000."

By December 2011, WSDOT is instructed to report on which RTPOs have developed, or are developing, plans with greenhouse gas strategies; which strategies appear to have the greatest potential to achieve the benchmarks; and what policy or funding issues need to be resolved to ensure implementation.

I. Introduction

This report summarizes the recent work of the Washington State Department of Transportation (WSDOT) to evaluate vehicle miles traveled (VMT) in the state and to develop strategies to reduce greenhouse gas (GHG) emissions from the transportation sector.

On May 21, 2009, Governor Gregoire signed Executive Order 09-05: Washington's Leadership on Climate Change (See Appendix B). The Executive Order builds upon previously established state law setting greenhouse gas emission reduction limits (RCW 70.235.020) and vehicle miles traveled benchmarks (RCW 47.01.440) for Washington State (See Appendices C and D). Section 2(a) of the Executive Order directed WSDOT to:

- Estimate current and future statewide levels of VMT,
- Evaluate potential changes to the VMT benchmarks established in RCW 47.01.440 as appropriate to address low- or no-emission vehicles, and
- Develop additional strategies to reduce GHG emissions from the transportation sector.

WSDOT worked collaboratively with an Executive Order Working Group to complete this work. Members of the group included representatives from the Departments of Ecology and Commerce, the state's four largest regional transportation planning organizations, local government, environmental organizations, and businesses. The group guided the work by providing input into the analysis process and discussing its findings. However, the findings, conclusions, and recommendations presented in this report are those of WSDOT. For a complete list of Working Group members, see Appendix A.

The issues discussed included:

- There are greenhouse gas emission limits in State statute.
- Transportation accounts for 47% of statewide GHG emissions.
- Therefore, understanding how Vehicle Miles Traveled connect to reductions in greenhouse gasses is important

Please note that RCW 47.01.440 specifically excludes vehicles that weigh ten thousand pounds or more. WSDOT estimates VMT using traffic counters that count the number of axles, not the weight of the vehicles. EPA and the Moving Cooler report define light duty vehicles as those weighing less than 8,500 pounds. For the purposes of this report, light duty vehicle means one that weighs less than 8,500 or is classified by WSDOT's vehicle counting system as a motorcycle, passenger car or truck with two axles and four tires.

II. What is WSDOT's Current Estimate of Statewide Levels of Vehicle Miles Traveled?

Washington monitors Vehicle Miles Traveled through the Highway Performance Monitoring System (HPMS). The HPMS is a nationally recognized database used to coordinate, synchronize, and report on statewide highway performance and conditions. All states are required to report HPMS data to the Federal Highway Administration (FHWA) on a regular basis. FHWA uses the data to monitor the condition of the nation's roadways, identify deficiencies, and determine how highway funds should be distributed. FHWA also exercises quality oversight on HPMS data collection (see Appendix G). The HPMS estimates and monitors statewide VMT through traffic data collected at over 4,400 state highway and 3,170 non-state roadway sample locations.

WSDOT estimates that the annual statewide VMT in 2009 was 56 billion or 8,400 VMT per capita (including both light and heavy duty vehicles). For 2009, WSDOT estimates that about 10.8 percent of this VMT came from heavy duty vehicles.

WSDOT evaluated existing tools to estimate VMT and concluded HPMS is the appropriate tool for estimating statewide VMT. VMT will be monitored and reported annually, but WSDOT will conduct a full assessment of trends in VMT per capita every five years as indicated in RCW 47.01.440 (2)(e).

HPMS also includes information at the regional and local level because it estimates VMT for county roads and city streets. However, regional and local estimates are based on a less comprehensive set of data collection points. As a result, WSDOT is continuing conversations with local and regional transportation professionals to determine the merits and options for estimating at the local and regional levels.

Recommendation

WSDOT recommends the use of HPMS as the appropriate tool to monitor statewide VMT. WSDOT should continue the discussion with the RTPOs in 2011 to determine the most appropriate tool for monitoring VMT at the local and regional level.

III. What is WSDOT's Current Estimate of Future Statewide Levels of Vehicle Miles Traveled?

Previous estimates of future VMT were derived from gas tax revenue forecasts; however, WSDOT has developed a new VMT-specific forecasting model. A detailed report on the updated forecast and methodology is provided in Appendix E. Figure 1 shows the VMT benchmarks as per capita values calculated using 75 billion total VMT in 2020 and the 2007 population forecast, which was the forecast at the time RCW 47.01.440 was adopted.

Year	Reduction Percentage (RCW 47.01.440)	Light Duty Vehicle Per Capita Benchmarks
2020	18%	7,065
2035	30%	6,031
2050	50%	4,308

Figure 1. Statewide Per Capita VMT Reduction Benchmarks (Light Duty Vehicles) Based on 2020 Forecast of 75 Billion VMT

The previous model was intended to forecast gas tax revenue, not VMT, and the model's projections were not consistent with the flattening in per capita VMT observed in more recent years in Washington and nationwide. A review of previous WSDOT VMT forecasts indicates that VMT forecast models have been fairly accurate (within three percent) in predicting VMT in the near-term (within two to four years). However, the level of accuracy in predicting future VMT (beyond four years) tapers off.

To directly forecast VMT, WSDOT developed a new VMT-specific forecasting model using economic variables based on employment, vehicle registration, and gasoline prices. A VMT Technical Working Group, with representatives from the Department of Licensing, the Office of Financial Management, the Economic and Revenue Forecast Council, and Senate and House Transportation Committee Staff, helped to develop a new forecast model. The June 2010 VMT forecast, based on current economic inputs, forecasts 2020 total VMT to be 66 billion, which is 12 percent less than the February 2008 forecast. Revisions to the economic variables have a significant impact on VMT projections. WSDOT expects to update its VMT forecasts each June.

Figure 2 shows historical and forecast total VMT and per capita VMT to the year 2050. Note that the forecast was developed only to the year 2031. It was extended to 2050 for the purpose of the analysis described in this report. See Appendix E for more information on how the forecast was extended.

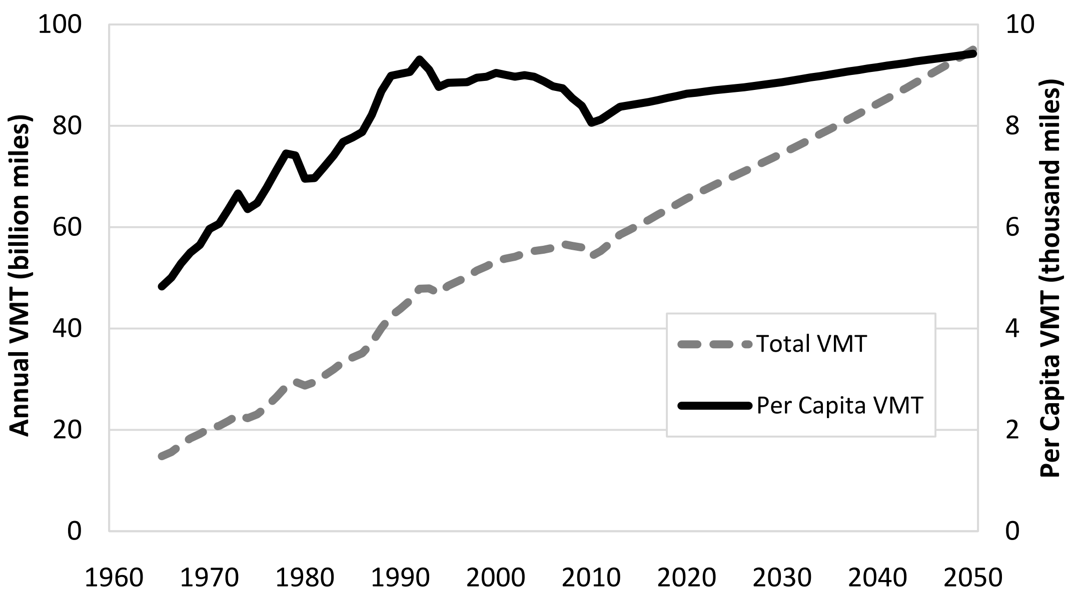


Figure 2. Washington State VMT: historical and forecast
Source: Washington State Department of Transportation (population numbers from Washington State Office of Financial Management)

Using forecasted VMT as a benchmark

Using a forecast-based baseline for setting VMT benchmarks is problematic for two primary reasons. First, although WSDOT has developed a forecast model that appears to better project statewide VMT, any VMT forecast model will need continuous revisions and updating. Therefore, the projected future VMT will be updated each year with each model update. It becomes confusing to explain the relationships between the 75 billion VMT in statute, the most current VMT forecast, and VMT reductions needed to meet the benchmarks.

For example, the statutory VMT benchmarks use a VMT baseline in 2020 of 75 billion VMT as determined by the February 2008 VMT forecast. The June 2010 VMT estimate is 12 percent lower for the year 2020. Using the most current VMT forecast, meeting the VMT benchmark in 2020 now only requires a reduction in light duty vehicle VMT of eight percent, rather than the 18 percent indicated in statute. It becomes confusing to explain to people that an 18 percent reduction from the old forecast results in the same VMT as an eight percent reduction from the new forecast.

Second, the state and Regional Transportation Planning Organizations (RTPO) use very different methods to forecast VMT (some regions have very limited capabilities for forecasting VMT), and the results of the VMT forecasts may be very different. For instance, the state's VMT forecast may indicate that VMT will increase by about 1.3 percent a year. However, each RTPO develops its own VMT forecast using its own tools and methodologies, based on regional land use and other characteristics. One RTPO may forecast an annual VMT increase of about 1.5 percent, another may forecast an annual increase of 0.9 percent, and still another may forecast an annual increase of about 0.5 percent. These are very different models and adding all the RTPOs' forecasts, even if they were available, would not result in a forecast comparable to the statewide forecast.

WSDOT proposes that the legislature consider using historical VMT to set the VMT baseline against which progress towards benchmarks can be measured. Equivalent per capita VMT reductions using data from an historical year are shown in Figure 3 below. Regions may find benchmarks based on historical per capita VMT more useful for understanding the VMT reductions needed for their own regional plans to be consistent with the statewide VMT benchmarks. For instance, Figure 3 indicates that for the year 2050, light duty vehicle VMT per capita would need to be 45.5 percent lower than 2005 light duty vehicle per capita VMT . A region will have its own estimate of 2005 per capita VMT, so it can estimate what 2050 per capita VMT would need to be (45.5 percent less) to be consistent with the statewide benchmarks.

Comparative Reductions in Per Capita Light Duty Vehicle VMT to Meet VMT Benchmarks

Year	Current Benchmarks (75 billion in 2020, as described in statute)	From 2000 Per Capita VMT	From 2005 Per Capita VMT	From 2010 Per Capita VMT
2020	18.0%	14.1%	10.7%	5.8%
2035	30.0%	26.7%	23.7%	19.5%
2050	50.0%	47.6%	45.5%	42.5%

Figure 3. VMT Benchmarks and Comparative Reductions from Recent Years
Source: Washington State Department of Transportation (population numbers from Washington State Office of Financial Management)

Recommendation

WSDOT recommends that the legislature use historical, measured VMT (e.g., 2000, 2005, or 2010 levels), rather than forecasted VMT, to set the VMT baseline.

IV. Do the VMT Benchmarks Need to be Changed to Address Low- or No-Emission Vehicles?

If very low-emission or no-emission vehicles become a large share of the vehicle fleet, or low carbon fuels become more prevalent, there may be less need to reduce VMT to reduce GHG emissions from the transportation sector. This section describes potential improvements in vehicle technologies and fuels, and whether these potential changes warrant changes to the VMT benchmarks.

Under direction from the Governor in Executive Order 09-05, The Department of Ecology (Ecology) is evaluating whether a low carbon fuel standard[1] (LCFS) should be adopted by the State. They are examining the emission and economic effects of a 10 percent reduction in carbon intensity (as measured in CO_2e per unit of energy in the fuel), implemented over ten years.

In conjunction with their work on the LCFS, Ecology developed three sets of assumptions on alternative vehicle market penetration and alternative fuels use. This work has been incorporated into the scenarios evaluated in the next section.

Although any projection of technology advances and regulatory changes likely to happen over 40 years is highly speculative, even in Ecology's most aggressive case, vehicle technology and fuel changes occur relatively slowly.

Recommendation

WSDOT recommends that the VMT benchmarks should not be changed at this time to address low- or no-emission vehicles. In the coming years, the VMT benchmarks may need to be reassessed for numerous reasons. Some potential reasons for further assessment in the future may include more rapid market penetration of low- or no- emission vehicles than expected, better VMT estimates and data, advancements in technology, and the implementation of regional or national policies to reduce GHG emissions.

[1] Low Carbon Fuel Standard report may be found at http://www.ecy.wa.gov/climatechange/fuelstandards.htm.

V. What Additional Strategies are Available to Reduce Emissions from the On-Road Transportation Sector?

Transportation accounts for 47% of statewide GHG emissions; 34% of the state's emissions are from on-road transportation, with the reminder of the transportation emissions coming from marine, rail, off-road, and aviation – see Figure 4.

Reducing emissions from transportation activities is challenging given that transportation is an activity undertaken by myriad citizens and businesses, using privately owned vehicles on facilities provided by a plethora of public and private agencies to move people, goods, and information in largely independent and individual travel patterns. The common factor with regard to climate change is that most of these vehicles use fossil fuels that, when combusted, release carbon dioxide into the atmosphere.

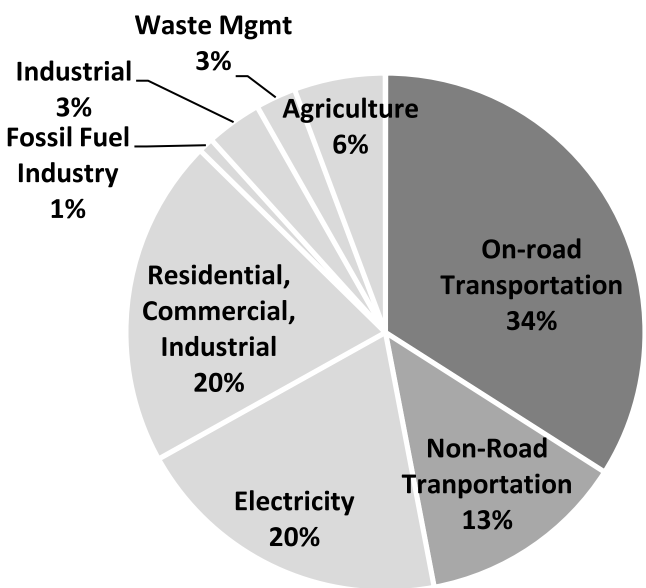


Figure 4. Statewide Sources of Greenhouse Gas Emissions, 2007
Source: Washington State Department of Ecology

Strategies to reduce on-road GHG emissions run the gamut, including changing land use development patterns to be more transportation efficient, developing pricing strategies on vehicle and facility use, changing the technologies that power our vehicles, and eliminating the need for some travel altogether. In addition to a number of transportation-related strategies identified in the Climate Action Team's Transportation Implementation Working Group (TIWG) and the Land Use and Climate Change Advisory Committee (LUCC) 2008 reports, WSDOT has identified a number of strategies within four broad categories:

- Operating the system more efficiently
- Advancing vehicle technology
- Improving fuels
- Reducing VMT

Operating the system more efficiently

Improving system efficiency will help reduce GHG emissions from the transportation sector by smoothing the flow of traffic to prevent stop-and-go driving, and by maintaining vehicle speeds at 45-65 mph, considered to be the optimal range for vehicle fuel efficiency and, therefore, reducing GHG emissions.

System efficiency strategies are easy to implement, low cost, and will begin reducing GHG emissions almost immediately. Other types of strategies such as new technology advances, alternative fuel vehicle fleet penetration, and major policy changes, face bigger barriers to quick implementation. While system efficiency strategies offer smaller annual gains than many other strategies suggested in this document, the ability to implement them immediately and their cumulative contributions for reducing emissions over the long-term remain important. These strategies can also have a major impact on reducing individual and transit travel times and increasing safety.

WSDOT and local agencies will continue to deploy system efficiency strategies such as ramp metering, incident response, signal synchronization, traveler information, travel management center (TMC) operations, active traffic management (ATM), and roundabouts under their existing plans. Additional funding for reducing GHG emissions could be deployed for system efficiency strategies in the locations that would provide the largest decrease in emissions. The cost range for these operating activities is between a few million to tens of millions of dollars. Installation of area-wide ramp meters, intelligent transportation system devices, and active traffic management projects are more expensive. Other operating strategies such as incident response and signal timing review and improvements are relatively inexpensive and can be implemented quickly.

The Moving Cooler report[2], the only comprehensive attempt to calculate system efficiency GHG-reduction measures, has estimated approximately a one percent reduction in

[2] Moving Cooler (July, 2009)

transportation-related emissions from system efficiency strategies. This is an under-studied area. In-house WSDOT studies have estimated the improvement from some system efficiencies as higher and future research could identify greater benefits from these strategies. For more information on system efficiencies see Appendix H.

Advancing vehicle technology

Advancing vehicle technology is one important strategy to reduce GHG emissions. Strategies to improve vehicle efficiency and move to lower carbon fuels are closely related. One way for vehicles to make a leap in fuel efficiency is for them to be based on different energy sources that are either inherently cleaner or can be utilized more efficiently. New vehicle technologies are being developed that use nontraditional fuels such as electricity and biofuels.

Alternative vehicle technologies and fuels may be used by both light duty and heavy duty vehicles. Figure 5 compares the contribution of each vehicle type to both VMT and GHG emissions in 2005 and 2050, and shows the disproportionate growth of GHG emissions from heavy-duty vehicles as light-duty vehicles become more efficient in the coming years.

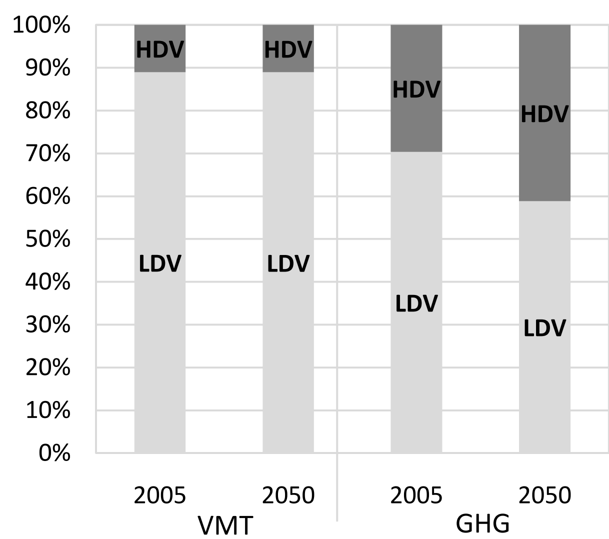


Figure 5. VMT and GHG Contributions from Light- and Heavy-Duty Vehicles
Source: Washington State Department of Transportation (emissions from VISION Model)

Light duty vehicle fuel efficiency

Historically, light duty vehicle efficiency improvements have been driven by federally established Corporate Average Fuel Efficiency standards, more commonly known as CAFE standards. The first CAFE standards took effect in 1978 and progressively increased until the mid-1980s. Until recently, fuel efficiency standards remained fairly stagnant with an emphasis placed on larger, more powerful vehicles e.g., sport utility vehicles. Higher standards take effect in 2011 and are set to increase annually to 2016.

On September 30, 2010, the Environmental Protection Agency (EPA) and the National Highway Traffic Safety Administration (NHTSA) issued a Notice of Intent to develop standards for light duty vehicles for the period from 2017 to 2025. In the accompanying Technical Assessment Report, the agencies evaluated four scenarios, with annual increases from three to six percent.[3] Figure 6 shows historical and future CAFE standards for passenger cars and light trucks. The dashed lines in the chart show the results of potential three percent and six percent annual increases in fuel economy between 2017 and 2025.

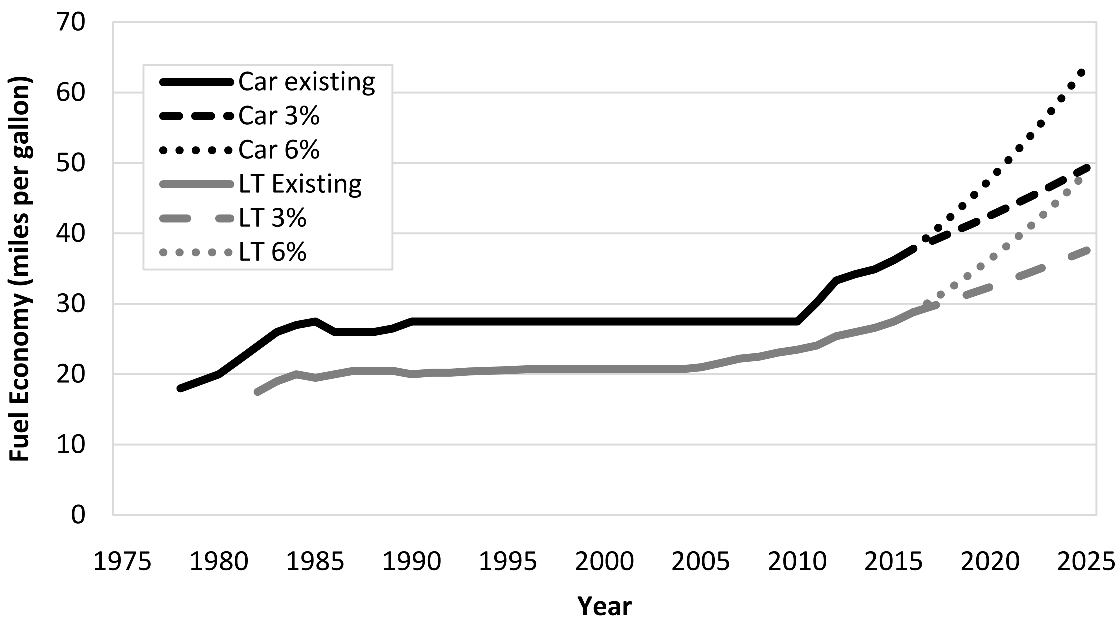


Figure 6. Light Duty CAFE Standards, Historical, Future, and Under Consideration
Source: *Transportation Energy Data Book*. Oak Ridge National Laboratory and Center for Transportation Analysis. Edition 29. June 30, 2010.

Heavy duty vehicle fuel efficiency

The fuel efficiency of medium and heavy duty vehicles has not been regulated in the past, but President Obama has directed EPA and NHTSA to develop the first standards for medium and

[3] Notice of Intent. National Highway Traffic Safety Administration, Environmental Protection Agency. http://www.nhtsa.gov/staticfiles/rulemaking/pdf/cafe/2017+CAFE_and_GHG_Notice_of_Intent.pdf, accessed on 10/9/2010.

heavy duty vehicles.[4] His memo directs the agencies to finalize the standards by July 30, 2011. The standards are to cover the years 2014 to 2018. In its fact sheet on the upcoming standards, NHTSA states that, "While the medium- and heavy-duty truck sector is very diverse and opportunities to reduce GHGs and increase fuel economy vary, preliminary estimates indicate that large tractor trailers – representing half of all GHG emissions from this sector – could reduce GHG emissions by as much as 20 percent and increase fuel efficiency by as much as 25 percent by 2018 through the use of existing technologies."[5]

Improving transportation fuels

Another strategy to reduce GHG emissions in the transportation sector is reducing the carbon content of fuels. This could be done at a statewide level by instituting a Low Carbon Fuel Standard (LCFS) or another alternative fuel mandate.

Under Executive Order 09-05, the Department of Ecology (Ecology) is evaluating whether a low carbon fuel standard should be adopted by the State. They are examining the emission and economic effects of a 10 percent reduction in carbon intensity (as measured in CO_2e per unit of energy in the fuel), implemented over ten years from 2013 - 2023.

LCFS programs work by requiring fuel providers to ensure that the fuel they sell meets declining lifecycle GHG emission standards, measured as grams CO_2e per unit of fuel energy sold.[6] Standards can be met by selling fuels with lower carbon intensities, using credits previously banked, or purchasing credits from other fuel suppliers. Because no specific technology is required, the market is free to meet the goals in the most economically viable manner.

California adopted an LCFS in 2009. Its reductions take effect in 2011 and reach a 10 percent carbon intensity reduction in 2020. In Oregon, the Department of Environmental Quality has been given authority (through legislation) to adopt an LCFS and is currently developing the program. British Columbia has adopted its own standard.

In conjunction with their work on the LCFS, Ecology developed estimates of alternative vehicle market penetration and quantities of alternative fuels needed to meet the 10 percent carbon

[4] President Barack Obama, Presidential Memorandum Regarding Fuel efficiency Standards, http://www.whitehouse.gov/the-press-office/presidential-memorandum-regarding-fuel-efficiency-standards, accessed on 10/9/2010.
[5] NHTSA and EPA to Propose Greenhouse Gas and Fuel Efficiency Standards for Medium- and Heavy-Duty Trucks; Begin Process for Further Light-Duty Standards; Fact Sheet. NHTSA. May 2010. http://www.nhtsa.gov/staticfiles/rulemaking/pdf/cafe/LD_HD_FE_FactSheet.pdf, accessed on 10/9/2010.
[6] The Role of a Low Carbon Fuel Standard in Reducing Greenhouse Gas Emissions and Protecting Our Economy. Office of the Governor. State of California. http://gov.ca.gov/index.php?/fact-sheet/5155/, accessed on 10/9/2010.

intensity reduction. This work has been incorporated as part of the scenarios evaluated in the "Transportation sector strategy analysis: Evaluation of scenarios" section below.

Washington State is actively involved in the West Coast Green Highway initiative to promote the use of cleaner fuels. By increasing the market demand for high-efficiency, zero- and low-carbon-emitting vehicles, this initiative aims to reduce the transportation sector's impact upon the environment and dependency on foreign oil. The West Coast Green Highway is the 1,350 miles of Interstate 5 (I-5) stretching from the U.S. border with Canada, through Washington, Oregon, and California, to the U.S. border with Mexico. The drivers of hundreds of thousands of cars and trucks that travel on this major roadway each day will soon be able to select from a menu of clean alternative fuels, such as natural gas, biodiesel, ethanol, or hydrogen.
The west coast is getting ready for the electric vehicles (EVs) expected to roll out during the next couple of years from major auto manufacturers. President Obama established a goal of bringing 1 million plug-in hybrid electric vehicles (PHEV) onto this country's roads by 2015. Washington State's Transportation and Commerce departments are partners in implementing the nation's first "electric highway," an initial network of public-access electric vehicle (EV) recharging locations along Interstate 5.

Reducing VMT

Reducing per capita vehicle miles traveled is an important element for improving the efficiency of the transportation system and reducing transportation-related emissions. VMT is a measure of the amount of vehicle travel. Individuals in every community play a role in how people, goods, and information move around.

Strategies to reduce VMT include a wide range of approaches, including providing more options for making trips; building safe networks for bicycles and pedestrians; changing the way that basic services are accessed; and changing land use patterns. Recent work in our state by the Climate Action Team's Transportation Implementation Working Group (TIWG) and the Land Use and Climate Change Advisory Committee (LUCC) identified a number of transportation-related strategies for reducing greenhouse gas emissions. WSDOT conducted a national literature review to identify additional strategies beyond those considered in previous work. A comprehensive list of VMT reduction strategies is included at the end of Appendix F.

WSDOT reviewed national studies to determine the potential effectiveness of VMT strategies. The review of studies highlights the types of strategies that may reduce statewide VMT and ranges of potential VMT reductions.

Review of studies of the effectiveness of VMT reduction strategies

Considerable uncertainty exists regarding the range of VMT reductions possible in our state. Most studies imply that light duty vehicle fleet VMT reductions between 7 and 33 percent from the future 2050 baseline may be possible (the 2050 VMT benchmark requires a 50 percent per capita reduction in VMT). However, the political and practical feasibility of achieving VMT reductions at the higher end of that range is unclear, since it appears that widespread pricing signals equivalent to an additional fuel cost of several dollars a gallon would be required, along with supportive bold and transformative land use and transit strategies.

This summary focuses on more recent studies that cover a large geographic scale (e.g., nationwide or statewide as opposed to within a local area or central business district). This summary only focuses on recent major studies, and it is not intended to be a comprehensive review of all available studies. VMT reductions in studies are generally reductions from future "business as usual."

The studies included in this summary, by geographic scale, are as follows:

Washington State

- WA Climate Action Team transportation policy options analysis (December, 2007)

United States

- Transportation Role in Reducing U.S. GHG Emissions: Report To Congress (April, 2010)
- Moving Cooler (July, 2009)
- Harvard Kennedy School Belfer Center for Science and International Affairs Study, Analysis of Policies To Reduce Oil Consumption and Greenhouse-Gas Emissions from the US Transportation Sector (February, 2010)
- EPA Analysis of the transportation Sector Greenhouse Gas and Oil Reduction Scenarios (February, 2010)

Regional Studies

- U.C. Berkeley Study: Review of Modeling Analysis of Transit, Land Use, and Auto Pricing Strategies to Reduce VMT and GHG Emissions, C. Rodier, for CARB and Caltrans (October, 2009)

Some strategies appear to offer more promise for reducing VMT than others and combining strategies appears to be more effective than implementing any individual strategy in isolation. The studies also indicate, at a high level, the potential GHG reductions needed from other strategies. In general, the studies indicate the following:

- **Transit strategies**. Modest to moderate VMT reductions are possible from transit expansion alone; more significant reductions are possible if accompanied by land use and pricing strategies.
- **HOV and commuter strategies**. VMT reductions for HOV and commuter strategies are similar to transit.
- **Land use/smart growth**. Moderate VMT reductions are possible in the long term; greater reductions are possible if land use strategies are combined with transit and pricing.
- **Non-motorized**. For strategies focusing on pedestrians and bicyclists, modest VMT reductions are possible from expansion of non-motorized facilities; greater reductions if combined with supportive land use, transit, and pricing strategies.
- **Pricing strategies**.
    - Studies suggest moderate to major VMT reductions are possible, particularly when combined with land use and transit strategies.
    - Major VMT reductions would appear to require broad-based pricing signals with equivalent fuel prices increased by several dollars a gallon.
    - Studies indicate that an economy-wide carbon price of $30-$60/ton[7] CO_2 increases fuel prices only modestly.
    - In addition to reducing VMT, pricing signals could encourage the transition to a more greenhouse gas-efficient vehicle fleet (these benefits could exceed the VMT reduction benefits).

Projections of potential VMT reductions in Washington

To determine a range of potential reductions in statewide VMT, WSDOT used the assumptions and analysis in one study, *Moving Cooler*, to develop two scenarios projecting what types of VMT reductions might be possible from various strategies. The *Moving Cooler* report is the only national study that provides ranges of VMT reductions from a wide range of strategies. The sponsors of *Moving Cooler* included organizations with a diverse set of interests, including Intelligent Transportation Society of America, American Public Transportation Association, Federal Highway Administration and Federal Transit Administration, Natural Resources Defense Council, Rockefeller Foundation, Shell Oil Company, Urban Land Institute; and the Environmental Protection Agency.

This study was prepared by the nationally recognized transportation consulting firm, Cambridge Systematics. This study also formed the basis for the April 2010 USDOT report *Transportation's Role in Reducing U.S. GHG Emissions: Report to Congress.* Our analysis combined strategies for

[7] $30-$60/ton is the range typically referred to in a national cap and trade type program.

reducing light duty vehicle VMT and constructed scenarios based on “bundles” of strategies. The “low” VMT bundle has moderate implementation costs with comparatively fewer barriers for implementation. The “high” VMT bundle is an aggressive, higher cost bundle with more barriers to implementation.

Consistent with the findings from other studies, the “high” VMT bundle would require bold and transformative land use and transit strategies, and significant pricing signals (see Appendix F for the complete list). Following are a few of the many strategies included in the “high” VMT bundle:

- A VMT or carbon fee equivalent to $0.03/mile (represents an additional $0.63 per gallon indexed to fuel economy);
- Peak period congestion pricing at an average peak hour per mile price of $0.65 on congested segments;
- For new development, 90 percent is located in neighborhoods in attached or small-lot detached units, in pedestrian- and bicycle-friendly neighborhoods, with mixed-use commercial districts, and with high-quality transit;
- Local plan/zoning code compliance is 100 percent; and
- Transit service is expanded proportional to 4.67 percent per year ridership growth.

In practice, implementation of these strategies is dependent on a mix of state, regional, local, and private action. Even a bundle of moderate VMT reduction strategies will require substantial investments and changes in personal behavior, local, state, and federal policy, and an increase in funding.

The “high” VMT reduction scenario is estimated to achieve a 28 percent reduction in VMT in 2050. The “low” bundle achieves a 10 percent reduction in VMT. This analysis implies that meeting the 2050 VMT reduction benchmark (about a 50 percent reduction) is improbable.

Implementing GHG emissions reduction strategies

Some of the emissions reduction strategies studied for application in our state are already in use. These include commute trip reduction programs, deploying system efficiencies, using biofuels, and installing electric vehicle stations. Significantly reducing GHG emissions will require policy changes and additional or reprioritized investments at the state, regional, and local levels.

For example, pricing strategies (such as tolling, variable tolling, and HOT lanes) in Washington State are currently used primarily to fund transportation facilities and to operate them more efficiently. Recent studies suggest that pricing has strong potential for reducing VMT by modifying travel behavior when designed accordingly. However, the public acceptability and the social desirability of significant pricing schemes designed to reduce travel and GHG emissions remain major questions for the likely implementation of these strategies.

The state cannot reduce emissions substantially without collaborative and comprehensive efforts by private citizens, businesses, and regional and local governments. People and businesses make decisions every day concerning where and how to travel, reside, and work. All of these decisions drive the demand for travel and use of the transportation system.

Transportation sector strategy analysis: evaluation of scenarios

Executive Order 09-05 directs WSDOT to "…develop additional strategies to reduce emissions from the transportation sector." To develop those strategies, we needed to start by having a better understanding of how much of a GHG reduction may be feasible from each of the four broad approaches (vehicles, fuels, VMT, and operations) that affect on-road transportation GHG emissions in Washington State. This analysis would help identify what, if any, additional strategies would be needed to reduce emissions from the transportation sector.

For this analysis, we estimated GHG emissions to the year 2050 for four scenarios. Given that there is much uncertainty in a forty year forecast, the scenarios include what we consider possible using existing technology and reasonable assumptions. Each scenario consists of a package of vehicle and fuel strategies, a bundle of VMT strategies, and assumptions regarding system efficiency improvements. The VMT bundles used in the analysis are described in *Potential VMT reductions in Washington* above, with additional details provided in Appendix F. System efficiency improvements were considered to reduce GHG emissions by one percent across the board in this analysis, as described above in the *System Efficiency* section. Improvements to vehicle technology and fuels are considered together in all scenarios, and we considered both light duty and heavy duty vehicles since both impact on-road transportation emissions.

For assumptions regarding vehicles and fuels, the scenarios were developed in coordination with the Department of Ecology and emissions were estimated using the VISION model. Note that the statutory statewide GHG reduction limits (RCW 70.235.020) apply to all emissions across the state with no exemptions noted in the law. Unlike RCW 70.235.020, the VMT law specifically excludes heavy duty vehicles (10,000 pounds and more) from the reduction benchmarks. Additional details on the vehicle and fuel assumptions for the scenario analysis are provided in Appendix I.

Scenarios

Four scenarios were considered in this analysis:

1. Low/Business as Usual
2. Mid/Likely
3. High/Aggressive
4. High Extended (added by WSDOT)

Vehicle and fuel assumptions for scenarios 1 through 3 were developed by the Department of Ecology (Ecology). These three scenarios represent changes in the vehicle fleet and fuels that Ecology's research indicates may be achievable. However, all modeling results out to 2050 remain highly uncertain. Because these scenarios have been developed based on Ecology's LCFS work, which only considers improvements to the year 2023, the improvements remain constant after 2023. To get a better understanding of potential longer-term vehicle and fuel improvements, WSDOT added a fourth scenario, the High Extended scenario, which continues improvements to the vehicle fleet out to the year 2050.

Figure 7 summarizes the assumptions for vehicles and fuels, VMT, and system efficiency in the four scenarios.

Scenario	Vehicles and Fuels	VMT	System Efficiency
Baseline	Ecology's Low case (45 mpgge in 2050)8	WSDOT June 2010 forecast (8,350 mi/person in 2050)	Nothing beyond projects currently programmed
Mid	Ecology's Mid / Most Likely case (49 mpgge in 2050)	Low bundle, 10% below forecast in 2050 (7,550 mi/person in 2050)	1% GHG reduction from additional improvements
High	Ecology's High / Aggressive case (66 mpgge in 2050)	High bundle, 28% below forecast in 2050 (6,010 mi/person in 2050)	1% GHG reduction from additional improvements
High Extended	Ecology's High / Aggressive case + fuel economy improvements beyond 2025 (69 mpgge in 2050)	High bundle, 28% below forecast in 2050 (6,010 mi/person in 2050)	1% GHG reduction from additional improvements

Figure 7. GHG Scenario Overview

[8] Miles per gallon gasoline equivalent is used here to represent the carbon efficiency of the vehicles in terms familiar to most people.

Scenario analysis of greenhouse gas emissions

The expected GHG emissions from these four scenarios are shown in Figure 8. For illustrative purposes only, Figure 8 includes a line indicating 50 percent of the on-road transportation's 1990 emissions. It is important to note that statewide GHG reduction goals apply to all sectors as whole, not just transportation.[9]

The shaded area in the chart indicates emissions estimated; the model used for this analysis does not include the years 1990 to 1999.

The High Extended scenario's reductions shown in this chart correspond to roughly a ten percent reduction in total state emissions in 2050. The scenario analysis suggests that actively pursuing each and every GHG reduction strategy from transportation will be critical to significantly reduce the state's emissions. There is no silver bullet.

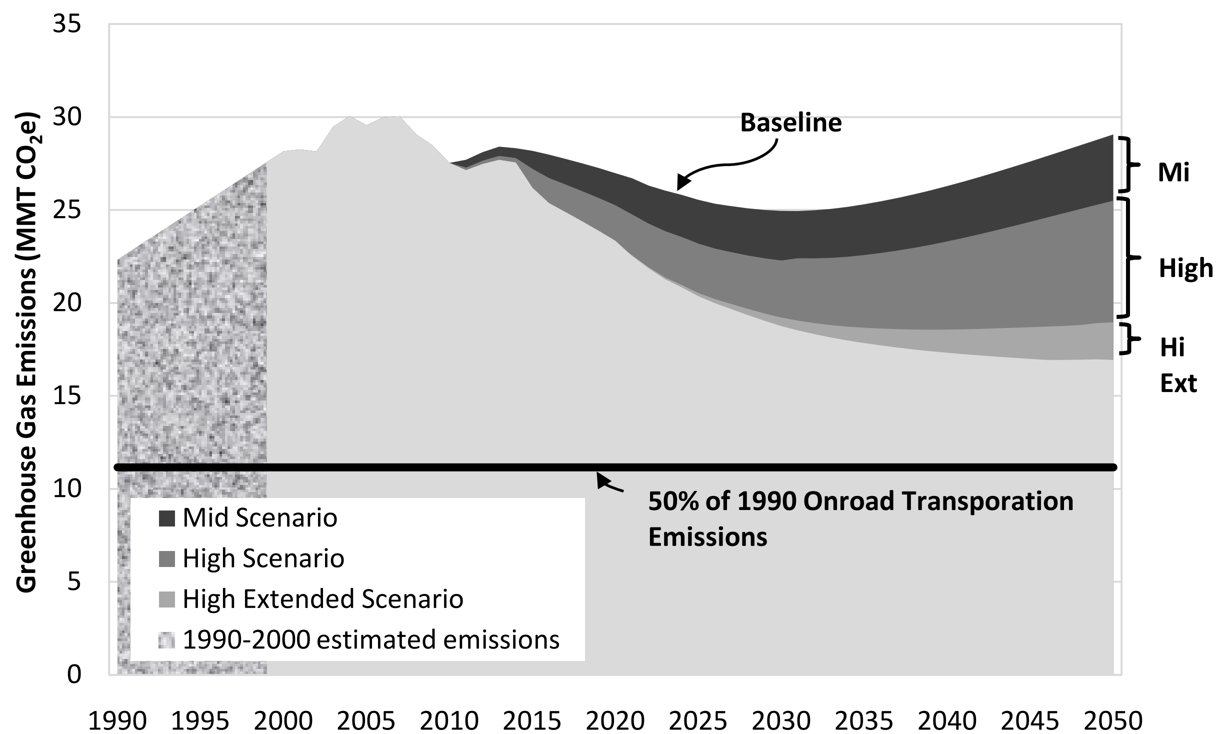


Figure 8. On-Road Greenhouse Gas Reduction Scenarios
Source: VISION Model

WSDOT's analysis suggests that implementing combinations of aggressive transportation strategies could achieve roughly a ten percent reduction in total state GHG emissions compared to 2050 baseline. Implementing many of these strategies would require changes in policy,

[9] See Technical Appendix C: Revised Code of Washington 70.235.020

funding, and authority, and also assumes ambitious improvements in vehicles and fuels. WSDOT did not assess the political or financial feasibility of implementing the strategies.

Recommendation

WSDOT recommends that the state consider the most viable ways to reduce statewide GHG emissions across all sectors. In 2011, WSDOT will continue to work with the four largest RTPOs identified in the Executive Order as part of the Section 2(b) work, which would further inform practical approaches for reducing GHG emissions at the regional level.

VI. Unresolved Issues

Several issues emerged through the course of this analysis. These issues appear to have a relationship and influence over the topics covered in this report, but were not thoroughly assessed given the direction of Section 2(a). WSDOT will respond to these issues as necessary in context with regional characteristics and need as part of the Section 2(b) work in 2011.

Cost effectiveness of strategies

WSDOT did not perform an in-depth cost effective analysis of strategies. The outcome of this assessment is likely to differ across the state depending on regional characteristics and needs. A closer look at the cost effectiveness of VMT and GHG reduction strategies at the regional level is anticipated in 2011.

Role of transit

A closer look at the role of transit at the regional level is anticipated in 2011. However, the statewide scenario analysis of VMT reduction strategies did assume expansion of transit service as described in Appendix F, Figure F-14.

Transportation energy strategy

The Department of Ecology is evaluating the feasibility of statewide Low Carbon Fuel Standards. Ecology's draft staff recommendation suggests that a low carbon fuel standard could reduce greenhouse gas emissions from transportation by 9.5 to 12 percent. Ecology has not yet developed a recommendation on whether the state should move forward with an LCFS. Ecology hopes to answer some questions about the availability of low-carbon fuels and engage with other jurisdictions considering LCFs prior to making a recommendation to the Governor. A comprehensive energy strategy that addresses transportation fuel consumption would help reduce GHGs.

Regional and federal climate policies and strategies

Regional and federal policies and actions on climate change will influence our state's efforts. WSDOT's analysis does not consider the potential impacts of external actions. It is uncertain what and when regional and federal actions will be taken and how these could affect Washington's strategies to reduce emissions.

VII. What are the Next Steps?

Section 2(b) of Executive Order 09-05 directs WSDOT to apply the information developed for this report and work with the Puget Sound Regional Council, Spokane Regional Transportation Council, Southwest Washington Regional Transportation Council, and Thurston Regional Planning Council to "cooperatively develop and adopt regional transportation plans that will, when implemented, provide people with additional transportation alternatives and choices, reduce GHG and achieve the statutory benchmarks to reduce annual per capita vehicle miles traveled in those counties with populations greater than 245,000."

By December 2011, WSDOT is instructed to report on which Regional Transportation Planning Organizations have developed, or are developing, plans with greenhouse gas strategies; which strategies appear to have the greatest potential to achieve the benchmarks; and what policy or funding issues need to be resolved to ensure implementation.

VIII. Technical Appendices

Appendix A

Executive Order 09-05, Section 2(a) Working Group Members

2009-10 Executive Order 09-05, Section 2(a) Working Group Members

Representative	Title	Agency/Organization
Jim Anderson	Shoalwater Bay Tribal Gaming Commission Chairman	Shoalwater Bay Indian Tribe
Leonard Bauer	Managing Director	Washington State Department of Commerce Growth Mgmt Services
Thera Black	Senior Planner	Thurston Regional Planning Council
Gustavo Collantes	Senior Energy Policy Specialist	Washington State Department of Commerce Energy Policy Division
Lynda David	Senior Transportation Planner	Southwest Washington Regional Transportation Council
Mike Harbour	General Manager	Intercity Transit
Charlie Howard	Transportation Planning Director	Puget Sound Regional Council
Eric Johnson	Executive Director	Washington State Association of Counties
Bill LaBorde	State Policy Director	Transportation Choices Coalition
Dean Lookingbill	Transportation Director	Southwest Washington Regional Transportation Council
Kelly McGourty	Program Manager	Puget Sound Regional Council
Glenn Miles	Transportation Manager	Spokane Regional Transportation Council
Carol Moser	Chair	Washington State Transportation Commission
Grant Nelson	Government Affairs Director	Association of Washington Business
Karl Otterstrom	Director of Planning	Spokane Transit Authority
Dave Overstreet	Public Affairs Director	AAA Washington
Joyce Phillips	Senior Planner	Washington State Department of Commerce Growth Mgmt Services
Keith Phillips	Executive Policy Advisor	Governor Gregoire's Executive Policy Office
Ashley Probart	Legislative & Policy Advocate	Association of Washington Cities
Anna Ragaza-Bourassa	Transportation Planner Supervisor	Spokane Regional Transportation Council
Mark Richard	Spokane County District 2 Commissioner	Spokane County Board of Commissioners
Phil Rockefeller	Senator	Washington State Legislature
Gary Rowe	Managing Director	Washington Association of County Engineers
Bob Saunders	Air Quality Program Strategic Planner	Washington State Department of Ecology
Jeff Selle	Manager of Government Affairs	Spokane Regional Trans. Council
Brian Smith, Co-Chair	Director	WSDOT Strategic Planning and Programming
Leslie Stanton	Team Lead Climate & Transportation	Puget Sound Clean Air Agency
Katy Taylor, Co-Chair	Director	WSDOT Public Transportation
Dave Upthegrove	Representative	Washington State Legislature
Jeff Wilkens	Executive Director	Wenatchee Valley Trans. Council
Lon Wyrick	Executive Director	Thurston Regional Planning Council

Appendix B

Executive Order 09-05:

Washington’s Leadership on Climate Change

CHRISTINE O. GREGOIRE
Governor

STATE OF WASHINGTON

OFFICE OF THE GOVERNOR

P.O. Box 40002 · Olympia, Washington 98504-0002 · (360) 753-6780 · www.governor.wa.gov

EXECUTIVE ORDER 09-05
WASHINGTON'S LEADERSHIP ON CLIMATE CHANGE

WHEREAS, Washington is particularly vulnerable to the impacts of climate change, and without additional action to reduce carbon emissions, the severity of the impacts will negatively affect nearly every part of Washington's economy and environment; and

WHEREAS, Washington is already experiencing the effects of a changing climate and needs to address current and future projected impacts; and

WHEREAS, greenhouse gases are air contaminants within the meaning of the state's Clean Air Act and pose a serious threat to the health and welfare of Washington's citizens and the quality of the environment; and

WHEREAS, energy independence and security are vitally important, and maintaining Washington's leadership position in the development of clean energy and green jobs is critical to our economic and energy future; and

WHEREAS, RCW 70.235.020 establishes greenhouse gas emission reduction limits for Washington State, and RCW 47.01.440 establishes vehicle miles traveled benchmarks for Washington State; and

WHEREAS, alternative vehicle technologies can provide economic development opportunities and reduce Washington's transportation sector greenhouse gas emissions, criteria pollutants, and toxic air contaminants; and

WHEREAS, Washington's extensive forest resources play an important role in capturing and storing carbon dioxide; and

WHEREAS, it is critical to Washington's economic future that greenhouse gas reduction strategies be designed and implemented in a manner that minimizes cost impacts to Washington citizens and businesses; and

WHEREAS, President Obama and the United States Congress are actively working to establish a strong federal response to climate change, and regional and state level greenhouse gas reduction programs will inform and complement a federal program; and

WHEREAS, effective and immediate action to reduce greenhouse gas emissions – preferably at the federal level but at the regional or state level as necessary – is essential to the future well being of all Washingtonians.

NOW, THEREFORE, I, Christine O. Gregoire, Governor of the state of Washington by virtue of the power vested in me by the Constitution and statutes of the state of Washington do, effective immediately, hereby order and direct:

1. The Director of the Department of Ecology to:

(a) Continue to participate in the Western Climate Initiative to develop a regional greenhouse gas emission reduction program and to work with the federal Administration, Washington's congressional delegation and appropriate committees to help design a national greenhouse gas emission reduction program that reflects Washington State priorities. Those priorities include: protecting small businesses and families, particularly those with low incomes, in the transition to a clean energy future; investing in clean energy development, demonstration and deployment; ensuring appropriate credit for early emission reductions; providing a level playing field that allows Washington's businesses to fairly compete; recognizing Washington's unique electricity-generating portfolio, its forest industry and other important resources; and ensuring the program spurs the creation of green jobs.

(b) By December 1, 2009, provide to each facility that the Department of Ecology believes is responsible for the emission of 25,000 metric tons or more of carbon dioxide equivalent each year in Washington with (1) the Department's best estimate of each facility's baseline greenhouse gas emissions; and (2) each facility's proportionate share greenhouse gas emission reduction necessary to achieve the state's 2020 emission reduction in RCW 70.135.020; and (3) a request to each facility, or groups of facilities representing a sector of Washington's economy, for any recommended strategies or actions they believe would achieve the needed reductions. By October 1, 2010, the Department of Ecology shall develop emission reduction strategies and actions, including complementary policies, to achieve the state's 2020 emissions reduction targets.

(c) In consultation with business and other interested stakeholders, develop emission benchmarks, by industry sector, for facilities the Department of Ecology believes will be covered by a federal or regional cap and trade program. The Department of Ecology shall support the use of these emission benchmarks in any federal or regional cap and trade program as an appropriate basis for the distribution of emission allowances, and as a means to recognize and reward those businesses that have invested in achieving emission reductions. These benchmarks shall be based on industry best practices, reflecting emission levels from highly efficient, lower emitting facilities in each industry sector. The benchmarks shall be developed to allow their application as state-based emissions standards, should they be needed to complement the federal program, or in the absence of a federal program.

Recommendations on industry benchmarks, and the appropriate use of these benchmarks in achieving the state emission reduction targets, shall be submitted to the Governor by July 1, 2011;

(d) Work with the existing coal-fired plant within Washington that burns over one million tons of coal per year, TransAlta Centralia Generation LLC, to establish an agreed order that will apply the greenhouse gas emissions performance standards in RCW 80.80.040(1) to the facility by no later than December 31, 2025. The agreed order shall include a schedule of major decision making and resource investment milestones;

(e) In consultation with the Department of Natural Resources and the forest carbon sector working group, develop by September 1, 2010, recommendations for forestry offset protocols as well as other financial incentives for forestry and forest products. The starting point for this work should be the 2008 forest sector working group report; and

(f) In consultation with the Departments of Commerce and Transportation, assess whether the California low-carbon fuel standards; standards developed or proposed in other states, provinces or for the nation; or modified standards or alternative requirements to reduce carbon in transportation fuels would best meet Washington's greenhouse gas emissions reduction targets. By July 1, 2010, provide to the Governor a recommendation regarding which standards or requirements should be adopted for Washington, either by rule or legislation.

2. The Secretary of the Department of Transportation to:

(a) In consultation with the Departments of Ecology and Commerce, and in collaboration with local governments, business, and environmental representatives, estimate current and future state-wide levels of vehicle miles traveled, evaluate potential changes to the vehicle miles traveled benchmarks established in RCW 47.01.440 as appropriate to address low- or no-emission vehicles, and develop additional strategies to reduce emissions from the transportation sector. Findings and recommendations from this work shall be reported to the Governor by December 31, 2010; and,

(b) Work with the Puget Sound Regional Council, Spokane Regional Transportation Council, Southwest Washington Regional Transportation Council and Thurston Regional Planning Council to cooperatively develop and adopt regional transportation plans that will, when implemented, provide people with additional transportation alternatives and choices, reduce greenhouse gases and achieve the statutory benchmarks to reduce annual per capita vehicle miles traveled in those counties with populations greater than 245,000. By December 1, 2011, the Department will report to the Governor on which regional transportation planning organizations have developed, or are developing, plans with greenhouse gas strategies, which strategies appear to have the greatest potential to achieve the benchmarks, and what policy or funding issues need to be resolved to ensure implementation;

3. The Office of the Governor shall work with affected state agencies to develop and seek federal funds to implement a project for the electrification of the West Coast interstate highway and associated metropolitan centers, including request for federal funding to purchase electric vehicles and install public infrastructure for electric and other high-efficiency, zero- or low-carbon vehicles. The Office shall invite the collaboration of the states of Oregon and California and participation by the private sector in developing and implementing this project and in requesting federal support.

4. The Director of the Department of Ecology shall evaluate the potential impacts of sea level rise on the state's shoreline areas, including the potential increases in storm surge and coastal flooding, increased erosion, and loss of habitat and ecosystems, and develop recommendations for addressing these impacts. The Department shall invite the Washington State Association of Counties and the Association of Washington Cities to collaborate in conducting the evaluation and developing recommendations.

5. The Director of the Department of Ecology and the Secretary of the Department of Health, in consultation with other affected state, local and federal agencies, shall develop specific guidelines, tools, and recommendations to assist the state and its water users to meet the anticipated changes in water resources due to climate change impacts.

6. In implementing all aspects of this Executive Order, the state and its agencies shall consult, on a government-to-government basis with Washington's Native American Tribes.

7. The Director of the Department of Ecology, in cooperation with affected agencies shall provide a progress report to the Office of the Governor by December 31, 2010.

Signed and sealed with the official seal of the state of Washington on this 21st day of May 2009 at Seattle, Washington.

Appendix C

Revised Code of Washington 70.235.020
Greenhouse Gas Emissions Reductions — Reporting Requirements

Revised Code of Washington 70.235.020

Greenhouse gas emissions reductions — Reporting requirements

(1)(a) The state shall limit emissions of greenhouse gases to achieve the following emission reductions for Washington State:

> (i) By 2020, reduce overall emissions of greenhouse gases in the state to 1990 levels;
>
> (ii) By 2035, reduce overall emissions of greenhouse gases in the state to twenty-five percent below 1990 levels;
>
> (iii) By 2050, the state will do its part to reach global climate stabilization levels by reducing overall emissions to fifty percent below 1990 levels, or seventy percent below the state's expected emissions that year.

(b) By December 1, 2008, the department shall submit a greenhouse gas reduction plan for review and approval to the legislature, describing those actions necessary to achieve the emission reductions in (a) of this subsection by using existing statutory authority and any additional authority granted by the legislature. Actions taken using existing statutory authority may proceed prior to approval of the greenhouse gas reduction plan.

(c) Except where explicitly stated otherwise, nothing in chapter 14, Laws of 2008 limits any state agency authorities as they existed prior to June 12, 2008.

(d) Consistent with this directive, the department shall take the following actions:

> (i) Develop and implement a system for monitoring and reporting emissions of greenhouse gases as required under RCW 70.94.151; and
>
> (ii) Track progress toward meeting the emission reductions established in this subsection, including the results from policies currently in effect that have been previously adopted by the state and policies adopted in the future, and report on that progress.

(2) By December 31st of each even-numbered year beginning in 2010, the department and the *department of community, trade, and economic development shall report to the governor and the appropriate committees of the senate and house of representatives the total emissions of greenhouse gases for the preceding two years, and totals in each major source sector. The department shall ensure the reporting rules adopted under RCW 70.94.151 allow it to develop a comprehensive inventory of emissions of greenhouse gases from all significant sectors of the Washington economy.

(3) Except for purposes of reporting, emissions of carbon dioxide from industrial combustion of biomass in the form of fuel wood, wood waste, wood by-products, and wood residuals shall not be considered a greenhouse gas as long as the region's silvicultural sequestration capacity is maintained or increased.

[2008 c 14 § 3.]

*Reviser's note: The "department of community, trade, and economic development" was renamed the "department of commerce" by 2009 c 565.

Appendix D

Revised Code of Washington 47.01.440
Adoption of Statewide Goals to Reduce Annual Per Capita Vehicle Miles Traveled by 2050 — Department's Duties — Reports to the Legislature

Revised Code of Washington 47.01.440

Adoption of statewide goals to reduce annual per capita vehicle miles traveled by 2050 — Department's duties — Reports to the legislature

To support the implementation of RCW 47.04.280 and 47.01.078(4), the department shall adopt broad statewide goals to reduce annual per capita vehicle miles traveled by 2050 consistent with the stated goals of executive order 07-02. Consistent with these goals, the department shall:

(1) Establish the following benchmarks using a statewide baseline of seventy-five billion vehicle miles traveled less the vehicle miles traveled attributable to vehicles licensed under *RCW 46.16.070 and weighing ten thousand pounds or more, which are exempt from this section:

(a) Decrease the annual per capita vehicle miles traveled by eighteen percent by 2020;

(b) Decrease the annual per capita vehicle miles traveled by thirty percent by 2035; and

(c) Decrease the annual per capita vehicle miles traveled by fifty percent by 2050;

(2) By July 1, 2008, establish and convene a collaborative process to develop a set of tools and best practices to assist state, regional, and local entities in making progress towards the benchmarks established in subsection (1) of this section. The collaborative process must provide an opportunity for public review and comment and must:

(a) Be jointly facilitated by the department, the department of ecology, and the **department of community, trade, and economic development;

(b) Provide for participation from regional transportation planning organizations, the Washington state transit association, the Puget Sound clean air agency, a statewide business organization representing the sale of motor vehicles, at least one major private employer that participates in the commute trip reduction program, and other interested parties, including but not limited to parties representing diverse perspectives on issues relating to growth, development, and transportation;

(c) Identify current strategies to reduce vehicle miles traveled in the state as well as successful strategies in other jurisdictions that may be applicable in the state;

(d) Identify potential new revenue options for local and regional governments to authorize to finance vehicle miles traveled reduction efforts;

(e) Provide for the development of measurement tools that can, with a high level of confidence, measure annual progress toward the benchmarks at the local, regional, and state levels, measure the effects of strategies implemented to reduce vehicle miles traveled and adequately distinguish between common travel purposes, such as moving freight or commuting to work, and measure trends of vehicle miles traveled per capita on a five-year basis;

(f) Establish a process for the department to periodically evaluate progress toward the vehicle miles traveled benchmarks, measure achieved and projected emissions reductions, and recommend whether the benchmarks should be adjusted to meet the state's overall goals for the reduction of greenhouse gas emissions;

(g) Estimate the projected reductions in greenhouse gas emissions if the benchmarks are achieved, taking into account the expected implementation of existing state and federal mandates for vehicle technology and fuels, as well as expected growth in population and vehicle travel;

(h) Examine access to public transportation for people living in areas with affordable housing to and from employment centers, and make recommendations for steps necessary to ensure that areas with affordable housing are served by adequate levels of public transportation; and

(i) By December 1, 2008, provide a report to the transportation committees of the legislature on the collaborative process and resulting recommended tools and best practices to achieve the reduction in annual per capita vehicle miles traveled goals.

(3) Included in the December 1, 2008, report to the transportation committees of the legislature, the department shall identify strategies to reduce vehicle miles traveled in the state as well as successful strategies in other jurisdictions that may be applicable in the state that recognize the differing urban and rural transportation requirements.

(4) Prior to implementation of the goals in this section, the department, in consultation with the **department of community, trade, and economic development, cities, counties, local economic development organizations, and local and regional chambers of commerce, shall provide a report to the appropriate committees of the legislature on the anticipated impacts of the goals established in this section on the following:

(a) The economic hardship on small businesses as it relates to the ability to hire and retain workers who do not reside in the county in which they are employed;

(b) Impacts on low-income residents;

(c) Impacts on agricultural employers and their employees, especially on the migrant farm worker community;

(d) Impacts on distressed rural counties; and

(e) Impacts in counties with more than fifty percent of the land base of the county in public or tribal lands.

[2008 c 14 § 8.]

Reviser's note: *(1) RCW 46.16.070 was recodified as RCW 46.16A.455 pursuant to 2010 c 161 § 1217, effective July 1, 2011.
**(2) The "department of community, trade, and economic development" was renamed the "department of commerce" by 2009 c 565.
Findings -- Intent -- Scope of chapter 14, Laws of 2008 -- Severability -- 2008 c 14: See RCW 70.235.005, 70.235.900, and 70.235.901.

Appendix E

Vehicle Miles Traveled Statewide Forecast Model

NOTE: The following information has been reformatted for use in this report

Vehicle Miles Traveled (VMT) Statewide Forecast Model

Washington State Department of Transportation – Economic Analysis

Work Group Participants: Washington State Department of Transportation, Washington State Office of Financial Management, Washington Department of Licensing, Washington State Economic and Revenue Forecast Council, and House and Senate Legislative staff

April 2010

Table of Contents

Acknowledgements

In September 2009, the Washington State Department of Transportation formed a Technical Workgroup to develop a revised statewide vehicle miles traveled forecast. The Technical Workgroup met numerous times between September to April of 2010 to review the current vehicle miles traveled forecast and analyze methods for modifying the forecast. Presentations and group discussions examined data issues, forecast methodologies, critical assumptions, forecast drivers, forecast performance and local vehicle miles traveled issues. The following persons participated in the Technical Workgroup:

Department of Transportation:
Doug Vaughn
Lizbeth Martin-Mahar
Thomas L. Smith
Fanny N. Roberts
Kasi Reeves
Jeff Caldwell
Brian Smith
Elizabeth Robbins
Judy Lorenzo
Kathy Leotta
Karin Landsberg
Pat Morin
George Xu
Brian Calkins
Shuming Yan

Department of Licensing:
Jean Du
Alice Vogel

Office of Financial Management:
Lorrie Brown

Economic & Revenue Forecast Council:
Lance Cary

Senate Transportation Committee staff:
David Ward
Amanda Cecil

House Transportation Committee staff:
Jerry Long
Mark Matteson

Most of the analysis of the forecasts that appears in this study is the result of the eight months of research that this group devoted to evaluating the VMT forecast. Special thanks go to them for devoting their time to studying and improving the forecasting process for VMT.

Executive Summary

Vehicle Miles Traveled Data and Past Forecast Methodology

- For more than 20 years WSDOT-Economic Analysis has been forecasting Washington VMT statewide
  - Past Methodology: The VMT forecast used the quarterly forecast of net fuel gallons and multiplied that number by a forecast of fleet miles per gallon to get vehicle miles traveled statewide.
  - Last Forecast (February 2008): This forecast projected Washington VMT to grow by 45% between FY 2008-2025 with total VMT reaching 75 billion miles by FY 2020

- WSDOT-Transportation Data Office (TDO) collects VMT at various levels: statewide, county and by type of vehicle

- Numerous uses of VMT forecasts:
  - future alternative revenue source for transportation
  - transportation planning purposes
  - green house gas emission statewide targets
    - Washington's Greenhouse Gas emission standards and vehicle miles traveled reduction targets were set in law with a baseline of 75 billion VMT for 2020.

Factors Affecting Vehicle Miles Traveled

- There are many factors which determine the number of vehicles on the roadways, number of trips taken per driver and distance traveled per trip

- Numerous independent variables were tested in a econometric forecast model for VMT
  - Fuel consumption
  - Gas prices – as well as percentage change in prices and dummy variable for large price changes
  - Washington motor vehicle registrations
  - Washington employment
  - Washington unemployment rate
  - Washington personal income
  - Washington personal income per capita
  - Washington wages and salaries
  - Total and driver aged population
  - Labor force and population density
  - In-driver population
  - In-migration population
  - Total and interstate lane miles

- Various model functional forms and the necessity for lagging independent variables were also considered in a revised statewide VMT forecast model

New Statewide VMT Forecast Methodology

- The final statewide econometric VMT forecast model was determined after considering various forecast model specifications

- The final model is of log-log functional form which includes log of the following independent variables:
  - Washington employment
  - Washington motor vehicle registrations
  - Washington gas prices

- This new forecast model considers three separate types of impacts on VMT: economic activity, registration vehicles and gas prices

- This regression model was selected because it had the best overall fit, significant t-statistics and other critical statistics in the model

- Each of the independent variables have their own separate and distinct forecast which can be used to project VMT statewide

Next release of VMT Forecast

- The revised statewide VMT forecast model will be used to project VMT for the June 2010 transportation revenue forecast. This VMT forecast will be completed once a year typically in June, if new VMT data is available from the TDO in time for that forecast.

Conclusions

- In the last two years, revisions to the economic forecast drivers have a very significant impact on the VMT projections

- The further out the forecast is, the less reliable the forecast becomes
    - The past VMT forecasts have been fairly accurate, within 3%, in the near-term (up to 4 years out)

- This new regression model will improve the forecasting of statewide VMT by incorporating economic factors into a forecast model which will explain historical VMT trends
    - This new forecast produces lower VMT results than past forecasts under a different methodology

- This VMT forecast will be more transparent by separating out the VMT forecast into an alternative forecast in the June transportation forecast with an explanation of the econometric VMT forecast model, work group process and recent projections

Chapter 1: Vehicle Miles Traveled Forecast Background

Washington State Department of Transportation has been producing a statewide forecast of vehicle miles traveled (VMT) for more than 20 years. This VMT forecast had been a product of econometric fuel consumption forecasts that were completed each quarter. Essentially, the projected growth rate of gallons consumed of motor fuel was the driving indicator of VMT projections, not the actual VMTs in the state. This VMT forecast methodology had been the same for years and had not been reviewed by others for years. Even as recently as 2006, OFM reviewed the methodology for all the major transportation forecast models and the VMT forecast was not part of the bigger transportation forecast reviews.

Some of the reasons for the formation of this workgroup to review the Department's VMT forecast were due to the following:

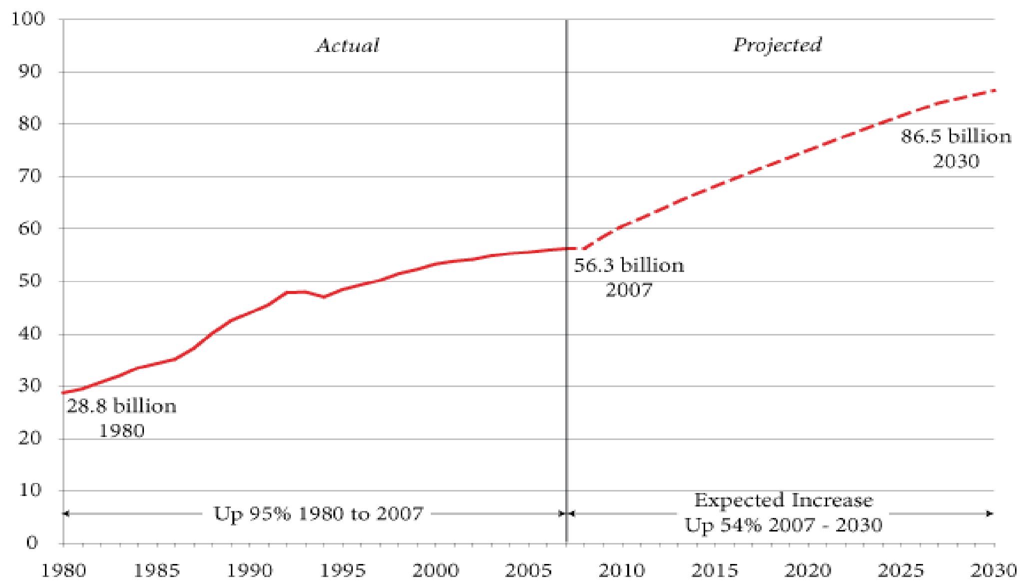
- an actual forecast model for Washington VMT had never been developed
- in light of the more recent trend of national and Washington VMT flattening, the accuracy of the past steep upward trending forecast was being questioned
- consultants and legislative staff have requested estimates for a VMT related tax as a new transportation revenue source
- capital planning purposes - to have an updated and accurate projection of VMT statewide
- enactment of Engrossed Second Substitute House Bill 2815 in 2008 established Washington statewide per capita VMT in order to reduce greenhouse gas emissions (RCW 47.01.440 2008 c. 14 § 8) where the baseline 2020 VMT was set at 75 billion VMT benchmark, consistent with the February 2008 VMT forecast for 2020.

Trends in Washington's VMT Forecast Model

Figure E-1 is Washington's actual and forecasted VMT since 1980, with forecasts for years 2008 and beyond based on the February 2008 projections. Even though the average historical growth rate from 1980 to 2007 was 3.5%, some observers have commented that the VMT forecast through 2030 was too aggressive given the recent flattening of the VMT trend in the period 2000 to 2008.

Others have noticed this trend change in national VMT data. Polzin, (2006), Polzin et al. (2004a), Polzin et al. (2004b), and the East-West Gateway Council of Governments (2008) are among those who have noticed the flattening of national and regional VMT growth and have speculated why that growth has moderated. For many years VMT, both nationally and in Washington State, experienced robust growth. Between 1984 and 2000, national VMT grew at an average rate of 3.1% (FHWA, 2009) while Washington's VMT growth was 3.0% for the same period. In recent years, VMT growth has slowed. From 2000 to 2008, the national average growth rate was 1.2%, while Washington's was 0.7% for 2000 to 2008. For the last year, national VMT growth was negative, at -0.8% for 2008. Washington had a -0.9% growth rate for 2008 (Transportation Data Office, 2009).

Figure E-1. Total Vehicle Miles Traveled 1980 - 2030 (February 2008 Forecast)
(Miles in billions)



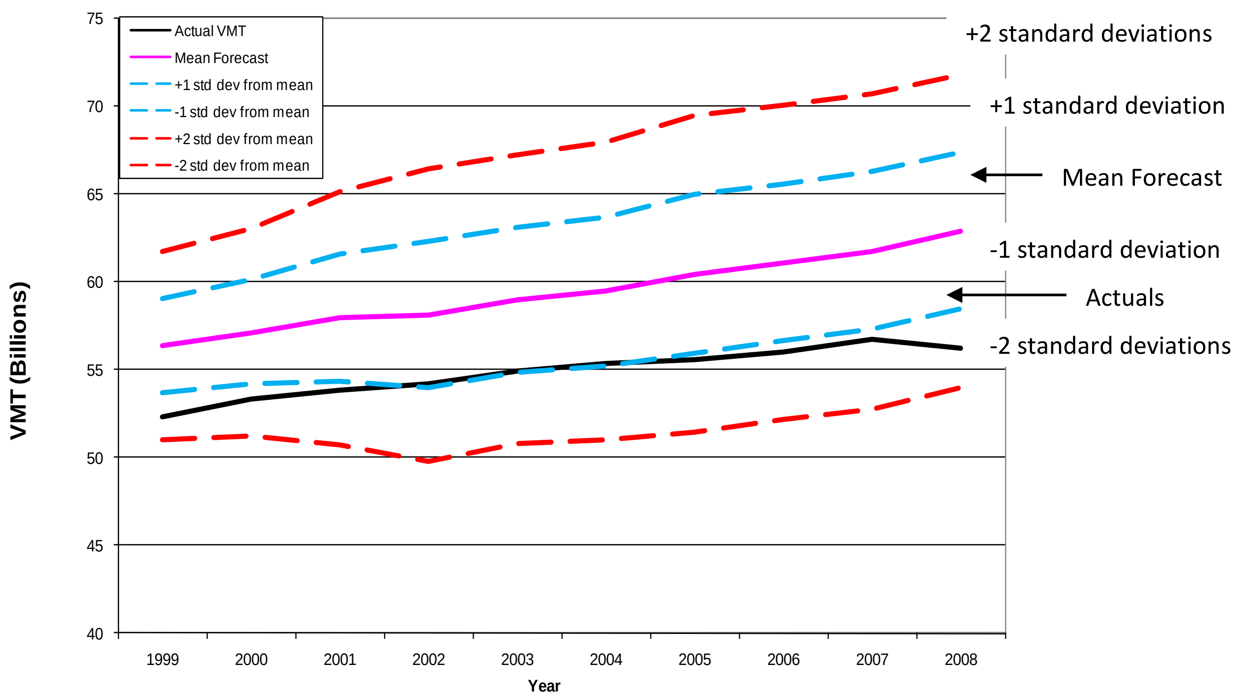
Components of OLD VMT Forecast Model

WSDOT's old methodology for forecasting VMT was essentially a by-product of its fuel revenue forecasts. The VMT forecast uses the quarterly forecast of net fuel gallons and multiplies that number by a forecast of fleet miles per gallon. The net fuel gallons forecast was based on two separate consumption models: one for gasoline fuel and another for diesel fuel consumption. Washington's forecast of gasoline consumption per capita in gallons uses a log-log regression model with past consumption of gasoline, annual moving average of fuel prices, fuel efficiency and dummy variable for oil supply disturbances as the independent variables in the model. Washington's forecast of diesel consumption in gallons uses a log-log regression model with past consumption of diesel and personal income.

Forecast Accuracy – Old Methodology

In the beginning of this VMT forecast technical workgroup, WSDOT-Economic Analysis section analyzed the accuracy of the forecast methodology prior to February 2008. In order to determine the accuracy of the past VMT forecasts, WSDOT-Economic Analysis compared VMT forecasts published by the Transportation Revenue Forecast Council (TRFC) from 1991 to 2008 with the actual VMT as reported by the WSDOT- Transportation Data Office. This study compared the February (in even years) or March (in odd years) forecast for each year to test accuracy. The results from 177 forecasts revealed that forty-eight forecasts had percentage errors less than 3%, 27 between 3 and 6%, and 101 exceeded 6%. For the period 1991 to 2008, the forecast proved to be accurate between plus or minus 3 per cent, 27% of the time. The majority of the time, the VMT forecasts had an error of 6% or greater. The results revealed that the forecasts were consistently overestimating vehicle miles traveled as seen in Figure E- 2 as the actual VMT for years 1999-2008 was consistently below the mean forecast every year. If the absolute mean percent error is examined by the number of periods in the future the forecast is made, the results reveal that in the near term, like up to 4 years, the forecast has been very accurate, within 3%. The further out the forecast, the less reliable the projection becomes. For further information on the analysis of the old VMT forecast methodology, see the report titled DOT's Vehicle Miles Travelled (VMT) Forecast Accuracy Prior to 2009 (WSDOT 2009).

Figure E-2. Mean Forecast (Years 1999-2008) Compared to Actual VMT (billions of miles)



Chapter 2: Independent Variables and Functional Forms Considered

The key factors that determine the total vehicle miles in the state can be broken down into the number of vehicles on the roads, the number of trips people take each year and the miles traveled on each trip. Identifying key factors that can be used in an econometric model can be complex. Some of these factors are hard to predict (e.g., socio-demographics, cultural shifts, gas prices, road capacity); some factors are random (e.g., weather conditions). Typically, economists only have a limited number of economic variables which can be used to predict relationships in regression models. The following independent variables were tested in an econometric forecast model for statewide VMT.

- Fuel consumption
- Gas prices; percentage change in fuel prices; “dummy” variable for large fuel price changes
- Washington motor vehicle registrations
- Washington employment
- Washington unemployment rate
- Washington personal income
- Washington personal income per capita

- Washington wages and salaries
- Total and driver aged population
- Labor force and population density
- In-driver population
- In-migration population
- Total and interstate lane miles

Functional Forms for Econometric Forecast Model

The workgroup was presented with various functional forms for the VMT regression model. A linear VMT forecast model was the starting point and other forms like log-log, logistic, cubic were tested to see if they fit the historical VMT data better. Figures E3-E6 are graphs of the historical VMT data, in billions, compared to a forecast with trends of different functional forms. The * depict the actual historical VMT and the blue line of ++++ depict the forecasted trend line. The linear trend model overestimates VMT in recent years, since 2003, as the amount of vehicle miles traveled has leveled off. The log trend model underestimates VMT since 1990. The logistic model is similar in form to the log model and it fits the historical VMT better than the log functional form. The forecast with the logistic trend is more optimistic than the forecast with the log trend form. The cubic functional form fits the historic VMT the best but given the trend of a cubic function, the forecast for VMT with the cubic trend is downward sloping. That may not be realistic to assume VMT will fall in the future consistent with a cubic trend curve. These different functional form trends are interesting to consider how the historical VMT fits these curves and their prediction of future VMT. Considering different types of trends is important for improving the overall fit of a forecast model and the fit of independent variables in the model.

Figure E-3. VMT and linear trend model

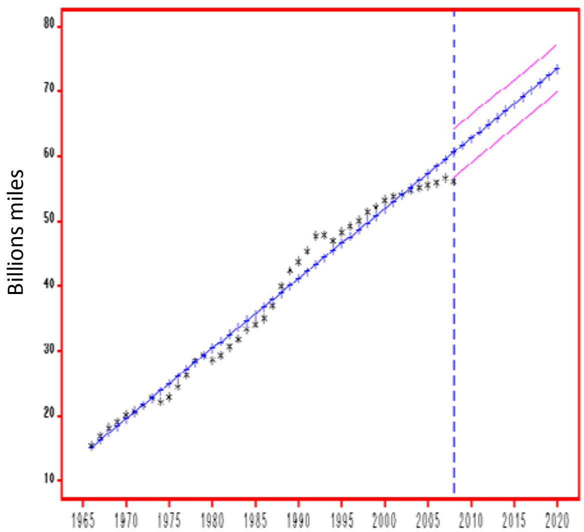


Figure E-4. VMT and log trend model

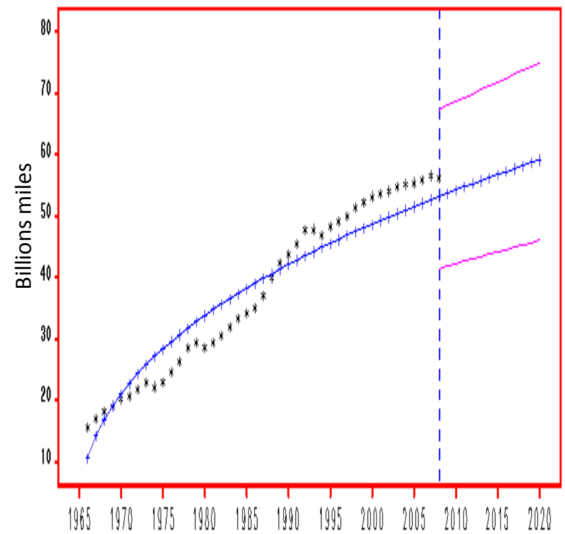


Figure E-5. VMT and logistic trend model

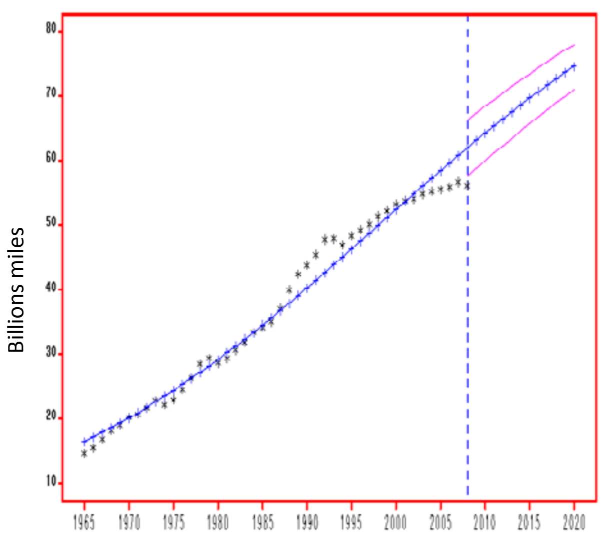
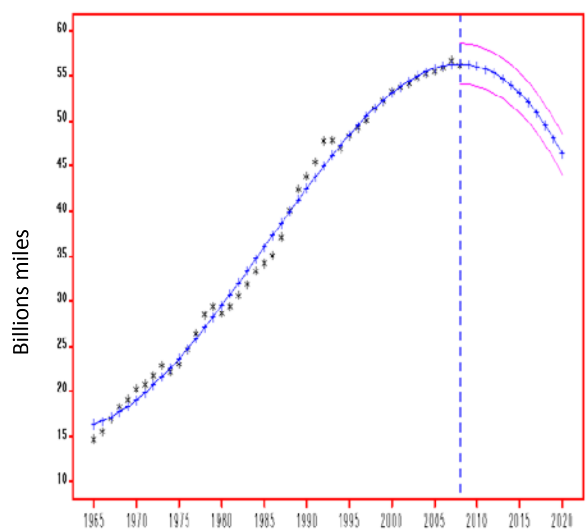


Figure E-6. VMT and cubic trend model



The independent variables considered by the workgroup in the VMT forecast model fell into one of five broad categories: economic activity, population, motor vehicle registrations, fuel consumption & prices and lane miles. The majority of these potential independent variables were very closely correlated with VMT as reflected in high correlation coefficients.

Economic Activity Independent Variables

Various measures of economic activity in the state were considered as independent variables in the VMT forecast model. We anticipated needing an economic activity variable to predict when people's driving behavior may change due to the economy. The tested variables included: Washington employment, Washington unemployment rate, Washington personal income and personal income per capita. From an economic perspective, one would predict that as Washington employment, personal income or personal income per capita rises, so would vehicle miles traveled. As people have employment or additional income then they will likely make more vehicle trips to work or other extracurricular activities. More families will take vacations further away from home as incomes rise. As employment and state income rises, so should business activities on the highways as businesses fulfill orders and provide services which would increase vehicle miles traveled in the state. In contrast to the positive relationship between VMT and income and employment, there should be a negative relationship between VMT and the unemployment rate. As the unemployment rate rises, employment falls so there are less people traveling to work daily so VMT is anticipated to fall.

Model results, as summarized in Figure E-7, revealed the following:

- Washington employment, personal income and personal income per capita all had a positive correlation with VMT
- When used in separate models with an autoregressive term of lag 1, Washington employment, personal income and personal income per capita each had significant t-statistics in their respective models
- Due to the correlation between the economic activity variables, only one of these variables can be used in a regression model
- Log-log forecast models did the best at producing the highest regression statistics for the economic activity variables
- The unemployment rate as an independent variable did the poorest of the four economic activity independent variables as it was not statistically significant
- Wages and salaries, a component of personal income, was tested in the VMT regression model as a substitute for personal income but the correlation between wages and salaries and VMT was not as strong as personal income and VMT
- Both log employment and log personal income performed well in the VMT regression models

Figure E- 7. Regression Results from Economic Activity Independent Variables

Independent Variables	Estimate	T-statistic	R^2 / RMSE
Log real personal income + ARMA(1)	0.630	5.63	0.994 / 0.85
Log real personal income per capita + ARMA(1)	0.892	4.80	0.994 / 1.09
Log employment + AR(1)	0.839	6.27	0.994 / 1.01
Log unemployment rate + ARMA(1)	-0.0014	-0.34	0.996 / 0.78

Population Independent Variables

There were several population statistics that were considered in the regression model;

- total population
- driver age population (16 years and older)
- driver age population less elderly population over age 75 years
- labor force
- population density
- in-migration population
- in-driver population

From an economic perspective, one would predict that as Washington population (total, driver age, in-migration and in-driver) as well as labor force increases so would vehicle miles traveled. More people in the state means more people on the road traveling so total vehicle miles traveled is likely to increase. One could hypothesize that using a broad measure of population may be helpful at capturing all the different factors that determine how many trips people take each year. Certainly, the "pre-driving age" or "elderly" population has an influence on the number of trips and the distance traveled by car that each household makes annually.

Model results, summarized in Figure E-8, with population independent variables revealed the following:

- Washington total population, driver age population, driver aged population less elderly population and labor force all had a positive correlation with VMT when used separately in regression models
- There was only a minimal difference in the forecast model results from using total population versus driver age population; or driver age population less elderly population; or adding the teenage population to the driver age population
- Washington in-migration and in-driver populations were positively correlated with VMT but they were not very effective at predicting past or future VMT

- these independent variables produced fairly volatile VMT forecasts due to the irregular nature of the change in these variables themselves

- When used in separate models with an autoregressive and moving average term of lag 1, Washington total population, driver age population, population density and labor force each had significant t-statistics in their respective models (See Figure E-8)
- Due to the correlation between the different population variables, only one of these variables can be used in a forecast model
- Log-log forecast models did the best at producing the highest regression statistics for the population variables
- Both log employment and log personal income performed well in the VMT regression models

Figure E-8. Regression Results from Population Related Independent Variables

Independent Variables	Estimate	T-statistic	R^2 / RMSE
Log total population + ARMA(1)	0.0003	2.38	0.994 / 1.00
Log driver age population + ARMA(1)	0.0003	3.35	0.994 / 0.95
Log population density + ARMA(1)	0.0193	5.69	0.995 / 0.85
Log labor force + ARMA(1)	1.1572	19.76	0.995 / 0.87

Motor Vehicle Registrations Independent Variable

Washington private motorized vehicle registrations were tested in the VMT forecast model. The motor vehicle registrations included all vehicles paying the $30 basic fee, all combined license fee vehicles, restored antique vehicles and mopeds. One would expect that the number of motorized vehicles in the state to be closely tied to vehicle miles traveled in the state. As motor vehicle registrations increase statewide so should vehicle miles traveled. This reasoning can be flawed if we see that Washington families are getting more vehicles per household but still taking the same number of trips and driving the same distance only using more vehicles to perform the same amount of travel over Washington roads. The correlation between motor vehicle registrations and VMT is bound to be strong but it could <u>overstate</u> VMT growth in the future if families are not driving more miles, just driving more vehicles. On the business side, we should see a close correlation between truck registrations and truck VMT. As the economy improves and truck registrations increase, then we should see an increase in VMT from added truck traffic on the roadways.

Model results with motor vehicle registration variable, as shown in Figure E-9, revealed the following:

- Washington total car and truck registrations had a strong positive correlation with VMT

- Both a linear and log VMT model were tested with Washington motorized vehicle registrations and the log-log model produced the best overall regression statistics with higher adjusted R squared and lower root mean square error

Figure E-9. Regression Results from Motor Vehicle Registrations Independent Variables

Independent Variables	Estimate	T-statistic	R^2 / RMSE
Motor Vehicle Registrations	0.0100	47.56	0.981 / 1.86
Log Motor Vehicle Registrations + ARMA(1)	27.697	8.83	0.995 / 0.89

Fuel Consumption and Prices Independent Variables

Washington motor fuel consumption was tested in the VMT forecast model. One would expect that as fuel consumption grows so should vehicle miles traveled. It is logical that since fuel consumption is necessary in order to have vehicle miles traveled statewide so the trend of this variable would be a good predictor of VMT. In the past, the fuel consumption (gasoline and diesel) model projections were the primary driving forces in the old VMT forecasts.

Regression model results with fuel consumption variable, summarized in Figure E-10, revealed the following:

- Washington motor fuel consumption had a strong positive correlation with VMT
- Both a linear and log VMT model were tested with Washington vehicle registrations and the log-log model with an autoregressive term lagged 1 quarter produced the best overall regression statistics with higher adjusted R squared and lower root mean square error

Figure E-10. Regression Results from Fuel Consumption Independent Variables

Independent Variables	Estimate	T-statistic	R^2 / RMSE
Motor Fuel Consumption	0.0197	40.73	0.975 / 2.16
Log Motor Fuel Consumption + AR(1)	0.6526	5.84	0.994 / 0.98

Washington fuel prices are currently forecasted by WSDOT-Economic Analysis section and could be used as a factor in predicting statewide VMT. One would expect that as fuel prices get high enough, some people may choose other transportation options besides driving a car and decrease their number of trips which would reduce VMT statewide. In order to attempt to capture this change in household behavior, Washington gasoline prices, percentage change in gasoline prices as well as a “dummy” variable for times of large swings in gasoline prices were tested in the VMT forecast model. The same is true for businesses as they may find ways to reduce the number of vehicles they drive as fuel prices increase and thus reduce truck VMT statewide.

Model results with gasoline prices, summarized in Figure E-11, revealed the following:

- Washington gasoline prices had a negative correlation with VMT in the tested models
- Washington gasoline prices or the change in gasoline prices were most closely correlated with VMT as opposed to the “dummy” variable for times of large swings in gasoline prices
- As revealed in Figure E-11 below, the log-log VMT models had significant t-statistics for the gas prices and percentage change in gas prices as independent variables but the “dummy” variable for large changes in gas prices was not significant at 95% confidence level
- The log-log VMT model with Washington gas prices and an autoregressive and moving average term lagged 1 year produced the best overall regression statistics with higher adjusted R squared and lower root mean square error

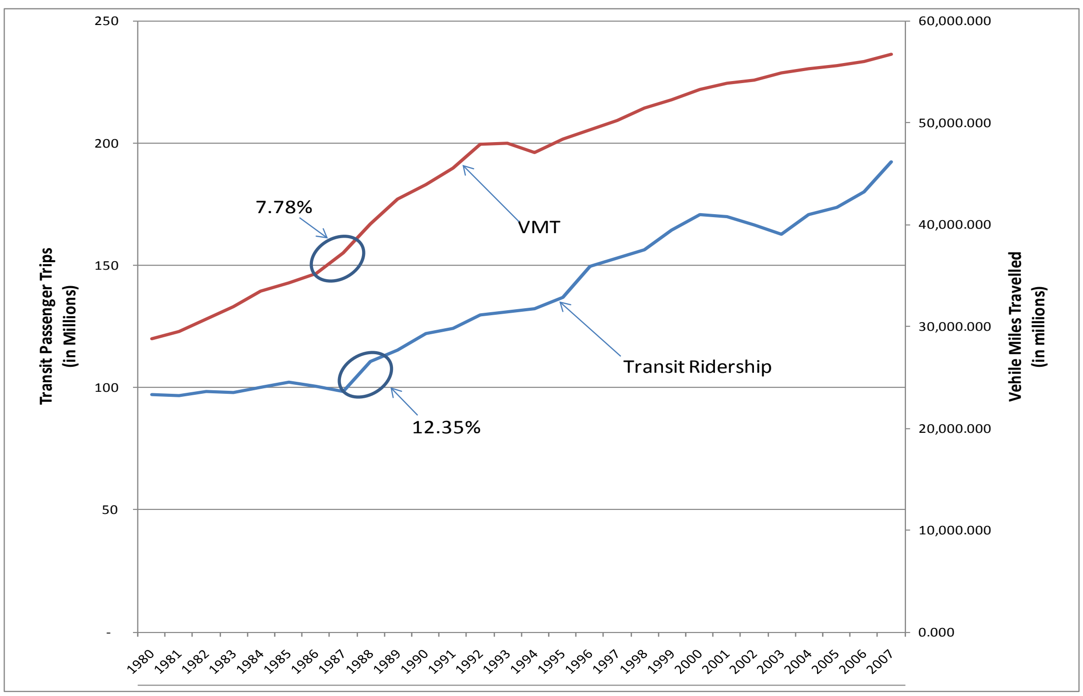
Figure E-11. Regression Results from Gasoline Price Independent Variables

Independent Variables	**Estimate**	**T-statistic**	**R^2 / RMSE**
Log Gas Prices + ARIMA(1)	-2.119	-2.72	0.997 / 0.63
Log % Change Gas Prices + ARIMA(1)	-1.011	-2.48	0.997 / 0.66
Log “Dummy” Variable (High % Chg Gas Prices) + ARIMA(1)	-0.247	-1.21	0.997/ 0.68

Transit Ridership Independent Variable

This technical workgroup also considered the impact of transit ridership on statewide VMT. An independent variable for transit ridership was added to the VMT regression model. We believed that as transit ridership increased, VMT would likely fall due to fewer people driving their own vehicle on the roadways so we anticipated a negative relationship between these variables. The data revealed that in recent years VMT has been growing at a slower pace than the growth in transit ridership. Figure E-12 graphically shows the growth, of both VMT and transit ridership, from 1980 to 2007. While both data series trended upwards throughout the period, their growth rates were very different. Therefore, as forecast models with transit ridership as an independent variable were developed, it was found that there was a strong positive not negative correlation between transit ridership and VMT. In most circumstances, VMT and transit ridership increased at the same time and in the same direction. One might conclude that the underlying economic factors that cause increases in VMT also affect transit ridership in the same manner. In periods of economic growth, people make choices about getting to work and doing business. Some chose to travel in passenger vehicles, while others choose public transit. Second, there is a close connection between gas prices and transit ridership. There is a strong body of work that demonstrates this connection (Boyle 1982; Chang and Sinha 1981; Currie and Phung 2007; Transit Cooperative Research Program 2005; Mattson 2008; Haire and Machemehl 2007) and transit agencies are very aware how gas price increases affect transit ridership. In times of steep and sustained gas price increases, we can see transit ridership increase and VMTs decrease, however, in the forecast of VMT, this impact can be modeled by including gas prices, which have external forecasts available. We do not have reliable statewide forecasts for transit ridership. As a result, transit ridership is not recommended to be included in the VMT forecast model but gas prices would be a better proxy for capturing the change in household behavior regarding transit ridership. For further information on this topic see the WSDOT report titled Transit Ridership and Vehicle Miles Traveled (WSDOT 2009).

Figure E-12. Transit Passenger Trips (in millions) Compared to VMT (in millions)



Lane Miles Independent Variables

The technical workgroup had several discussions about the limiting factors on vehicle miles traveled and wanting to test those factors in the VMT forecast model. Some of these limiting factors on VMT that were brainstormed at meetings were congestion, lane miles and travel time. Unfortunately, we had trouble finding a history for one single measure for congestion and travel time that would be important for statewide estimates of VMT. In addition, we needed the independent variable to have a forecast or be "easily" forecasted. We did test total and interstate lane miles since 1980 as a predictor of VMT. Note that vehicle miles traveled in the state of Washington is a direct function of the number of center lane miles we have statewide. Including either total or interstate lane miles in a VMT forecast model was anticipated to be positively correlated because the independent variable was an indirect component of the calculation of the dependent variable VMT.

One question that arose during the workgroup's discussions on lane miles and VMT was which one caused the other. Does VMT growth cause more lane miles to be built or does roadway expansion increase VMT? On one side, people say that Transportation Departments build new roads and lanes where the traffic and congestion already exists so the VMT comes first. Others say that once a highway is expanded, more people are able to use it so VMTs increase for that segment of the highway. The traffic may not be "new" VMT to the state but drivers choosing now this expanded highway for their trips. Contradictory research suggests either causality relationship could be true (Cervero 2002) (Cervero and Hansen 2002) (Fulton et al, 2000) (Noland and Lem 2002) (Noland and Coward 2000) (Pozdena 2009).

The following four independent variables related to lane miles were tested to determine their relationship with VMT:

- Total and interstate lane miles
- Total and interstate land miles per driver

Model results with lane miles variables revealed the following, as summarized in Figure E-13:

- Washington interstate lane miles had a positive correlation with VMT provided the model was the log-log model but total lane miles logged had an insignificant negative correlation with VMT
    - One reason for this difference in the relationship between total lane miles and VMT and interstate lane miles and VMT is because the data for total lane miles is less reliable and could change irregularly given changes to local lane miles
- Washington interstate lane miles per driver was negatively correlated with VMT but total lane miles per driver was not correlated well with VMT
    - A reason for total lane miles per driver to not be correlated with VMT is because total lane miles has a shorter history than interstate lane miles and it has not been growing at the same pace as drivers. Therefore, the ratio of total lane miles to drivers has actually been falling or was fairly flat during this same period as VMT was increasing therefore little correlation existed between the two variables.
- As indicated in Figure E-13 below, the log interstate lane miles per driver model and the log interstate lane miles model both had significant t-statistics for interstate lane miles per driver and interstate lane miles

- Interstate lane miles per driver had a better overall fit as reflected in a higher R squared and lower root mean square error (RMSE)

These results revealed a negative correlation between interstate lane miles per driver and VMT. This indicates that interstate lane miles increased faster than the growth in drivers resulting in interstate lane miles per driver to increase over time at the same time as VMT was growing but at a slower pace. This result is counter intuitive to what one might have expected. Even though the log interstate lane miles per driver appeared to produce good overall regression statistics with an adjusted R squared of 0.982 and root mean square error of 1.69, other indicators revealed that the model was not stationary and a possible unit root could be present in the data. These indicators made it difficult to select this model as a reasonable VMT statewide forecast model.

Figure E-13. Regression Results from Lane Miles Independent Variables

Independent Variables	Estimate	T-statistic	R^2 / RMSE
Log Interstate Lane Miles per driver	-0.238	-47.79	0.982 / 1.69
Log Interstate Lane Miles	0.000438	16.69	0.880 / 3.10
Log Total Lane Miles	-5.54E-7	-0.049	-0.164/ 7.62

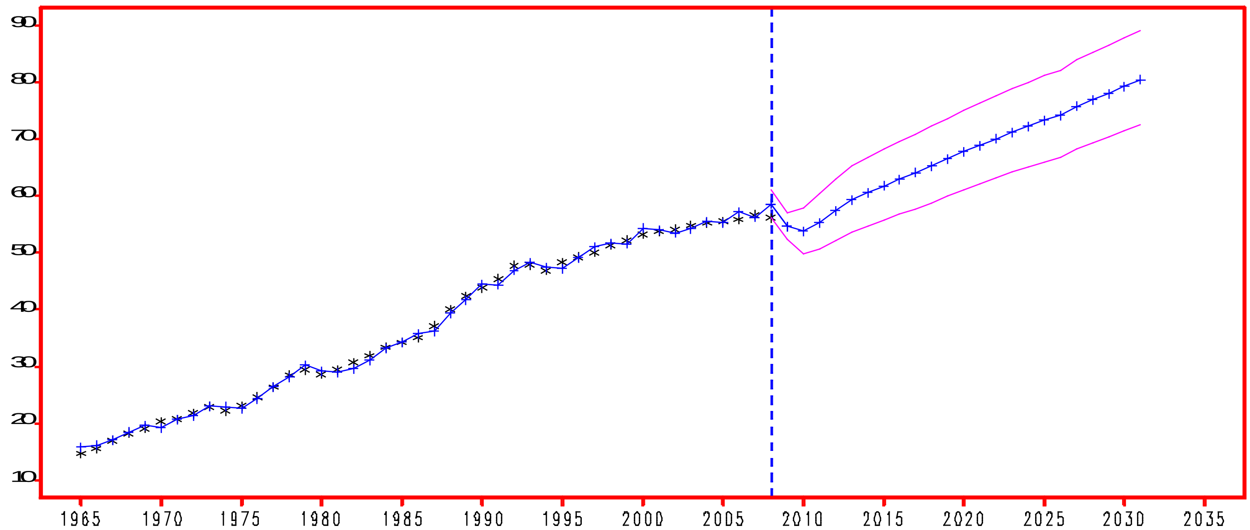
Chapter 3: New Statewide VMT Forecast Model

The next step after examining numerous independent variables separately in a VMT forecast model was to determine if there were combinations of variables which would improve any single regression forecast model for VMT. The forecast workgroup reviewed various combinations of independent variables in the statewide forecast model. The review examined data issues, forecast methodologies, model specifications, critical assumptions, and forecast performance. In this case, the workgroup examined the correlation between independent variables closely to verify that severe multicollinearity did not exist between independent variables in the regression model. The workgroup's review of the statewide VMT forecast arrived at the following econometric VMT forecast model specification and as outlined below.

Final Statewide VMT Forecasting Model

The technical workgroup determined that an econometric VMT forecast with three different independent variables would be best at predicting statewide vehicle miles traveled. This new forecast model has an economic activity, motor vehicle registrations and gas price independent variables. The economic activity variable is Washington non-farm employment, which was chosen because it helps captured those periods of recessions when there may be less truck and business traffic and fewer trips made by households because more are unemployed. Washington motor vehicle registrations was also chosen as an independent variable in the model because knowing the number of passenger cars and trucks that potentially are on the roadways will go a long way in estimating vehicle miles traveled. It was felt that motor vehicle registrations would be a closer nexus to vehicle miles traveled than just population. In addition, the long-term forecast for vehicle registrations is based on the growth rates of Washington population. Essentially, the vehicle registrations capture both economic indicators. Finally, Washington gasoline prices were added as a driver in the model because it explains a different trend not yet captured by the other two variables. The gas price variable explains that in certain period of rising gasoline prices, vehicle miles traveled will fall due to people finding new ways to minimize their trips, change their mode of transportation or shift trucks used on the roadways to lower their fuel costs. The final model was a log-log functional form model solved using ordinary least squares.

Figure E-14. Historical VMT Since 1965 and New VMT Forecast Model Estimates



* denote actual VMT

\+ denote forecast model estimate

Solid pink lines denote 95% confidence interval

Model Evaluation

The new VMT forecast methodology and model for gasoline consumption was accepted by the technical workgroup. The estimated model statistics (e.g., coefficients, t-statistics, R-squared, White noise tests, unit root tests) were examined. The individual regression coefficients are significant and have reasonable values. Overall, the independent variables are able to explain most of the variation in gasoline consumption. The model fits the historical VMT data well.

Forecasting Methodology and Model

- Equation – The equation for vehicle miles traveled in Washington is defined as

$$\ln(VMT) = \alpha + \phi \ln(WA\_Emp) + \delta \ln(WA\_reg) + \varphi(WA\_GasP) + \varepsilon$$

Where

VMT = Annual statewide vehicle miles traveled from WSDOT-TDO,

WA_Emp = Annual Washington non-farm employment,

WA_reg = Annual Washington motorized vehicle registrations,

WA_GasP = Annual Washington gas prices.

And

ε = Stochastic disturbance on vehicle miles traveled.

The model also has first-order autoregressive and moving average terms to correct for serial correlation.

The model has an Adjusted R-squared value of 0.996 and a root mean square error of .75068. The t-statistics for the variables include 4.76 for the Washington employment, 3.59 for Washington motor vehicle registrations, and -2.85 for the Washington gas prices. The model statistics are presented in the following table.

Figure E-15. Washington Statewide VMT Forecast Model Statistics

Dependent Variable: LOG(VMT)				
Method: Least Squares				
Sample: 1965- 2008				
Included observations: 44				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	-5.49495	0.6147	-8.9396	0
LOG(WA_Emp)	0.69795	0.1463	4.7696	0
LOG(WA_Reg)	0.46757	0.1304	3.5854	0.001
LOG(WA_GasP)	-0.07244	0.0252	-2.8786	0.0068
MA(1)	-0.73222	0.1730	-4.2336	0.0002
AR(1)	0.71161	0.1478	4.8143	0
R-squared	0.997	Model variance	0.00046	
Adjusted R-squared	0.996	Amemiya's Adjusted R-squared	0.995	
Mean Square Error	0.5635	Akaike info criterion	-11.5154	
Root Mean Square Error	0.75068	Schwarz criterion	-1.2339	

- <u>Forecast drivers</u> – Washington employment has the strongest explanatory power in the forecast model of all three independent variables. It is positively correlation to vehicle miles traveled. The model's coefficient value for the Washington employment is 0.70, which in a log model is also the employment elasticity for VMT. Washington motorized registrations also have a strong positive correlation to VMT but it is less important than employment in the model as the coefficient is 0.47. Gas prices are not as important in the forecast model as the other two drivers but it is still negatively correlated with VMT and statistically significant.

Figure E-16. VMT Forecast Model: Autocorrelations

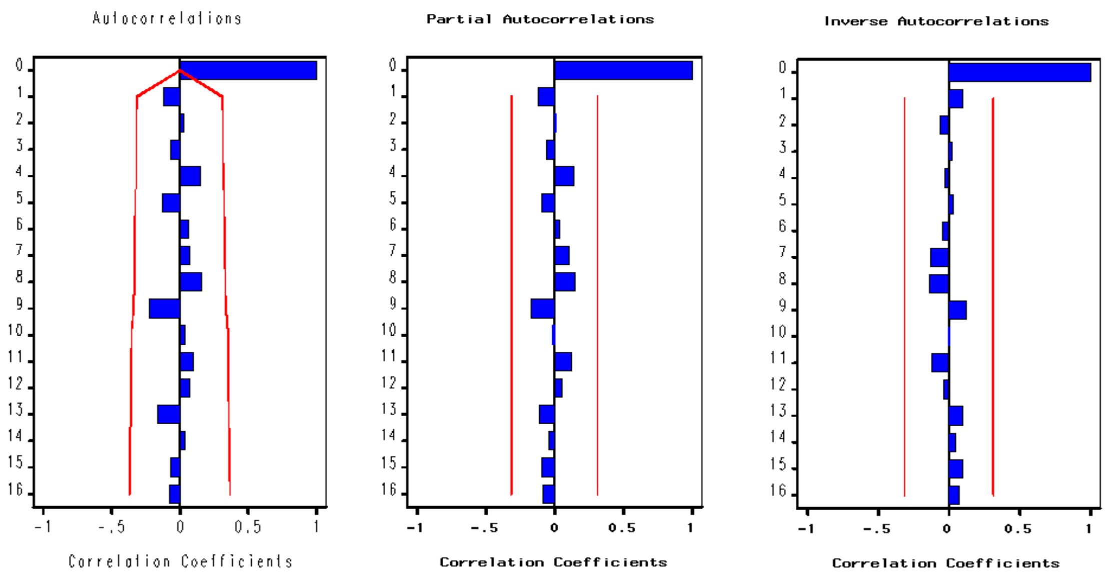
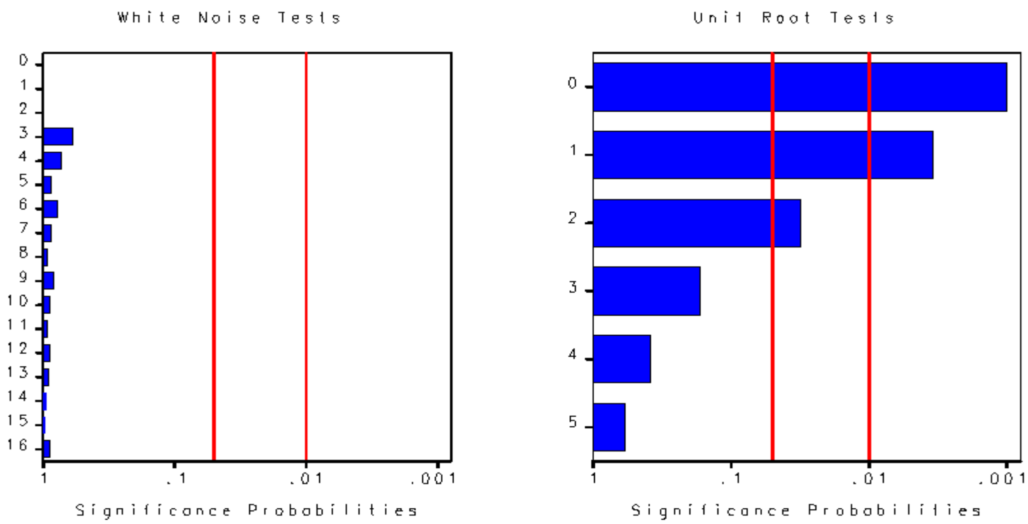


Figure E-17. VMT Forecast Model: White Noise and Unit Root Tests



Other Statistical Tests

- Autocorrelations

- Autocorrelation function plots show the degree of correlation with past values of the series as a function of the number of periods in the past (that is, the lag) at which the correlation is computed.
- As Figure E-16 reveals, in the current period (lag 0), all three of the autocorrelations have high correlation (nearly 1) which is a sign of a strong relationship between the dependent and independent variables in the model
- By examining the plots in Figure E-16, you can judge whether the series is stationary or nonstationary. In this case, a visual inspection of the autocorrelation function plot indicates that the VMT series is stationary, since the autocorrelation function decays quickly. In subsequent periods, the autocorrelations decrease significantly and stay within the red lines depicting the confidence band.
- The sample inverse autocorrelation function (SIACF) can be useful for detecting over-differencing. If the data come from a nonstationary or nearly nonstationary model, the SIACF has the characteristics of a noninvertible moving-average. Likewise, if the data come from a model with a noninvertible moving average, then the SIACF has nonstationary characteristics and therefore decays slowly. In this case, the SIACF decays quickly revealing a stationary series.
- All three autocorrelation graphs reflect a stationary series

- <u>White Noise Tests</u>
  - Tests were performed for model "white noise" or randomness implying that the sum of the squares of a group of consecutive autocorrelations should all sum to 0 for all periods
    - Ljung-Box Chi-square statistic – joint test for autocorrelations of residuals; this considers several autocorrelations together to calculate a statistic that has chi-square distribution
      - Figure 17 "White noise" tests reveals the significance possibilities of the Ljung-Box Chi-square statistics for 16 periods
        - Each bar shows the probability computed on autocorrelations up to the given lag with longer bars favoring rejection of the Null hypothesis that the prediction errors represent "White Noise" or randomness
        - In this case, the graph in Figure E-17 reveals a low level of significance meaning we can assume randomness in this VMT model

- <u>Unit Root Tests</u>
  - Tests were performed to see if the time series was stationary and if unit roots appeared; if a series has a unit root, the series is nonstationary and then the ordinary least squares estimator is not normally distributed
  - The Augmented Dickey-Fuller single mean test was completed to test the hypothesis that the variables in the model have a unit root

- Figure E-17 unit root test reveals the results of the unit root tests by showing the significant probabilities of the Augmented Dickey-Fuller test for unit roots;
- When the horizontal bars on the graph are longer and beyond the first vertical line, then you can reject the Null hypothesis that the series is non-stationary, meaning the series is stationary.
- The model results indicate that the series is stationary because the significance probability is above the threshold for the current and prior two periods.

Source of Independent Forecasted Variables

- Washington employment – The forecast for Washington employment was taken from the Economic and Revenue Forecast Council February 2010 forecast in the near-term and from OFM's 2009 long-term non-farm employment projections for Washington.

- Washington motorized vehicle registrations – The forecast for Washington motorized vehicle registrations was forecasted by WSDOT-Economic Analysis section for the Transportation Revenue Council and included the February 2010 forecast

- Washington gasoline prices – The forecast for Washington gasoline prices was taken from the WSDOT forecast for the Transportation Revenue Council for February 2010 forecast

Other Multivariate Forecast Model Specifications Considered

- The technical workgroup discussed other model specification before deciding on this final VMT forecast model (see Figure E-19). One alternative VMT forecast model that was considered was the final model without the gas price variable included. Some workgroup members expressed concerns with including gas prices in the model given the difficulty that is inherent in the gas price forecast. Figure E-18 reveals the difference between a VMT forecast model with and without gas prices. The graph indicates that a VMT forecast model without gas prices produces slightly higher VMT forecasts than a model with gas prices included. The difference between the two models in the near-term is insignificant. In the long-term, the higher future gas prices do have a dampening effect on the VMT forecasts. When you compare the Akaike's Information Criterion (AIC) for those two models, the regression model without gas prices had a slightly smaller AIC than the model with gas prices included indicating that the regression model without gas prices would be slightly better. Given our uses of this regression model and the fact that we receive questions on the impact of fuel prices on VMT, we wanted to keep the fuel price variable in the model so we could answer those types of questions.

- Another top VMT forecast model considered included personal income per capita plus motor vehicle registrations and that model was not selected as the best model because of the broad nature of personal income and the fact that an increase in personal income may not translate into increased vehicle miles traveled.

- Another top VMT forecast model considered was combining population with fuel consumption. The reason why this model was not selected was because motor vehicle registrations have a closer nexus to vehicle miles traveled than just population. Fuel consumption has been the primary driver in the past for VMT forecasts and has a close nexus with VMT when it is combined with MV registration, the data results in non-stationary and randomness problems. Having these two variables together in a single regression model for VMT is problematic.

- Another VMT model specification option considered was combining lane miles per driver with fuel consumption. The drawbacks to this model are that it lacks any economic activity independent variables and there is not a readily available forecast for lane miles. In the future as additional alternative fuel based vehicles become more common, there could be reductions in fuel consumption without corresponding reductions in VMT.

- During the course of the forecast review, model results were also run on truncated VMT annual data beginning in 1990. The reason why some workgroup members asked for a truncated model is because the trend in VMT in recent years has been flatter than the longer history. The truncated model produced flatter forecasts of VMT in the future. Currently the truncated model has only 18 observations, which is less than is advisable for forecasting models. If the flat VMT trend continues in the future, this issue may be re-visited.

Critical Forecast Assumptions

- <u>Forecast Procedure</u> – The calculation of the new VMT forecast each year will consist of running the econometric forecast model with new VMT actual and economic variables. The new forecast will be based on the model regression coefficients for each independent variable along with the last actual for statewide VMT and the new forecast for each independent variable. By using these components, the new VMT forecast will be calculated from the last actual VMT. This procedure helps reset the new forecast to the last known actual VMT while applying the same model growth rates.

- <u>Critical assumptions</u> – VMT forecast assumptions will be presented in a Transportation Revenue Forecast Council assumptions meeting before the forecast and at the forecast adoption meeting each year. An alternative forecast for the VMT projections will be completed along with a description of the forecast model. The most current statewide vehicle miles traveled from WSDOT-TDO and Washington motor vehicle registrations and gas price forecasts from WSDOT are incorporated into the VMT forecast.

Figure E-18. VMT Forecast Model: With and Without Gas Prices

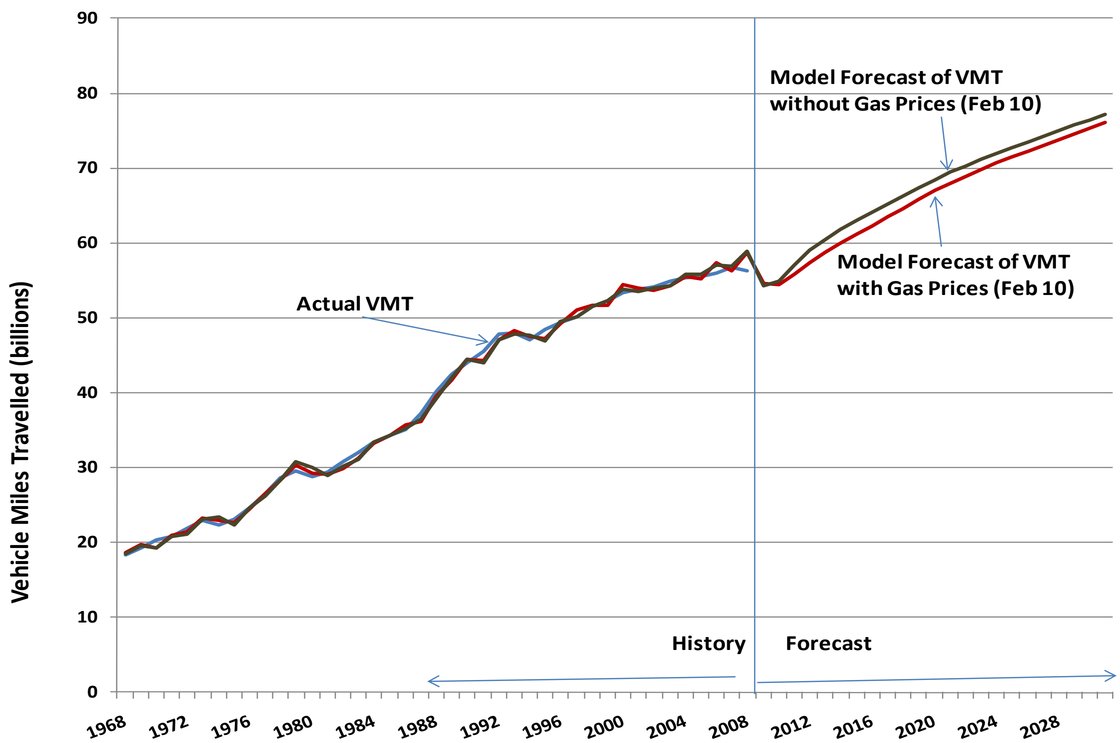


Figure E-19. Top VMT Forecast Models Considered

Model description	RMSE	Adj. R squared	Akaike Info Criterion (AIC)
Log WaEmp + Log Mv-Reg + Log GasP + ARMA(1,1)	0.75	0.996	-11.5154
Log WaEmp + Log Mv-Reg + ARMA(1,1)	0.78	0.996	-12.5435
Log Personal Income/pop + Log Mv-Reg + ARMA(1,1)	0.80	0.996	-8.1802
Log Pop + Log Fuel Consumption + ARMA(1,1)	0.79	0.996	-9.3378
Lane Miles per Driver + Log Fuel Consumption + ARMA(1,1)	0.87	0.995	-0.9979

The yellow highlighted model represents the final VMT forecast regression model

Chapter 4: Conclusions and Recommendations

Vehicle miles traveled has flattened in recent years and the revised VMT forecast model has reflected a slower growth for future VMT. This change in the VMT forecast has been the result of revised economic indicators and a new forecast modeling specification. In the past, the VMT forecast was fairly accurate, within 6% on average, in a 4-year near-term horizon. This new VMT forecast model has revised the February 2008 forecast projections downward 13% by FY 2020 and 15% by FY 2025. On average, this new VMT forecast has a growth rate of 1.3% between FY 2009 and 2027. It was found that this new model growth rate was comparable and even a little more conservative than national VMT forecasts from EIA[10].

The technical workgroup concluded that there were advantages to having an econometric VMT forecast model to project VMT based on the relationship of historical VMT to the historical data of other economic indicators. The new forecast model incorporated economic activity, motor vehicle registrations and fuel price independent variables. There were discussions by the workgroup about leaving off the gas price variable due to the difficulty in forecasting fuel prices. The model results indicated that removing the gas price variable from the model does not change the VMT forecast much at all. A detailed review of Washington's VMT forecast model revealed that other variables beside fuel consumption like motor vehicle registrations and employment are equally important in projecting VMT.

One problem with the old statewide VMT forecast was that it was not very transparent and the VMT forecast methodology was not documented. This new annual VMT forecast will be presented as a separate alternative forecast document each June in the Transportation Revenue Forecast Council quarterly forecast. In this alternative forecast, a description of the VMT forecast model and summary of the model projections will be provided.

Recommendation for further research includes the following:

> The Technical Workgroup should review this forecast model again in a few years to see if truncating the data would produce better forecasts than using the longer term history of VMT. In addition, periodically the group should monitor and coordinate consistency between the various transportation related forecasts.

[10] EIA 2009 VMT forecasts

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Table E-1: Washington Preliminary Statewide VMT Forecast

The following table provides the new preliminary forecast for VMT with the best available forecast data from February 2010 forecasts. This forecast will be revised for the June 2010 VMT forecast with another VMT actual for 2009 and revised economic forecasts for Washington employment, motor vehicle registrations and gas prices.

Fiscal Year	VMT (billion miles)	% change
2009	55.58	-1.17%
2010	53.89	-3.03%
2011	54.79	1.67%
2012	56.30	2.75%
2013	57.71	2.51%
2014	58.62	1.57%
2015	59.53	1.56%
2016	60.45	1.54%
2017	61.41	1.59%
2018	62.41	1.64%
2019	63.49	1.72%
2020	64.62	1.78%
2021	65.65	1.59%
2022	66.67	1.56%
2023	67.71	1.55%
2024	68.67	1.43%
2025	69.62	1.38%
2026	70.43	1.16%
2027	71.88	2.06%

Appendix F

Vehicle Miles Traveled Reduction and Strategies

Vehicle Miles Traveled Reduction and Strategies

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Introduction

Reducing vehicle miles traveled (VMT) is an important element for improving the efficiency of the transportation system and reducing transportation-related emissions. VMT can be reduced through a wide range of transportation strategies that focus on the infrastructure (transit vehicles and facilities, land use changes, non-motorized facilities), service (transit service, vanpools, etc.), and operation of the system (such as pricing strategies). A comprehensive list of VMT reduction strategies is included at the end of this report.

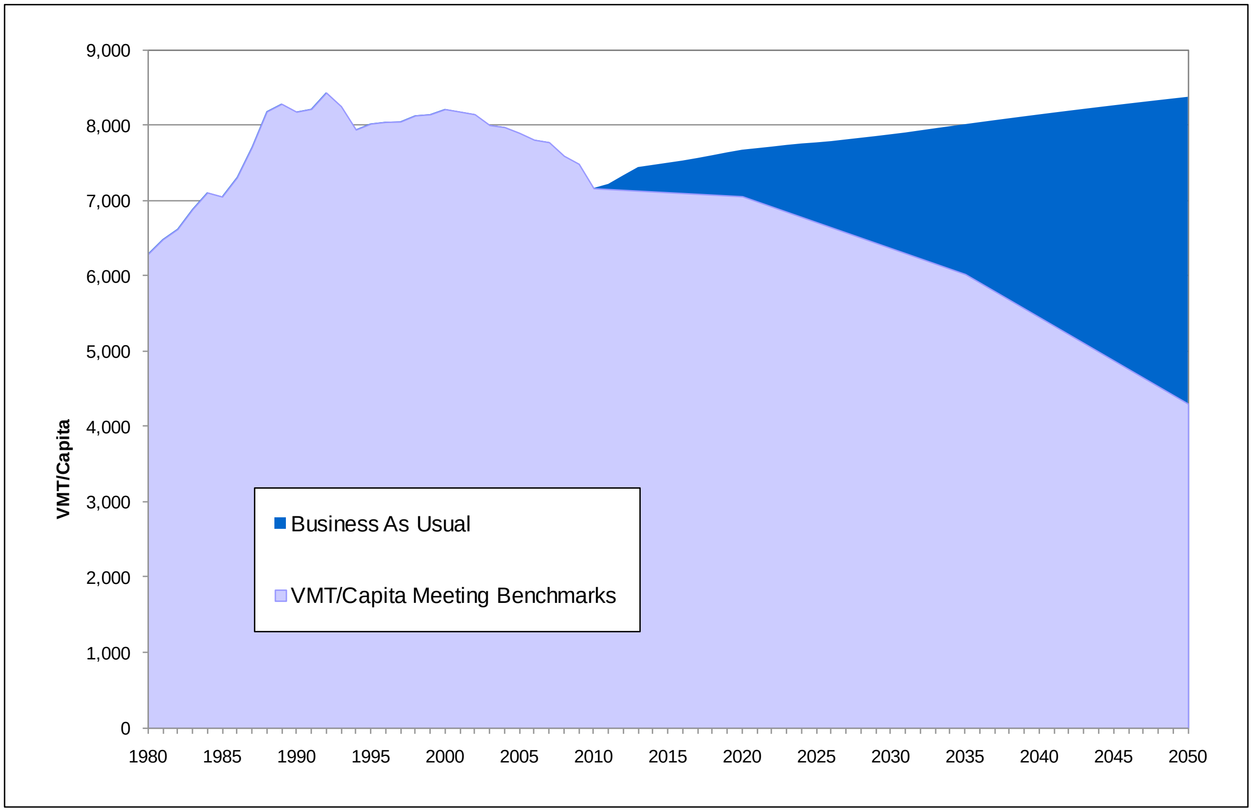
VMT Benchmarks

The state has adopted VMT reduction benchmarks. RCW 47.01.440 states:

> To support the implementation of RCW 47.04.280 and 47.01.078(4), the department shall adopt broad statewide goals to reduce annual per capita vehicle miles traveled by 2050 consistent with the stated goals of executive order 07-02. Consistent with these goals, the department shall:
>
> (1) Establish the following benchmarks using a statewide baseline of seventy-five billion vehicle miles traveled less the vehicle miles traveled attributable to vehicles licensed under RCW 46.16.070 and weighing ten thousand pounds or more, which are exempt from this section:
>
> (a) Decrease the annual per capita vehicle miles traveled by eighteen percent by 2020
>
> (b) Decrease the annual per capita vehicle miles traveled by thirty percent by 2035
>
> (c) Decrease the annual per capita vehicle miles traveled by fifty percent by 2050

Figure F-1 shows the VMT benchmarks as calculated based off of 75 billion total VMT and the 2007 population forecast, which was the current forecast at the time the law was written.

Figure F-1 - Washington State VMT/Capita - Business As Usual[11] and If Benchmarks Were Met



Source: Washington State Department of Transportation (population numbers from Washington State Office of Financial Management)

Effectiveness of VMT Reduction Strategies

Building off the transportation-related strategies identified in the Climate Action Team's Transportation Implementation Working Group (TIWG) and the Land Use and Climate Change Advisory Committee (LUCC) 2008 reports, this section examines the potential impact of a wide range of strategies on VMT reduction and greenhouse gas emissions. A number of studies have estimated the impact of different strategies on reducing VMT. This section summarizes some of the major studies, with an emphasis on more recent studies that cover a large geographic area (e.g., nationwide or statewide as opposed to within a local area or central business district (CBD)).

The review of studies highlights the types of strategies that may reduce statewide VMT and ranges of potential VMT reductions. It also indicates, at a high level, the potential greenhouse gas (GHG) emissions reductions needed from other strategies beyond VMT reduction to meet

[11] Business as usual in this figure based on VMT/capita using most recent VMT and population forecasts.

state goals. It is not intended to be a comprehensive review of all available studies. In general, the studies reviewed tend to indicate the following:

- Transit strategies – modest/moderate VMT reductions are possible from transit expansion alone; more significant reductions if accompanied by land use and pricing strategies.
- HOV and commuter strategies – VMT reductions for HOV/commuter strategies are similar to transit.
- Land use/smart growth – moderate VMT reductions are possible in the long-term; greater reductions are possible if land use strategies are combined with transit and pricing.
- Non-motorized – for strategies focusing on pedestrians and bicyclists, modest VMT reductions possible from expansion of non-motorized facilities; greater reductions if combined with supportive land use, transit, and pricing strategies.
- Pricing strategies: Studies suggest moderate to major reductions possible, particularly when combined with land use and transit strategies.
    - Major VMT reductions would appear to require broad-based pricing signals with equivalent fuel prices increased by several dollars a gallon.
    - Studies indicate an economy-wide carbon price of \$30-\$60/t CO^2 alone increases fuel prices only modestly.
    - In addition to reducing VMT, pricing signals could encourage the transition to a more GHG-efficient vehicle fleet (these benefits could exceed the VMT reduction benefits).

Overall VMT Reductions Possible

Overall, studies recognize that there is considerable uncertainty regarding the range of VMT reductions that may be possible through implementing a combination of strategies. Most studies imply 2050 VMT reductions from future baseline ranging from about seven percent to as high as 33 percent may be possible. VMT reductions at the higher end of that range would appear to require bold and transformative land use and transit strategies, along with widespread pricing signals equivalent to an additional fuel cost of several dollars a gallon.

Studies' Estimates of Effectiveness of Various VMT Reduction Scenarios

A number of studies have estimated the impact of different strategies on reducing vehicle miles traveled (VMT). This review of studies is intended to:

- Highlight the types of strategies that may be promising for reducing statewide VMT, and ranges of reductions, and
- Provide a high level indication of potential GHG reductions that may be needed from other strategies beyond VMT reduction to meet state GHG reduction goals.

All of the reviewed studies acknowledge that there is considerable uncertainty in the analysis. For example, the report *Transportation's Role in Reducing GHG Emissions, Report to Congress* (April, 2010), indicates that "The benefits of the strategies in this report are based on limited data and good faith assumptions. Numerical estimates contain substantial uncertainties."

In addition, the effectiveness of strategies to reduce VMT can vary considerably, depending on factors such as how and where strategies are implemented. In addition, the studies reviewed are based on historical data, and the future may bear little resemblance to the past. People may respond to strategies and change behavior in unexpected ways. Therefore, it is important to monitor the performance of our transportation system so we can refine our strategies and approaches in response to changing circumstances. Finally, this summary does not assess the feasibility or cost of implementing strategies.

Studies Included in Summary

This summary focuses on more recent studies that cover a large geographic scale (e.g., nationwide or statewide, as opposed to within a local area or CBD). This summary only focuses on recent major studies, and is not intended to be a comprehensive review of all available studies. VMT reductions in studies are generally reductions from future "business as usual."

The studies included in this summary, by geographic scale, are as follows:

- Washington State
  - Washington Climate Action Team transportation policy options analysis (December, 2007)
- United States
  - Transportation's Role in Reducing U.S. GHG Emissions: Report To Congress (April, 2010)
  - Moving Cooler (July, 2009)
  - Harvard Kennedy School Belfer Center for Science and International Affairs Study, Analysis of Policies To Reduce Oil Consumption and Greenhouse-Gas Emissions from the US Transportation Sector (February, 2010)
  - Environmental Protection Agency (EPA) Analysis of the Transportation Sector Greenhouse Gas and Oil Reduction Scenarios (February, 2010)
- Regional Studies
  - U.C. Berkeley Study: Review of Modeling Analysis of Transit, Land Use, and Auto Pricing Strategies to Reduce VMT and GHG Emissions, C. Rodier, for CARB and Caltrans (October, 2009)

Washington Climate Action Team Analysis

Washington state's Climate Advisory Team conducted a policy options analysis in 2007 (*Washington CAT Policy Options Analysis*, 12/07[12]). As part of this analysis, the Transportation Working Group estimated potential VMT reduction strategies for the year 2020. For some of the strategies, reductions were estimated for light duty vehicle VMT (see Figure F-2 below); for other strategies, the report provided only estimates for total on-road GHG emissions (see Figure F-3 below).

In addition, some GHG/VMT reductions in Figures F-2 and F-3 below, such as T-1.7, were reduction goals (as opposed to specific analysis of potential reductions from strategies). Other estimated reductions were based on modeling or related analysis.

[12] Archived here: http://www.ecy.wa.gov/climatechange/interimreport/122107_TWG_trans.pdf

Figure F-2 - Summary of Transportation Sector Technical Work Group Policy Option Analysis – Light Duty Vehicle VMT Reduced in 2020

Policy Option	% LDV VMT Reduced in 2020	Description
T-1.1: Sustained operating support for public transportation.	1.4%	Goal: 2% reduction in statewide urban area VMT.
T-1.3: Subsidized fares in the urbanized area.	3.6%	Goal: 50% reduction in urban area transit fares. Elasticity of demand assumed to be -0.4.
T-1.5: Commute trip reduction in dense urban centers	1.1%	Goal: 20% reduction in VMT in urban centers (areas covered by CTR program).
T-1.6: Trip reduction for commuters outside of dense urban centers	0.7%	Goal: 3% reduction in VMT outside urban centers (areas not covered by CTR program).
T-1.7: Non-commute trip reduction	7.2%	Goal: 10% reduction in non-commute trips. Assuming each household makes 8 trips per day, set a goal of reducing 1 trip per day per household. How this is accomplished would vary tremendously by geography, density and infrastructure level, and trip purpose. Assist citizens to bike, walk, use transit and rideshare for an increasing proportion of trips each year.
T-1.8: VMT reduction innovation grants	0.3%	Goal: 0.26% reduction in VMT annually.
T-2 - VMT Benchmarks	18%	LDV VMT benchmarks - 2020 VMT per capita is reduced by 18%. The state would design a plan that consists of both state actions and investments to achieve the targets. Much of the attainment in per capita VMT reductions is expected to result from complimentary actions considered by the TWG.

Source: Washington Climate Advisory Team Transportation Policy Option Descriptions, December 2007
http://www.ecy.wa.gov/climatechange/interimreport/122107_TWG_trans.pdf

Figure F-3 - Summary of Transportation Sector Technical Work Group Policy Option Analysis – On Road Greenhouse Gas Emissions Reduced in 2020

Policy Option	% On Road GHG Reduced in 2020	Description
T-3 Parking Cash Out	0.02%	By 2010, ensure that 50% of employers who provide leased parking spaces to employees will offer parking cash-out.
T-3 Parking Surcharge, PSRC area	0.05%	Implement 15% parking surcharge in the Puget Sound region; increase to 20% by 2009.
T-3 Mileage-Based Insurance	1.0%	Expand King County mileage-based insurance pilot program. By 2012, 5% of Washington drivers would be covered by mileage-based automobile insurance. By 2020, 20% of Washington drivers will be covered by mileage-based automobile insurance.
T-3 Variable Tolls on PSRC Hwy System	1.4%	By 2015, or sooner if possible, use variable pricing to manage demand on the highway system throughout the Puget Sound region.
T-4 - Compact TOD (Low)	3.9%	Goal is to reduce urban area VMT by 7%-15% in 2020 and by 25-50% in 2050. The 7% VMT reduction scenario based on PRSC Vision 2040 modeling of "Metropolitan Cities Alternative" and from land use scenario modeling in other metropolitan areas.
T-4 - Compact TOD (High)	9.3%	
T-6 Passenger Rail	0.2%	Future expansions commuter rail and Amtrak regional rail.
T-8 - Bicycle and Pedestrian	0.5%	Increase the bicycle and walking mode share (all trips) in Washington urban growth areas to 15% by 2020."Complete Streets" policy for all new streets or streets undergoing major maintenance; increased funding and planning for bicycle/pedestrian projects.

Source: Washington Climate Advisory Team Transportation Policy Option Descriptions, December 2007
http://www.ecy.wa.gov/climatechange/interimreport/122107_TWG_trans.pdf

Transportation's Role in Reducing U.S. GHG Emissions: Report To Congress, U.S. Department of Transportation

The April 2020 report, *Transportation's Role in Reducing U.S. GHG Emissions: Report To Congress, U.S. Department of Transportation,* evaluated potentially viable strategies to reduce transportation GHG emissions. The report was mandated in Section 1101 (c) of the Energy Independence and Security Act of 2007. The USDOT, in coordination with the U.S. Environmental Protection Agency (EPA) and consultation with the U.S. Global Change Research Program (USGCRP), studied the impact of the nation's transportation system on climate change. The report team identified four categories of strategies to mitigate the effects of climate change by reducing GHG emissions from transportation:

- Introduce low-carbon fuels
- Increase vehicle fuel economy
- Improve transportation system efficiency, and
- Reduce carbon-intensive travel activity

VMT reduction strategies fell into the group "reduce carbon intensive travel activity," and specifically included:

- Pricing
- Transit
- Land Use
- Non-Motorized
- Commuter/Work Trip
- Public Information Strategies

Potential GHG reductions from pricing were based on an assumption that comprehensive pricing strategies would affect all travel (e.g., higher fuel taxes, VMT fees, pay-as-you-drive insurance (PAYD)). The analysis estimated pricing of an additional two to five cents per mile, roughly equivalent to a $0.40 to $1.00/gallon gas tax. This was estimated as potentially reducing GHG emissions by 0.7 to 3.1 percent within five to 10 years.

Transit assumptions included nearly doubling the average annual ridership growth rate (from the current 2.4 to 4.6 percent). This would reduce transportation GHG emissions from 0.2 to 0.9 percent by 2030, or 0.4 to 1.5 percent in 2050. In addition, inter-city transit, including high-speed rail and bus, could reduce emissions by up to 0.2 percent in 2030.

Land use changes (density, diversity of land uses, neighborhood design, street connectivity, destination accessibility, distance to activity centers, and proximity to transit) were assumed to reduce trip lengths and support travel by transit, walking, and bicycling. The analysis focused on three studies: *Growing Cooler*; *Moving Cooler*; and *TRB Special Report 298: Driving and the Built Environment*. All three studies found GHG reductions from land use strategies of the same order of magnitude. Taking the middle section of the study ranges yielded a reduction of U.S. transportation GHG emissions of one to four percent in 2030 and three to eight percent in 2050.

The analysis included non-motorized improvements such as construction of pedestrian and bicycle transportation networks through dedicated rights-of-way and enhancements to existing rights-of-way that safely provide for bicycle and pedestrian traffic. These measures would reduce GHGs by 0.2 to 0.6 percent by 2030.

Increasing commute trip reduction programs could result in GHG reductions of 0.2 to 0.6 percent of all transportation sector emissions in 2030. Telework and other alternative work schedules can further reduce GHG from work travel by up to 0.5 percent.

Finally, it was estimated that an increase in public information presented a GHG reduction potential in the range of 0.1 to 0.2 percent of transportation GHG emissions.

The collective impact of these strategies that "reduce carbon intensive travel activity" on all transportation GHG emissions could range from five to 17 percent in 2030; or six to 21 percent in 2050. These numbers included eco-driving, which doesn't reduce VMT, but reduces GHG by 0.8 to 4.3 percent.

Moving Cooler

The July 2009 *Moving Cooler* study was commissioned by a diverse group of stakeholders, representing transportation experts, industry, federal agencies, and environmental organizations, and other non-governmental organizations.

Six Bundles of Various GHG Reduction Strategies In Published Report

In this analysis, six bundles of different transportation sector GHG reduction strategies were analyzed. VMT reduction and operational efficiency are the predominant strategies tested in *Moving Cooler* (versus improvements to vehicles and fuels), and the light duty vehicle fleet was assumed to operate at 43.3 mpg (GHG equivalent) in 2050. For each bundle, GHG reductions for all on-road vehicles and transit/intercity rail modes were estimated. Each bundle included selected strategies from all four legs of the "Transportation GHG Reduction Stool" (VMT reductions, vehicles, fuels, and operational efficiency improvements); and therefore not just VMT reduction strategies. The design of the bundles reflected different areas of policy focus to achieve system performance or financial goals.

For each bundle, the cumulative effect of bundles was estimated using a multiplicative approach. Here's how the multiplicative approach works:

- Strategy A reduces VMT by 10 percent
- Strategy B reduces VMT by another 10 percent.

Rather than assuming a 20 percent total reduction for both, strategy B would be a 10 percent reduction from the resulting 90 percent after strategy A is applied.

Figure F-4 below indicates the reductions in GHG emissions for U.S. surface transportation in 2050 for the various bundles. Details on strategies included in each bundle can be found in the *Moving Cooler* report. These reductions assume maximum deployment in 2050 compared to 2005 baseline.

Figure F4 – *Moving Cooler's* Bundle Analysis Results

Moving Cooler Bundle	2050 Greenhouse Reduction Relative to 2005
Bundle 1 (Near Term/Early Results)	**17 percent**
Bundle 2 (Long Term/Maximum Results)	**24 percent**
Bundle 3 (Land Use/Transit/Non-motorized)	**14 percent**
Bundle 4 (System and Driver Efficiency)	**12 percent**
Bundle 5 (Facility Pricing)	**4 percent**
Bundle 6 (Low Cost)	**18 percent**

For comparison, Washington state's 2050 GHG reduction mandate represents a 53 percent decrease, relative to 2005.

All of the six bundles analyzed above included various combinations of strategies to reduce VMT, improve the operational efficiency of the transportation, and improve vehicle fleet GHG efficiency, for both light duty and heavy duty vehicles. None of the strategies, however, focused exclusively on strategies to reduce light duty vehicle VMT.

New Analysis of Bundles Focused on Light Duty Vehicle VMT Reduction

For illustrative purposes, WSDOT analyzed additional "VMT specific bundles" that focused exclusively on light duty vehicle VMT reduction strategies. For this additional analysis, WSDOT obtained light duty vehicle VMT reductions from Cambridge Systematics, and used the multiplicative approach (as above) to estimate cumulative VMT reductions. WSDOT applied the reductions from these VMT specific bundles for illustrative purposes to Washington state, and compared the reductions to the state VMT reduction benchmarks. The specific categories of VMT reduction strategies included:

- Pricing
  - Pricing strategies focused specifically on facilities (i.e., parking, tolls, congestion pricing, etc.)
  - Pricing strategies impacting statewide travel (VMT fees, gas tax/carbon fees)
- Land Use, Smart Growth, and Non-Motorized
- Public Transportation
- Regional Ride-Sharing, Car-Sharing and Commuting Strategies
- Regulatory Strategies

Figure F-5 below summarizes the light duty vehicle VMT reductions from the various strategies in 2030 and 2050, from "expanded current practice" to "maximum implementation."

Figure F-5 - Moving Cooler Summary – Percent Light Duty Vehicle VMT Reduction from Strategies

	2030			2050			Cumulative Reduction - For 2030 Expanded Practice*	Cumulative Reduction - For 2050 Maximum*
	Expanded Current Practice	More Aggressive	Maximum	Expanded Current Practice	More Aggressive	Maximum		
Pricing								
- CBD/Activity Ctr. on-street parking	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
- Higher tax on free private parking	0.0%	0.1%	0.1%	0.0%	0.1%	0.1%	0.1%	0.2%
- Residential parking permits	0.0%	0.1%	0.1%	0.0%	0.1%	0.1%	0.1%	0.3%
- Cordon Pricing	0.1%	0.2%	0.3%	0.3%	0.3%	0.3%	0.2%	0.6%
- Congestion Pricing	1.5%	2.1%	2.7%	1.5%	2.3%	2.7%	1.8%	3.3%
- Intercity Tolls	0.1%	0.1%	0.2%	0.1%	0.1%	0.2%	1.8%	3.5%
- PAYD Insurance	1.9%	4.5%	6.0%	1.9%	4.5%	6.0%	3.7%	9.3%
- VMT fee	0.7%	2.0%	8.0%	0.7%	2.0%	8.2%	4.3%	16.7%
- Carbon Pricing LDV VMT Impact	0.7%	2.0%	8.0%	0.7%	2.0%	8.2%	4.9%	23.5%
Land Use and Smart Growth Strategies/Nonmotorized Strategies								
- Combined Land Use	0.3%	2.3%	3.9%	1.1%	4.9%	8.0%	5.3%	29.6%
- Combined Pedestrian	0.2%	0.5%	0.6%	0.2%	0.5%	0.6%	5.5%	30.1%
- Combined Bicycle	0.2%	0.4%	0.6%	0.2%	0.4%	0.6%	5.6%	30.5%
Public Transportation Strategies								
- Transit Fare Measures	0.0%	0.1%	0.2%	0.0%	0.1%	0.2%	5.7%	30.6%
- Transit Frequency/LOS/Extent	0.1%	0.3%	0.7%	0.3%	0.7%	2.5%	5.8%	32.3%
- Urban Transit Expansion	0.4%	0.9%	1.8%	0.8%	1.8%	4.2%	6.2%	35.2%
- Intercity Passenger Rail	0.1%	0.1%	0.2%	0.1%	0.1%	0.1%	6.3%	35.3%
- High-Speed Passenger Rail	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	6.4%	35.4%
HOV/Carpool/Vanpool/Commute Strategies								
- Car-Sharing	0.1%	0.2%	0.4%	0.1%	0.2%	0.4%	6.5%	35.7%
- Employer-Based Commute Strategies	0.7%	1.4%	3.2%	0.7%	1.4%	3.2%	7.2%	37.7%
Regulatory Strategies								
- Nonmotorized Zones	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.2%	37.7%
- Urban Parking Restrictions	0.1%	0.4%	0.9%	0.7%	1.4%	2.0%	7.3%	39.0%

*Using multiplicative approach.

WSDOT analyzed three VMT reduction "bundles," which represent "expanded current practice" to "maximum implementation":

Version 1: All strategies considered that reduce VMT except VMT fee and carbon pricing.

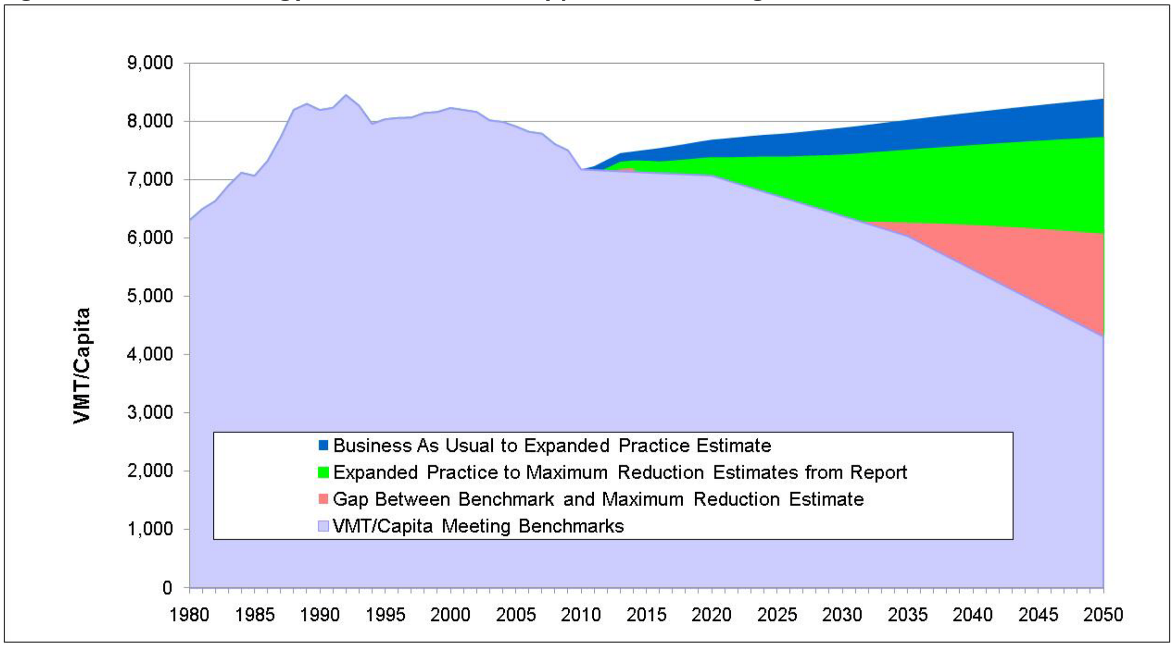
Version 2: Same as 1, plus VMT fee.

Version 3: Same as 2, plus carbon pricing.

The maximum implementation level intended to set a threshold on the highest-end GHG reduction potential and would require "substantial policy changes and significantly increased levels of investment – consistent with a singular commitment to reduction in GHGs." Figures F6 through F8 show a range of potential VMT/capita reductions ("expanded current practice" to "maximum implementation") for the three VMT reduction "bundles" compared to "business as usual" and the state VMT benchmarks. Figure F-9 summarizes all three.

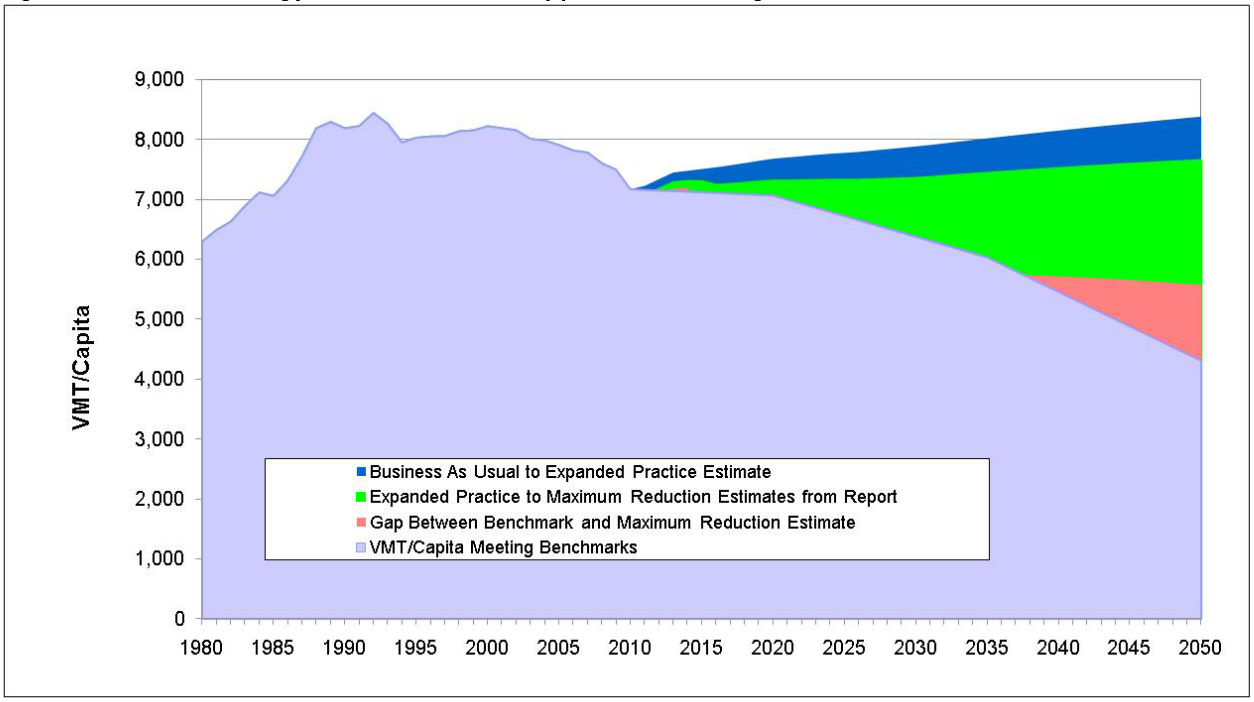
The *Moving Cooler* report has more specific information on assumptions and strategies included for expanded current practice and maximum implantation, but a summary of 2050 assumptions for maximum implementation for the three VMT reduction scenarios is described below.

Figure F-6 - VMT Strategy Bundle Version 1 Applied to Washington State



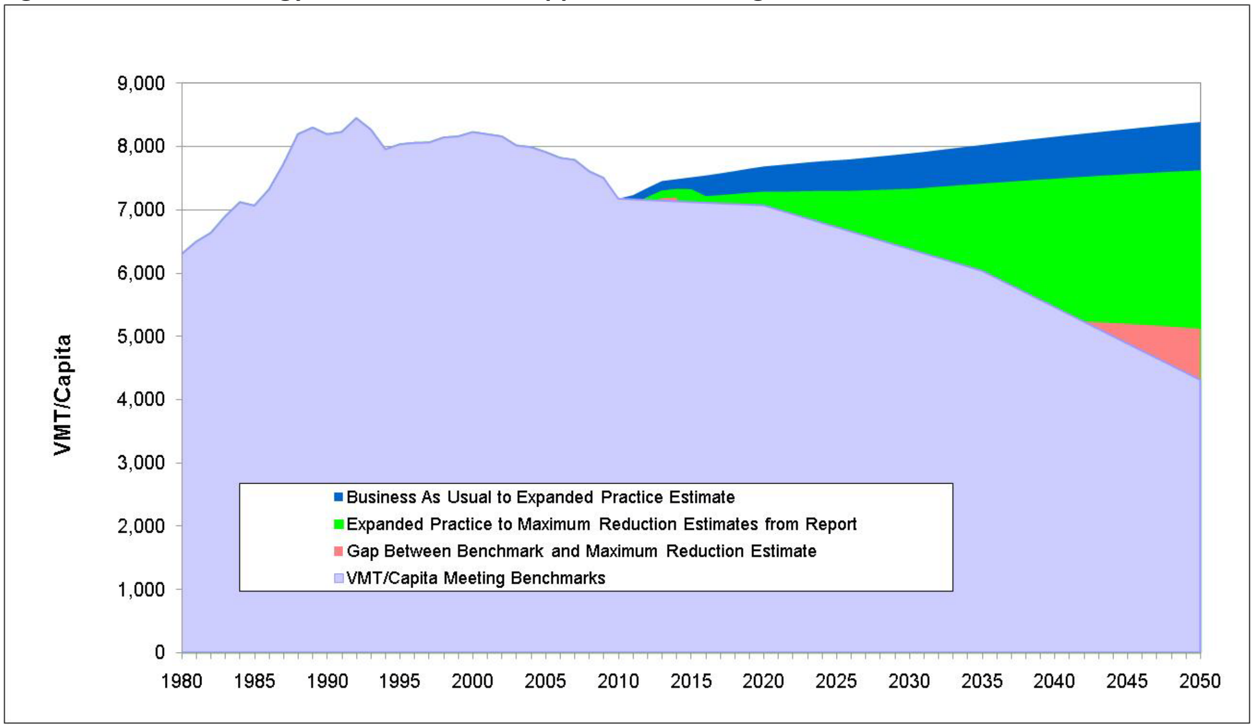
Source: Washington State Department of Transportation (population numbers from Washington State Office of Financial Management)

Figure F-7 - VMT Strategy Bundle Version 2 Applied to Washington State



Source: Washington State Department of Transportation (population numbers from Washington State Office of Financial Management)

Figure F-8 - VMT Strategy Bundle Version 3 Applied to Washington State



Source: Washington State Department of Transportation (population numbers from Washington State Office of Financial Management)

Figure F-9 - Estimated Percent Total VMT Reductions from Moving Cooler Future Baseline, Compared to VMT Benchmarks (Using Multiplicative Approach)

	2030			**2050**		
	Expanded Current Practice	**More Aggressive**	**Maximum**	**Expanded Current Practice**	**More Aggressive**	**Maximum**
Meeting State VMT Benchmarks	19.1%	19.1%	19.1%	48.6%	48.6%	48.6%
Version 1: (All light duty vehicle fleet VMT reduction strategies except VMT fee and carbon pricing.)	6.0%	13.0%	20.3%	8.0%	17.6%	27.6%
Version 2: (Same as Version 1 plus VMT fee.)	6.7%	14.8%	26.7%	8.7%	19.3%	33.5%
Version 3: (Same as Version 2 plus carbon pricing.)	7.3%	16.5%	32.5%	9.3%	21.0%	39.0%

Source: Washington State Department of Transportation (population numbers from Washington State Office of Financial Management)

Specific Strategies Included in VMT Reduction Bundles

Below are the specific assumptions included for the "Maximum" implementation in 2050 for the three VMT reduction bundles above. Assumptions for other years, and for the "more aggressive" and "expanded current practice," can be found in appendices of the *Moving Cooler* report.

VMT Strategy Bundle Version 1 – Maximum implementation in 2050 assumptions:

Pricing:

- Residential parking permit for on-street parking in residential areas; minimum cost: $400 biannually.
- Delivery and service vehicles and visitors need permits.
- Implement area pricing in CBDs and major employment and retail centers.
- Congestion pricing on urban roads to maintain LOS D; rural freeways and arterials to maintain LOS C (average peak hour per mile price of $0.65 on congested segments)
- Toll all rural interstates at $0.05 per mile.
- All vehicle insurance paid via PAYD.

Land Use, Smart Growth, and Non-Motorized Transportation:

- Urban area growth boundaries.
- Growth areas in town/village centers at a min. of 8 units/acre.
- Metropolitan land use plans and local zoning provide for 90% of new development in neighborhoods in attached or small-lot detached units, in pedestrian- and bicycle-friendly neighborhoods (e.g., sidewalks, bicycle facilities, good connectivity) with mixed-use commercial districts and high-quality transit.
- Local plan/zoning code compliance is 100%.
- Density minimums established inside urban growth boundaries.
- Requirements established for minimum fractions of new jobs and housing located within walking distance of high frequency transit.
- MPOs have authority to disapprove local land use plans and ordinances if not consistent with regional plan; enforced through withholding of funding for transportation projects.
- Existing streets within 1/2 mile of transit stations, schools, and business districts audited for pedestrian accessibility and retrofitted as appropriate to improve pedestrian accessibility.
- New development areas include off-street paths at ¼ to ½ mile intervals. City-level plans support linkages among local paths.

- Bicycle network at combined ¼ mile spacing (half bicycle lanes and one-quarter each bicycle boulevards and shared-use paths), in areas with population density >2,000 persons per square mile.
- "Bike stations" at major activity centers, transit hubs, and CBDs.

Public Transportation Improvement Strategies

- Lower transit fares by 50%
- Signal prioritization and synchronization, limited stop service, intersection reconfiguration, AVS to improve travel speed an additional 30%; boost reliability by 40%; integrate transit fare systems; full scale BRT deployment.
- Increase transit level of service by 4 times trend revenue mile expansion rates.
- Investments targeted in areas with 4,000+ persons/square mile.
- Expand service proportional to 4.67% per year ridership growth.
- Increase Federal capital and operating assistance to improve service in existing markets, introduce rail in new markets, and fund/subsidize a national network of intercity bus service.
- Funding for high-speed rail for regional networks and additional selected key markets, with a 15-year full implementation

Ride-Sharing, Car-Sharing and Commuting Strategies

- Provide subsidy or public procurement for continuous presence of public, private or nonprofit car-sharing organizations.
- Provide free/subsidized lease usage of convenient public street parking for carsharing vehicles. Goal: one car per 1,000 inhabitants of med-density and per 500 inhabitants of high-density census tracts.
- All government agencies require four-day work weeks.
- Federal/state tax levied on all commercial parking spaces ($5/space/weekday); employers pass along this cost to employees; proceeds used to provide free transit passes for employees and other transportation demand management activities (e.g., transit shuttles).
- Continue regional ridematching, vanpool, guaranteed ride home, transit discount, and employer outreach programs.

Regulatory Measures

- Convert 6% of CBD, regional employment, and retail center centerline miles to transit malls, linear parks, or other non-motorized zones.

- Implement a parking freeze on new parking supply (similar to Boston and San Francisco), capping the absolute number of commuter spaces in CBDs and regional employment and retail centers.
- Over 10 years, phase-in the conversion of 10% of spaces to carpool-designated.

VMT Strategy Bundle Version 2 – Maximum implementation in 2050 assumptions:
Bundle 2 includes all strategies in Bundle 1 above, plus:

VMT fee of $0.12/mile (represents an additional $2.53 per gallon indexed to fuel economy).

The maximum level of VMT fees tested in *Moving Cooler* reflects an approximate increase needed to roughly mimic fee/tax levels in Europe.

VMT Strategy Bundle Version 3 – Maximum implementation in 2050 assumptions:
Bundle 3 includes all strategies in Bundles 1 and 2 above, plus carbon pricing (VMT impacts only). This would increase the federal and/or state gasoline and diesel taxes to equivalent $0.12 per mile (new tax is $2.71 per gallon indexed to fuel economy). It's important to point out that in *Moving Cooler*, carbon pricing and VMT fees were never "bundled" together. They were viewed as two alternate options for pricing general travel. They are combined in this analysis only for illustrative purposes. The maximum level of carbon pricing reflects an approximate increase needed to roughly mimic fee/tax levels in Europe.

Harvard Kennedy School Belfer Center for Science and International Affairs Study, Analysis of Policies To Reduce Oil Consumption and Greenhouse-Gas Emissions from the US Transportation Sector

This February 2010 study explored several policy scenarios for reducing oil imports and greenhouse gas emissions from the transportation sector. In this analysis, scenarios were analyzed using the Energy Information Administration's National Energy Modeling System (NEMS) model.

Scenarios Analyzed

The scenarios analyzed included:

- Business as usual.
- Economy-wide CO_2 tax of $30/t of CO_2 in 2010 and escalating to $60/t in 2030 (a surrogate for a cap-and-trade system). Tax revenue returned to consumers through income tax reductions.

- The economy-wide CO_2 tax, plus a strong gasoline and diesel tax ($0.50/gal in 2010 and increasing 10% per year, resulting in a $3.36/gal tax in 2030).
- The economy-wide CO_2 tax, plus improved Corporate Average Fuel Economy (CAFE) standards during 2020-2030, reaching a new standard of 43.7 mpg in 2030.
- The economy-wide CO_2 tax plus aggressive performance-based tax credits for alternative motor vehicles.
- The United States adopts all of these policies.

Findings

Overall, the study found that increasing the cost of driving is essential to obtaining significant reductions in GHG emissions from transportation. Oil prices at $198 per barrel by 2030, combined with high fuel taxes would result in stabilized CO_2 emissions for the transportation sector near 2010 levels. The equivalent gasoline prices that achieve these reductions are in the range of seven to nine dollars per gallon. However, if underlying world oil prices lower than indicated above during the next two decades, as EIA predicts, then none of the policy scenarios modeled achieve the desired targets for annual U.S. CO_2 emissions.

The analysis found that, specifically, direct transportation (fuel) taxes generate the greatest reductions in CO_2 emission from transportation, achieving CO_2 emissions at 86% of 2005 levels by about 2025. (Note that from other studies, an analysis of the American Power Act indicates the act would price carbon at $12-$25/ton[13]. Furthermore, analysis by the EPA estimates that cap and trade could increase gasoline prices by about $0.25/gallon in 2030[14]; $50/ton carbon pricing would equate to about a $0.50/gallon increase[15].)

EPA Analysis of the Transportation Sector Greenhouse Gas and Oil Reduction Scenarios

This EPA study completed in February, 2010 focused on GHG and oil consumption reduction in transportation sector from:

- Improvements in vehicle technologies and fuels, and
- Improvements in travel efficiency.

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[13] National Commission on Energy Policy (http://bipartisanpolicy.org/news/articles/2010/05/climate-bills-side-side)

[14] February 2010 report EPA Analysis of the Transportation Sector Greenhouse Gas and Oil Reduction Scenarios

[15] David L. Greene, ORNL, 5/26/2010, Reducing GHG through Low-Carbon Fuels and Fuel-Efficient Vehicles

Improvements in Travel Efficiency

In this study, the travel efficiency scenarios were based largely on the *Moving Cooler* analysis, and analyzed two different scenarios. Scenario A assumed an increasing application of strategies with total annual light duty vehicle GHG emissions reductions reaching 12 percent by 2030. The 12 percent travel efficiency GHG reductions in Scenario A are from the following:

- 4.7% from speed limit reductions and urban parking restrictions
- 2.3% from pricing (e.g., parking taxes, congestion pricing)
- 1.8% from intelligent transportation and eco-driving
- 1.7% from land use and Smart Growth
- 1.0% from HOV/vanpool/carpool/commute strategies
- 0.1% from public transportation strategies

Scenario B had more aggressive assumptions and assumed an increasing application of strategies with total annual light duty vehicle GHG emissions reductions reaching 16 percent by 2030. For Scenario B, the 16 percent travel efficiency GHG reductions are from the following:

- 5.0% from speed limit reductions and urban parking restrictions
- 3.1% from intelligent transportation and eco-driving
- 3.0% from land use and SmartGrowth
- 2.9% from pricing (e.g., parking taxes, congestion pricing)
- 2.3% from HOV/vanpool/carpool/commute strategies
- 0.1% from public transportation strategies

Improvements in Vehicle Technology and Fuels

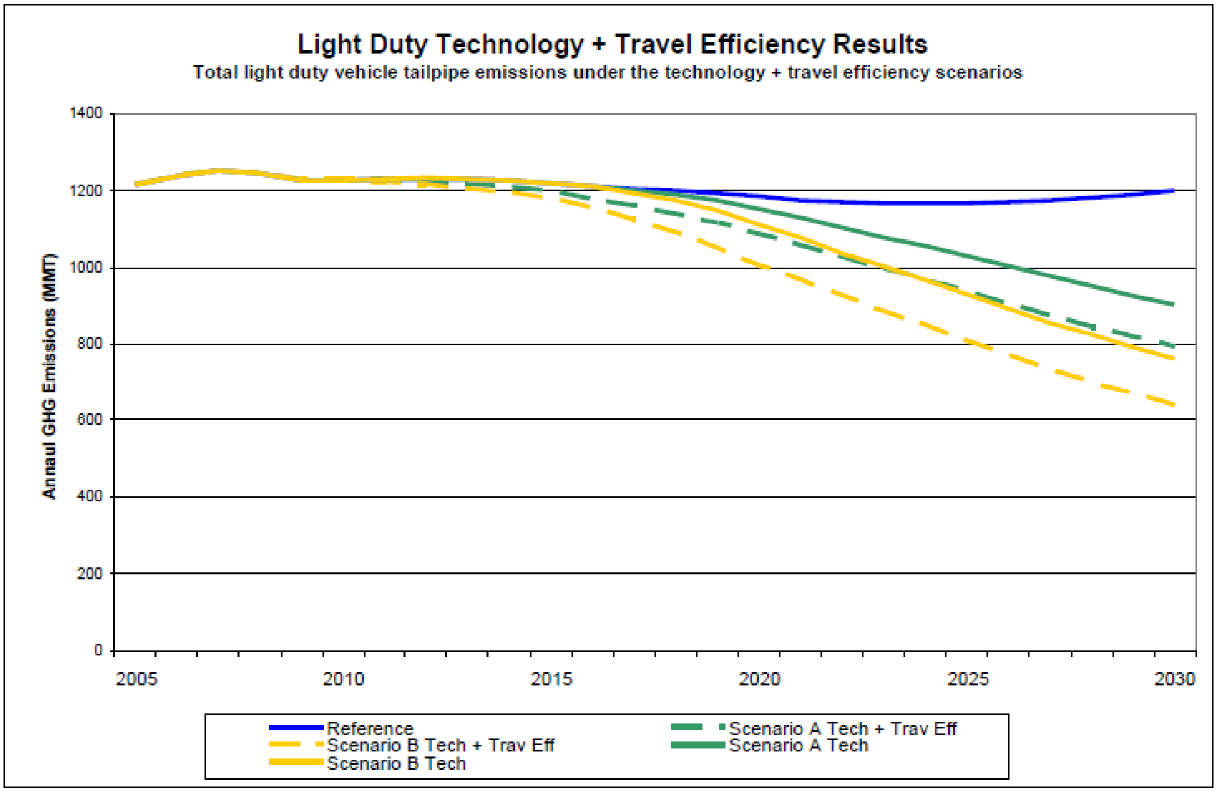
The study also analyzed changes to the light duty vehicle fleet and fuel, assuming a VMT rebound effect of 10% in U.S. due to improved vehicle efficiency. Overall, the assumptions included a significant increase in electrification of the transportation system, as follows:

- Electric vehicles (EVs) and plug-in hybrid electric vehicles (PHEVs) enter the fleet in 2015. In 2030, new sales reach 17- 19% PHEVs and 13%-30% EVs.
- EVs and PHEVs share of entire light duty vehicle fleet in 2030:
  - Scenario A = 14%
  - Scenario B = 21%
- Assumes annual improvement in new LDV GHG emission rates of 5 to 6% a year, such that by 2030:
  - Scenario A – new LDVs GHG equivalent of ~70 mpg
  - Scenario B – new LDVs GHG equivalent of ~ 90 mpg

Summary of Results

As shown in Figure F-10, the analysis overall found that Scenario A would result in a 28 percent reduction in 2030 light duty vehicle fleet GHG emissions compared to reference, and Scenario B would result in a 40 percent reduction in GHG emissions compared to reference.

Figure F-10 - Summary of Light Duty Technology and Travel Efficiency Results from EPA Study



Source: www.epa.gov/otaq/climate/kerry-analysis-02-18-2010.pdf

U.C. Berkeley Study: Review of Modeling Analysis of Transit, Land Use, and Auto Pricing Strategies to Reduce VMT and GHG Emissions, C. Rodier, for CARB and Caltrans

This October 2009 study was a meta-analysis of about 40 modeling studies in the U.S. and 6 other countries. The report reviewed the international modeling literature on land use, transit, and auto pricing policies to suggest a range of VMT and GHG reduction that regions might achieve if such policies were implemented. The synthesis of the literature categorized studies by geographic area, policy strength, and model type, to provide insight into order of magnitude estimates for 10-, 20-, 30-, and 40-years time horizons. The analysis also highlighted the effects of modeling tools of differing quality, policy implementation timeframes, and variations in urban form on the relative effectiveness of policy scenarios.

Because the modeling was conducted at regional levels, the analysis may not be representative of a broader statewide impact. Figure F-11 below summarizes the VMT reductions for various combinations of strategies for the 40-year horizon. The table identifies median VMT reductions, as well as the low to high range of VMT reductions for a 68 and 95 percent range of study scenario results.

As shown, the modeling analysis finds that combined strategies result in much greater VMT reductions than individual strategies. However, the study points out that "…even improved calibrated travel models are likely to underestimate VMT reductions from land use, transit, and pricing policies. These models simply are not suited for the policy analysis demands in the era of global climate change."

Figure F-11 - Summary of Regional VMT Reductions from Regional Modeling Analysis

		40 Year Regional VMT Reductions			
		68% of studies		95% of studies	
Strategy	**Median**	**High**	**Low**	**High**	**Low**
Combined Strategies					
- Land Use, Transit, and Pricing	-24.1%	-32.8%	-16.8%	-79.9%	-12.7%
- Transit and Pricing	-17.1%	-35.8%	-6.3%	-39.5%	-2.0%
- Combined Pricing	-16.6%	-17.0%	-16.3%	NA	NA
- Land Use and Transit	-15.8%	-20.7%	-6.7%	-27.5%	-2.7%
Individual Strategies					
- Fuel Tax	-12.9%	-14.9%	-4.0%	-16.9%	-3.5%
- VMT Pricing	-11.1%	-24.4%	-5.0%	-54.2%	-3.8%
- Congestion Pricing	-3.8%	-8.1%	-3.1%	-8.3%	-2.1%
- Parking Pricing	-2.0%	-2.6%	-0.7%	-6.1%	0.0%
- Cordon Pricing	-1.7%	-4.0%	-0.5%	-6.9%	-0.4%
- Land Use	-1.7%	-7.7%	-0.1%	-9.8%	0.2%
- Transit	-1.0%	-3.5%	-0.3%	-10.4%	0.0%

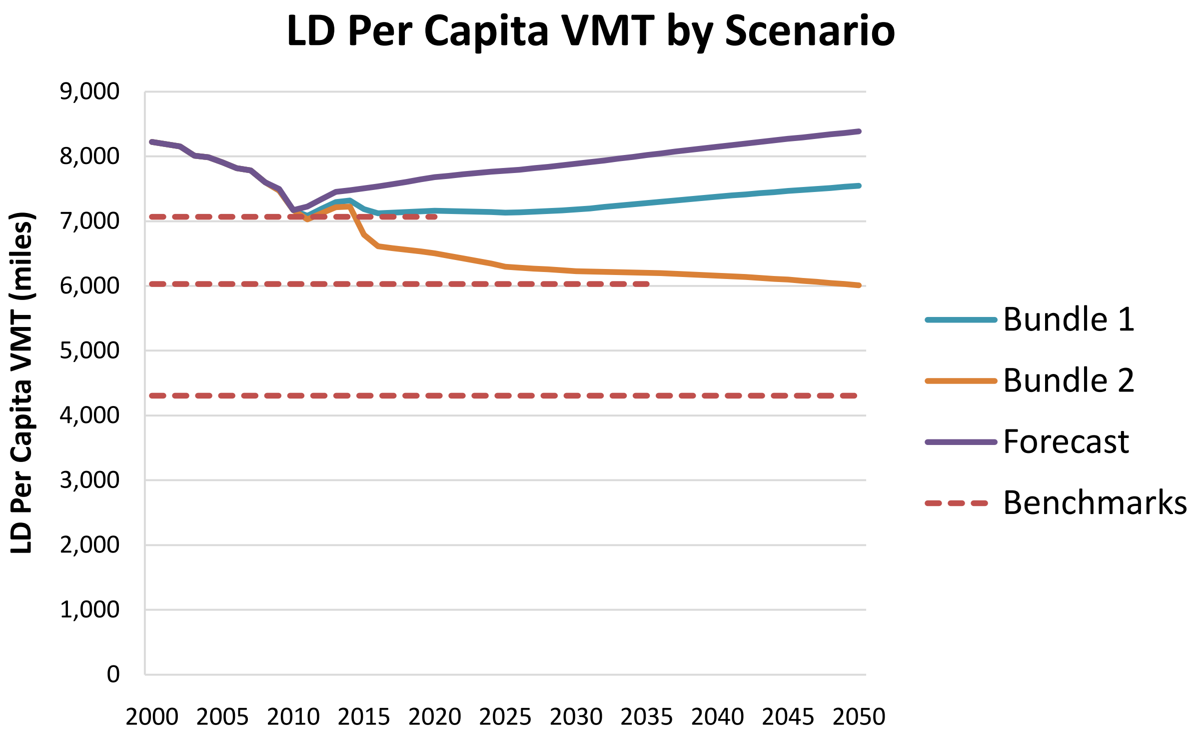
Source: U.C. Berkeley Study: Review of International Modeling Analysis of Transit, Land Use, and Auto Pricing Strategies to Reduce VMT and GHG Emissions, C. Rodier, for CARB and Caltrans, October, 2009, http://pubs.its.ucdavis.edu/download_pdf.php?id=1350

VMT Reduction Bundles for "Scenario" Analysis

WSDOT used the assumptions and analysis in *Moving Cooler* to develop two scenarios projecting what types of VMT reductions could be possible from various strategies. (The *Moving Cooler* report is the only national study that provides ranges of VMT reductions from a wide range of strategies.) These scenario "bundles" consisted of various subsets of VMT reduction strategies and are described in detail below. The "low" VMT bundle is moderate cost, with comparatively fewer barriers for implementation. The "high" VMT bundle is an aggressive, higher cost bundle with more barriers to implementation. It is important to note that the strategies included in these bundles do not directly correspond to those identified in the TIWG and LUCC, because they rely on the national analysis in the *Moving Cooler* study. While the bundled strategies are somewhat complementary, they are more specific and quantifiable than those in the TIWG and LUCC.

The projected reductions in VMT per capita from the two bundles relative to the baseline VMT forecast and the VMT benchmarks are shown in Figure F-12. Consistent with the findings from other studies, the "high" VMT bundle would require bold and transformative land use and transit strategies, and significant pricing signals (although less than the several dollars a gallon cited above). This scenario would achieve an estimated 28 percent reduction in VMT in 2050, compared to the 48 percent total VMT reduction needed to meet the state's 2050 VMT benchmark (relative to the most recent VMT forecast). The estimated reduction from the high scenario falling well short of the 2050 VMT reduction benchmark suggests that the state will not be able to meet the benchmark, even with aggressive implementation of VMT strategies.

Figure F-12 – Light Duty VMT/Capita for VMT Bundles in Scenario Analysis



Source: Washington State Department of Transportation (population numbers from Washington State Office of Financial Management)

The "high" VMT reduction bundle that is projected to reduce VMT by 28 percent assumes that transformative land use, transit and pricing strategies would be evenly implemented around the state. In practice, implementation of these strategies is dependent on a mix of state, regional, local, and private action. Many of the strategies must be implemented by local governments and regional transportation planning organizations. Even moderate cost sets of VMT reduction strategies will require substantial investments and changes. These organizations will need to make choices about how to prioritize reducing VMT and greenhouse gas emissions and which strategies will help them meet their own goals.

Strategies included in each of these scenarios are listed in Figure F-14. The estimated percent light duty vehicle VMT reduction from future baseline from the two scenarios is indicated in Figure F-13.

Figure F-13 - Percent Light Duty Vehicle VMT Reductions from Two Scenarios for Scenario Analysis

	2020	2035	2050
Scenario Analysis A – Moderate VMT Reduction Bundle	**6.8%**	**9.2%**	**10.0%**
Scenario Analysis B – Much Higher Cost, More Barriers to Implementation	**15.3%**	**22.7%**	**28.3%**

Source: Washington State Department of Transportation (population numbers from Washington State Office of Financial Management)

Figure F-14 – Scenario Analysis VMT Reduction Bundles

Category	Low VMT Reduction Scenario Bundle Strategies	High VMT Reduction Scenario Bundle Strategies
Pricing	• Make VMT and GHG reductions a tolling objective and use revenues for sustainable transportation options • Apply tolls more broadly in Puget Sound region on all congested freeways, average peak hour per mile price of $0.49 on congested segments.	• Make VMT and GHG reductions a tolling objective and use revenues for sustainable transportation options. • VMT or Carbon fee of $0.03/mile (represents an additional $0.63 per gallon indexed to fuel economy). • Congestion pricing on urban roads to maintain LOS D; rural freeways and arterials to maintain LOS C (average peak hour per mile price of $0.65 on congested segments).
Parking management and pricing	• Price all CBD/employment center/retail center street parking. For large and medium metropolitan areas with higher transit begin in 2015; other metropolitan areas begin in 2020. Complete over eight years.	• Price all CBD/employment center/retail center street parking. For large and medium metropolitan areas with higher transit begin in 2015; other metropolitan areas begin in 2020. Complete over eight years. • Implement a parking freeze on new parking supply in CBDs and regional employment and retail centers. • Over 10 years, convert 10% of spaces to carpool-designated.
Transit and Rail Expansion	• Expand transit service to accommodate 3% per year increase in ridership. • Eliminate existing bottlenecks and increase intercity rail system capacity to accommodate passenger rail growth. • Increase capital and operating assistance over trend by 5% per year for 20 years to improve service in existing markets and expand operation of Amtrak associated motor coach service.	• Signal prioritization and synchronization, limited stop service, intersection reconfiguration, automatic vehicle supervision, to improve travel speed an additional 30%; boost reliability by 40%; integrate transit fare systems; full scale BRT deployment. • Increase transit LOS by 4 times the trend revenue mile expansion rates. • Investments targeted in areas with 4,000+ persons/square mile. • Expand service proportional to 4.67% per year ridership growth. • Increase Federal capital and operating assistance to improve service in existing markets, introduce rail in new markets, and fund/subsidize a national network of intercity bus service.

Category	Low VMT Reduction Scenario Bundle Strategies	High VMT Reduction Scenario Bundle Strategies
Pay-As-You-Drive insurance	• 50% of insurance policies statewide have 50% of premiums based on mileage; increasing to 75% of policies by 2025.	• By 2015, all auto insurance policies must have at least 75 percent of premiums paid for on a mileage basis, allowing but not mandating adjustments in mileage rates based on time of day, location, driving style or other factors. • Assume 100 percent policy penetration by 2025.
Land Use Strategies	• By 2015, in urban areas at least 60% of new development in attached or small-lot detached units, in pedestrian- and bicycle-friendly neighborhoods with mixed-use commercial districts and high-quality transit. • The majority of communities adopt zoning and planning standards allowing for sufficient densities and requiring pedestrian-friendly design in these areas. • Provide state transportation funding incentives for regional comprehensive planning activities and local planning and implementation (infrastructure) activities	• State and metro agencies adopt enforceable growth boundaries around urban areas consistent with Oregon's model. • Growth areas in town/village centers at a min. of 8 units/acre. • 90% of new development in neighborhoods in attached or small-lot detached units, in pedestrian- and bicycle-friendly neighborhoods, with mixed-use commercial districts, and high-quality transit. • Local plan/zoning code compliance is 100%. • Density minimums established inside urban growth • boundaries. • Requirements established for minimum fractions of new jobs and housing located within walking distance of high frequency transit. • MPOs have authority to disapprove local land use plans and ordinances if not consistent with regional plan; enforced through withholding of funding for transportation projects.

Category	Low VMT Reduction Scenario Bundle Strategies	High VMT Reduction Scenario Bundle Strategies
Urban Commute Trip Reduction, Rideshare Programs, and Carsharing	• Expand state support for telework and flexible work schedules • Implement aggressive outreach program to inform major employers (100+ employees) of alternative travel options, assist with providing information and incentives to employees. Transit agencies make monthly passes available through employers at discounted rates. • Establish requirements for employers w/ >50 employees to develop and implement plans to reduce SOV trips by 10% compared to baseline levels; offer technical assistance to employers for these plans; provide incentives/disincentives for compliance. • Continue regional ridematching, vanpool, guaranteed ride home, and transit discount services. • Value of parking benefits is taxed; value of cash-out or transit benefits is not. • For private sector, provide employer goals and tax incentives to offer and adopt telecommuting and compressed work week targets. Provide public funding or subsidies for the private provision of regional telework centers and shared satellite offices. • Require elimination of telecommuting barriers in state and local tax codes (e.g., double taxation) • Public Sector: All government agencies allow option of telecommuting and compressed work.	• Same as Low Bundle Plus: - Provide subsidy or public procurement sufficient to ensure continuous presence of one or more public, private or nonprofit car-sharing organizations per market. Provide free or subsidized lease usage of convenient public street parking for carsharing vehicles. Five-year goal of one car per 1,000 inhabitants of medium-density and per 500 inhabitants of high-density census tracts. - All government agencies require four-day work weeks. - Federal/state tax levied on all commercial parking spaces ($5/space/weekday); employers pass along this cost to employees; proceeds used to provide free transit passes for employees and other TDM activities (e.g., transit shuttles). - Continue regional ridematching, vanpool, GRH, transit discount, and employer outreach programs.

Category	Low VMT Reduction Scenario Bundle Strategies	High VMT Reduction Scenario Bundle Strategies
Encourage Bicycle and Pedestrian Accessibility	• By 2015: - Require appropriate pedestrian & bicycle accommodations on all roadways. - All new developments in urban areas have buffered sidewalks, marked/signalized pedestrian crossings at intersections on collector/arterial streets, and lighting. - In denser urban neighborhoods traffic calming measures to shorten street-crossing distances - Bicycle parking at all commercial destinations. - Buses fitted with bicycle carriers, rapid transit stations have bicycle parking, and all rapid transit lines are bike-accessible during off-peak hours. - School curriculums include safe cycling skills for children. - Major CBDs have a "bike station" that provides services, including parking, rentals, repair, changing facilities, and information.	• All of Low Bundle plus the following modifications: - Existing streets within 1/2 mile of transit stations, schools, and business districts audited for pedestrian accessibility and retrofitted as appropriate to improve pedestrian accessibility. - New development areas include off-street paths at ¼ to ½ mile intervals. City-level plans support linkages among local paths. - Bicycle network at combined ¼ mile spacing (half bicycle lanes and one-quarter each bicycle boulevards and shared-use paths), in areas with population density >2,000 persons per square mile. - "Bike stations" at major activity centers, transit hubs, CBD.

Category	Low VMT Reduction Scenario Bundle Strategies	High VMT Reduction Scenario Bundle Strategies
Encourage Bicycle and Pedestrian Accessibility	- All metropolitan areas have citywide and/or regional plans developed for on-street bicycle accommodations to create a continuous network of routes. The planned network includes bicycle lanes at one mile intervals, and other facilities (shared-use markings, signed routes using neighborhood streets) at one-mile intervals, for a combined network density of one-half mile, implemented in areas with population density >2,000 persons per square mile. - All new commercial buildings >100,000 square feet required to provide showers, lockers, and covered/protected bicycle parking; all new multi-unit residential buildings have indoor bicycle parking • By 2025: - Existing streets in urban areas retrofitted w/ curb ramps, sidewalks, and crosswalks. - All metropolitan areas have implemented citywide and/or regional bike routes described in plan above.	

Figure F-15 -VMT Reduction Strategies for Consideration at the State, Regional or Local Levels

This section provides a list of VMT reduction strategies that can be considered at the state, regional, or local levels.

Land Use and Smart Growth Strategies/Nonmotorized Strategies

- Encourage Compact and Transit Oriented Development (CTOD)
- Promote and support housing and employment density
- Develop and provide parking incentives and management
- Implement a parking freeze on new parking supply in CBDs and regional employment and retail centers
- Comply with local plan/zoning code
- Encourage new development in neighborhoods in attached or small-lot detached units, in pedestrian- and bicycle-friendly neighborhoods (e.g., sidewalks, bicycle facilities, good connectivity) with mixed-use commercial districts and high-quality transit through Metropolitan land use plans and local zoning
- Encourage bicycle and pedestrian accessibility for existing streets
- Require new development areas include off-street paths. City-level plans support linkages among local paths
- Require Bicycle network (half bicycle lanes and one-quarter each bicycle boulevards and shared-use paths), in areas with higher population density
- Require "Bike stations" at major activity centers, transit hubs, and CBDs
- Require minimum fractions of new jobs and housing located within walking distance of high frequency transit
- Encourage urban Brownfield redevelopment
- Provide counties and cities more flexibility to use existing funding to support growth and density in urban areas
- Provide counties and cities with opportunities for new funds to support local efforts to reduce Greenhouse gas (GHG)
- Provide MPOs the authority to disapprove local land use plans and ordinances if not consistent with regional plan; enforced through withholding of funding for transportation projects
- Require growth areas in town/village centers at a minimum level of density
- Establish density minimums inside urban growth boundaries

- State and metro agencies adopt enforceable growth boundaries around urban areas consistent with Oregon's model
- No "backsliding" on current funding provided to local governments to support planning and implementation under the Growth Management Act (GMA)
- Support development of Transfer of Development Rights (TDR) programs
- Support the prioritization of new infrastructure funds to areas promoting development and transportation choices that support the reduction of GHG emissions and dependence on foreign oil
- Support the prioritization of existing infrastructure funds to areas promoting development and transportation choices that support the reduction of GHG emissions and dependence on foreign oil
- Encourage use of financing tools for local governments to encourage compact development in urban centers or other targeted areas within urban growth areas
- Require state agencies to provide technical guidance to local governments that voluntarily choose to use developer incentives to encourage compact development
- Amend GMA to require local governments to provide level of service (LOS) standards for all available or planned for modes of transportation and to require local governments to consider multimodal improvements or strategies in their transportation concurrency regulations
- Direct state agencies, in conjunction with regional and local transportation entities, to provide technical, non-binding guidance on multimodal transportation systems and how multimodal considerations can be included in and address during concurrency analysis at the local level
- Better enable GMA transportation concurrency in all modes of transportation
- Authorize Planning Environmental Review Fund (PERF) to provide loans to local governments and modify the PERF criteria to encourage locating more compact and sustainable development in urban growth areas
- Fund the PERF to increase local governmental use of environmental review in an upfront, programmatic manner
- Encourage greater use of State Environmental Protection Act (SEPA) in a programmatic, upfront manner that results in streamlining permitting for compact development in urban growth areas or urban centers
- Amend RCW 36.70A.100 to require that local government comprehensive plans be consistent with regional transportation plans
- Amend the County-Wide Planning Policy (CWPP) provisions of the GMA to include climate change issues

- Address reductions in GHG in the GMA goals
- Require non-motorized zones
- Require urban parking restrictions

Public Transportation Strategies

- Increase transit frequency/LOS/extent
- Provide signal prioritization and synchronization, limited stop service, intersection reconfiguration for public transportation
- Expand urban transit
- Eliminate bottlenecks on rail system
- Expand intercity passenger rail
- Expand high-speed passenger rail
- Decrease transit fares
- Coordinated strategy to assure that public transportation provides vital transportation connections to enable travel throughout Washington and provide affordable alternatives to driving alone.

HOV/Carpool/Vanpool/Commute Strategies

- Encourage and support car-sharing programs
- Expand the statewide vanpool fleet
- Upgrade and promote Rideshareonline.com
- Invest in park and pool (leased) lots to add more spaces for commuters to rideshare
- Expand state support for telework (toolkits, outreach and technical assistance)
- Encourage government agencies to implement a four-day work week
- Implement a statewide marketing campaign to provide information and tools, integrate Rideshareonline.com and traveler information
- Enhance and expand Commute Trip Reduction Program
- Enhance and expand Growth Transportation Employment Centers
- Encourage residential-based trip reduction strategies

- Create a vehicle miles traveled (VMT) innovation grant program to fund creative ideas to reduce VMT
- Provide state level support for implementation model, tools community level implementation to incorporate community messaging, support and outreach for a statewide residential trip reduction program

Pricing Strategies

- Price all CBDs, employment and retail centers street parking
- Impose higher tax on free private parking
- Provide free or subsidized lease usage of convenient public street parking for carsharing vehicles
- Require residential parking permits
- Apply cordon pricing
- Apply congestion pricing
- Apply intercity tolls
- Apply Pay As You Drive (PAYD) Insurance
- Apply VMT fee
- Apply carbon fee or increase fuel tax
- Design toll strategies to incorporate incentives that reduce per capita VMT and GHG emissions
- Apply tolls more broadly

State Transportation Funding

- Align transportation investments and operations with the achievement of the VMT/GHG reduction goals
- Provide state transportation funding incentives for regional comprehensive planning activities and local planning and implementation (infrastructure) activities
- Pursue new revenue sources to support transportation choices
- Use tolling/pricing revenues to fund more sustainable travel options
- Establish a legislative task force to propose tolls and other pricing mechanisms that could fund transportation needs and create price incentives to reduce per capita VMT and GHG emissions

Appendix G

Using the Highway Performance Monitoring System to Measure Annual State-Level Vehicle Miles Traveled

NOTE: The following information has been reformatted for use in this report

Using the Highway Performance Monitoring System to Measure Annual State-Level Vehicle Miles Traveled

Introduction

WSDOT is developing approaches for the best way to measure and monitor changes in vehicle miles traveled (VMT) at the state level, regional, and local level. This section discusses the proposed approach to measure annual progress toward VMT benchmarks at the **state** level: the Highway Performance Monitoring System (HPMS).

We are focusing our efforts on using the HPMS, which is the existing system we already use today. This system is our top pick because of its many features and benefits, including:

- Its robust data collection system has been used and refined over the years; its continued system evolution will improve state highway facility data collection in the near term.
- Wide implementation at the national, state and local level for a variety of planning and analysis purposes.
- Ability to conserve resources by repurposing a tried and true data collection system.

What is the Highway Performance Monitoring System?

The Federal Highway Administration (FHWA) developed the Highway Performance Monitoring System (HPMS) in 1978 as a national highway transportation system database and has been the nationally-chosen tool to help coordinate and synchronize numerous annual state data reports as well as special biennial state studies.[16] The major purpose of this system is to provide data that reflects the extent, condition, performance, use, and operating characteristics of our nation's highways. To meet this primary objective, the Highway Performance Monitoring System has gone through an evolutionary process that has recognized over time the changing needs for data related to these purposes.

What is HPMS Data Currently Used For?

HPMS is used at the federal level for apportionment of funding, performance measures, highway statistics and conditions reporting, and analytical models; it is one of the primary databases used by FHWA for conducting

[16] For more history on the Highway Performance Monitoring System, including the Sept. 2008 report HPMS Reassessment 2010+ check out FHWA's Web site at: http://www.fhwa.dot.gov/policy/ohpi/hpms/hpmspubs.cfm.

national-level surface transportation planning and policy studies. It is also used by a variety of state and local transportation agencies as well as other transportation interests.

It's most popular usage is estimating vehicle miles traveled and is calculated and used at the national, state, and local levels. This is not surprising since the original primary intent of Highway Performance Monitoring System when it was created in the late 1970s, was to provide a consistent basis for national vehicle miles traveled estimation.

The Highway Performance Monitoring System has become a data source for many developing applications. For example, FHWA's Highway Economic Requirements System (HERS) model and freight analysis framework rely on Highway Performance Monitoring System data. The HERS model is used for developing FHWA's conditions and performance reports, and the freight analysis framework is used for estimating current and future freight movement at the national level.

In addition, the Highway Performance Monitoring System serves needs of the states, transportation planning organizations, local government, and others in assessing highway condition, performance, air quality trends, and future investment requirements. Some states rely on traffic and travel data from the Highway Performance Monitoring System to conduct air quality analyses and make assessments related to determining air quality conformity. Others are using the same analysis models used by FHWA to assess their own highway investment needs.

Finally, data from the Highway Performance Monitoring System provides much of the information included in FHWA's annual highway statistics report and other media and publications. Highway Performance Monitoring System data are widely used in both the national and international arenas by other governments, transportation professionals, and industry professionals to make decisions that impact national and local transportation systems and our transportation dependent economy.

The FHWA has developed Highway Performance Monitoring System web application software, a *Highway Performance Monitoring System Field Manual,* a *Traffic Monitoring Guide* and other tools to assist states in the development of consistent Highway Performance Monitoring System data.[17]

How is HPMS Data Collected in Washington State?

In Washington, traffic data is collected at over 4,400 locations on state highways, providing accurate information for every mile of state highways. For non-state highways, data is collected at 3,170 sample

[17] Examples of HPMS guides and publications are included on the FHWA website: http://www.fhwa.dot.gov/policy/ohpi/hpms/hpmspubs.cfm

locations statewide with 2,000 of these for principal arterials. With this data set WSDOT can accurately estimate statewide VMT and monitor changes in statewide VMT over time. WSDOT is also able to estimate VMT for smaller geographic areas (such as county level VMT), but with less confidence due to a lower level of data collection on non-state owned highway facilities. See the section "Can HPMS Data be Used to Estimate VMT at the Local Level?" below for more discussion on the use of HPMS data to estimate VMT at a county or regional level.

How is HPMS VMT Estimated from Traffic Data?

At WSDOT, HPMS data is collected and VMT is calculated by the Transportation Data Office (see http://www.wsdot.wa.gov/mapsdata/tdo/hpms.htm). VMT is estimated using four components:

(1) **Time**: VMT is generally estimated for a year, so is given as an annual estimate; however it is not uncommon for VMT to be reported as a daily number as required in federal reporting standards.

(2) **Geographic Area**: HPMS VMT is calculated and grouped by rural and urbanized areas and by a road's functional class for these areas. Because of the roadway segmentation within our HPMS database, we are able to estimate VMT at the county level, or at even smaller geographic units. As the measured area gets smaller the reliability of the estimate becomes compromised due to the much smaller sample of traffic data typically available at a local geographic level.

(3) **Roadway Miles**: WSDOT can estimate miles of roadway for any geographic area. The Functional Classification section of the Transportation Data Office (TDO) works with all jurisdictions that own public roads and maintains an up to date inventory of all public road miles in the state as required by the Federal Highway Administration (FHWA).

(4) **Traffic Volume**: The traffic volume used in the estimation of VMT is annual average daily traffic (AADT). All jurisdictions that own public roads have a traffic counting program (some are more comprehensive than others), but the traffic counts represent only a small sample of the roadway system.

The most comprehensive traffic counting program is for state highways. For state highways WSDOT has count data at over 4,400 locations and is able to estimate the AADT for every 0.01 mile for all 7,042 miles. This gives WSDOT the ability to accurately report VMT on state highways down to very small areas. Even though other jurisdictions count traffic, traffic data at the local level is relatively sparse, and therefore traffic volume data is the limiting factor for estimating VMT down to very specific areas.

WSDOT uses HPMS software to estimate VMT from traffic count data. Estimates of VMT can be developed by direct computation for the highway system and principal arterials, and by expansion of the sample data for other systems. For highways and principal arterials, VMT is calculated by multiplying the length of the road segment by the AADT that traveled on that road segment. For example, a 15-mile road with 10,000 AADT would equate to 150,000 daily VMT or 54,750,000 annual VMT. For other facilities, VMT is estimated by multiplying the standard sample section AADT by the section length and by the standard sample expansion factor and summing the result to the HPMS stratification level desired (functional system, total rural, etc.). The HPMS software used by WSDOT performs these calculations by functional system.

Because the Revised Code of Washington (RCW) 47.01.440 exempts vehicles weighing ten thousand pounds or more and licensed under RCW 46.16.070 (which applies to trucks, buses, and “for hire” vehicles) from the VMT reduction goals, the mechanism for reporting statewide VMT needs to include a way to estimate the contribution of heavy trucks and buses. In order to determine the fraction of VMT from passenger vehicles, we need to know the percent each vehicle class contributes to the total VMT. Some of the traffic counters collect vehicle classification information. At these locations, direct estimates of truck traffic counts are provided. For locations where vehicle classification is not available, assumed truck percentages are assigned based on known site-specific values from other samples on the same route, or if unavailable, on routes with similar traffic characteristics. From these truck traffic counts or estimates, WSDOT can estimate the percentage of VMT from heavy trucks. The heavy truck estimates are only supplied as statewide estimates (see Table G-1).

Table G-1: 2008 Statewide Percent VMT by Vehicle Type

Rural/ Urban	Functional System	Motor-cycles	Passenger Cars	Light Trucks	Buses	Single Unit Trucks	Comb. Trucks
Rural	Interstate	0.25%	57.52%	24.21%	0.30%	5.57%	12.15%
Rural	Other Arterial	0.54%	57.72%	28.19%	0.27%	7.14%	6.15%
Rural	Other Rural	0.97%	56.87%	32.02%	0.20%	7.67%	2.28%
Urban	Interstate	0.29%	64.89%	24.76%	0.23%	4.40%	5.43%
Urban	Other Arterial	0.42%	66.94%	25.13%	0.25%	4.68%	2.59%
Urban	Other Urban	0.41%	60.20%	31.30%	0.21%	5.17%	2.71%
Total	**All**	**0.38%**	**62.86%**	**25.71%**	**0.25%**	**4.84%**	**5.96%**

Source: WSDOT travelactivity 2008-rpt.xls; 6/15/2008

* Note: Motorcycle percentage was estimated using Permanent Traffic Recorder data

For Other Urban Functional System (FC 17) where PTR data is not available, the next closest functional class was used.

What Roadway Facilities Are Included In the Statewide HPMS VMT Estimate?

All vehicle miles traveled in the state are included in the annual HPMS VMT estimate. Table G-2 below shows the percentage of VMT by jurisdiction. HPMS collects data for all miles of Principal Arterials and National Highway System (NHS) roads. Sample section data is collected to represent the rest of the mileage. Other jurisdictions include other federal and state agency owned roads, (i.e. colleges, forest service roads, and others).

Table G-2: 2008 Roadway Miles and VMT by Jurisdiction

Jurisdiction Level	Centerline Miles	Percent Centerline Miles	VMT(1,000,000)	Percent VMT
State Routes	7,041	8.4%	30,749	55.4%
City	17,207	20.6%	14930	26.9%
County	39,825	47.7%	9,138	16.5%
Other	19,450	23.3%	638	1.2%
Total	**83,526**	**100%**	**55,454**	**100%**

Data source: 2008 HPMS data submitted to FHWA

Can HPMS Data be Used to Estimate VMT at the Local Level?

The statewide VMT estimate is calculated based off of traffic counts on state highways, principal arterials, and county and local roads. State highways have extensive counting locations and VMT can be reported at a very high level of confidence, even down to a very specific location.

County and local roads, however, are sampled. While the statewide VMT estimate using HPMS appears to be relatively stable over time and accurate, using HPMS data to estimate VMT at the local level would currently prove more challenging. At the county level, the HPMS only includes the traffic volume from counties that have principal arterials, NHS roads, or HPMS sample sections. Counties have more traffic data than reported through the HPMS. The County Roads Administration Board (CRAB) requires counties to provide information on all segments of county roads. At the county level, this may be a source for better traffic volume coverage. Traffic counts from city roads are relatively sparse, and this may be a weak link in the capability to use HPMS data to estimate accurate VMT at the local level.

However, the HPMS is working to expand the collection of data from non-state highway roads (through the HPMS Reassessment 2010+ effort) to enhance the accuracy of traffic data at the local level by including AADT for all minor arterial and major collector segments in the HPMS. Inclusion of AADT for all minor arterials and major collectors should greatly improve the estimation of VMT for specific geographic areas.

How Does WSDOT Report VMT and to Whom?

WSDOT collects data for the HPMS throughout the year and reports the previous year's data to the FHWA in June. So, for example, the 2009 data will be available to report in June 2010.

Starting in 2011, as part of the HPMS Reassessment effort mentioned previously, WSDOT will be reporting data to FHWA in a geospatial format and WSDOT is hoping to collect and report all roadway data available through cities and counties, rather than the sample sections method now used. This should increase the reliability of estimating VMT to a finer granularity.

Should Other Tools, Such as Regional Models, Be Used to Estimate Statewide VMT?

Many regions across the state use travel demand forecast models. Typically, these models are calibrated to actual traffic counts within a reasonable range. As such, regional models have the capability to provide a gross estimate of current VMT and forecast future VMT at the regional level.

However, regional travel demand models are not available for all parts of the state. In addition, the base roadway network included in these estimates may differ from the network included in the HPMS estimate. For example, the HPMS estimate includes all roads whereas regional models may only include some classes of roads, typically major or minor collectors and above. Therefore, VMT estimates generated from these models will be different from VMT reported through HPMS. And because each regional model is different, the degree to which modeled results are different from the HPMS estimate will vary from region to region.

How Should Washington State Measure and Monitor Change to Statewide VMT?

As described, the existing HPMS system, with enhancements planned for the near future, is a reliable method for cost effectively monitoring statewide VMT. It has been in use for decades, a variety of tools/guides are already available for this system, and near-term refinements will further improve the data collected for the HPMS. VMT will be monitored and reported annually, but WSDOT will conduct a full assessment of trends in VMT/capita every five years as indicated in RCW 47.01.440 (2e).

Figure G-1 – 2008 HPMS Miles and AVMT by County

County Name	Centerline Miles	All Roads - AVMT (in 1000's)	State Route - AVMT (in 1000's)	Non-State Route - AVMT (in 1000's)	Percentage State Route - AVMT
King	7,880	16,062,773	8,404,917	7,657,856	52%
Pierce	5,051	6,200,508	3,090,471	3,110,037	50%
Spokane	4,686	3,530,759	1,528,149	2,002,610	43%
Yakima	4,637	1,771,130	760,346	1,010,784	43%
Snohomish	4,112	5,334,007	3,357,302	1,976,705	63%
Grant	3,821	960,276	613,389	346,887	64%
Okanogan	3,342	443,601	276,864	166,737	62%
Douglas	3,041	409,364	209,675	199,689	51%
Clark	2,811	2,705,198	1,395,272	1,309,926	52%
Adams	2,558	529,855	376,036	153,819	71%
Lincoln	2,440	333,130	206,375	126,755	62%
Whitman	2,435	408,682	241,036	167,646	59%
Stevens	2,339	363,520	220,553	142,967	61%
Kittitas	2,321	1,043,845	859,666	184,179	82%
Chelan	2,205	631,251	385,454	245,797	61%
Benton	2,020	1,369,806	709,206	660,600	52%
Whatcom	1,845	1,365,192	768,221	596,971	56%
Franklin	1,803	660,682	378,281	282,401	57%
Ferry	1,793	121,045	50,386	70,659	42%
Kitsap	1,775	1,615,061	901,861	713,200	56%
Thurston	1,774	2,363,419	1,207,676	1,155,743	51%
Lewis	1,646	1,012,342	764,767	247,575	76%
Grays Harbor	1,612	671,840	465,411	206,429	69%
Skagit	1,599	1,223,896	855,319	368,577	70%
Pend Oreille	1,577	148,778	80,284	68,494	54%
Klickitat	1,496	255,120	168,280	86,840	66%
Island	1,356	411,866	205,422	206,444	50%
Walla Walla	1,340	444,013	232,374	211,639	52%
Clallam	1,298	467,820	295,409	172,411	63%
Cowlitz	1,162	1,167,363	878,822	288,541	75%
Mason	943	499,778	290,500	209,278	58%
Jefferson	872	302,908	211,691	91,217	70%

County Name	Centerline Miles	All Roads - AVMT (in 1000's)	State Route - AVMT (in 1000's)	Non-State Route - AVMT (in 1000's)	Percentage State Route - AVMT
Columbia	830	73,630	31,483	42,147	43%
Pacific	737	202,911	162,448	40,463	80%
Asotin	657	108,690	38,425	70,265	35%
Skamania	612	90,928	61,676	29,252	68%
Garfield	560	61,519	28,099	33,420	46%
San Juan	355	36,979	0	36,979	0%
Wahkiakum	189	43,666	30,098	13,568	69%
Total All Roads	**83,526**	**55,447,151**	**30,741,644**	**24,705,507**	**55%**

Information is from the **2008** HPMS database. Local roads are assumed to have two lanes and VMT for Local roads is estimated.

Appendix H

System Efficiency

System Efficiency

Improving system efficiency will help reduce Greenhouse Gas (GHG) emissions from the transportation sector by smoothing the flow of traffic to prevent stop-and-go driving, and by maintaining vehicle speeds to 45-65 mph (the optimal range for reducing GHG emissions).

System efficiency strategies are easy to implement, very low cost, and will begin reducing GHG emissions almost immediately. Many strategies in the three other legs of the "Transportation GHG Reduction Stool" face barriers to quick implementation, such as new technology advances, vehicle fleet penetration, and/or major policy changes. While system efficiency strategies offer smaller annual gains than many other strategies suggested in this document, the ability to implement them immediately means that their cumulative effects could, over time, outweigh some longer-term GHG emission reduction strategies and provide larger annual benefits. These strategies can also have a major impact on reducing individual and transit travel times and increasing safety.

WSDOT will continue to deploy system efficiency strategies such as ramp metering, incident response, signal synchronization, traveler information, travel management center (TMC) operations, active traffic management (ATM), and roundabouts under its existing plans. If the agency receives additional funding to use system efficiency strategies to reduce GHGs, WSDOT will deploy the strategies in the locations that would provide the most decrease in emissions. These strategies can be implemented or expanded quickly. The cost range for these operating activities is between a few million to tens of millions of dollars. Installation of area wide ramp meters, intelligent transportation system devices and active traffic management projects are more expensive. Other operating strategies like the incident response and signal timing review and improvements are relatively inexpensive and can be implemented quickly.

Moving Cooler, the only comprehensive attempt to quantify system efficiency GHG-reduction measures, has estimated approximately a one percent reduction in transportation-related emissions from system efficiency strategies. This is an under-studied area. In-house WSDOT studies have pegged the improvement from some system efficiencies as higher, and future research could also provide insight on greater benefits from these strategies.

System efficiency on state highways

WSDOT is already pursuing several system efficiency strategies as part of its *Moving Washington* congestion relief work, but with additional funding, we could accomplish more to reduce congestion and GHG emissions. Several of these strategies will smooth the flow of traffic and allow cars to travel at more optimum speeds for GHG-reduction, as well as reduce start-and-stop traffic that results in more vehicle emissions. The following system efficiency strategies have been recommended for the GHG-reduction effort based on their ability to provide immediate benefits with a relatively high reduction rate:

Signal Timing. Signal timing involves calibrating signals in order to produce the optimal flow of traffic at intersections and through corridors. WSDOT currently operates 1,126 signals, and local jurisdictions operate the remainder. WSDOT currently re-calibrates signals regularly, but with additional funding, would be able to match the newest traffic patterns more frequently on key corridors. A recent study done by the WSDOT Environmental Office found that the re-timing of 347 signals in our most congested region would result in an annual decrease of 57,420 metric tons of CO_2 (Leth and Sexton, 2009).
There are 6,700 total traffic signals in Washington State; of these:

- 931 are WSDOT owned and operated
- 106 are owned by WSDOT and operated by others
- 195 are owned by others and operated by WSDOT

Incident Response (IR). Incident response drivers respond to the scene of disabled vehicles and collisions and remove those blockages from the road, allowing traffic to flow freely. WSDOT already has approximately 55 IR vehicles around the state. With additional funding for GHG-reduction, WSDOT would be able to concentrate more IR teams in congested areas, allowing traffic to flow more smoothly and enabling the system to run more efficiently.

Ramp Metering. Ramp meters control the rate at which cars enter the mainline, which results in a more smooth-flowing mainline. WSDOT has approximately 140 metered ramps around the state. According to a 2002 Minnesota study in which the city turned off all 420 Twin City ramp meters for approximately a month, "Ramp metering results in a net annual savings of 1,160 tons of emissions" (Twin Cities Metro Area Ramp Meter Study , Appendix D, p. 1-1 and 4-4, 2002). Strategically adding ramp meters to key highway high volume on-ramps during congested times will result in higher speeds on mainlines, and more GHG-reduction.

Traveler information and funding for TMC operations. Traveler information allows travelers to make the best decisions regarding their trip: informed choices about when to leave, what route to take, and what mode to take to ensure the smoothest possible trip. WSDOT currently hosts a website, a 5-1-1 phone line, and cellular phone applications, among several other sources of traveler information. Expanded TMC operations would allow WSDOT to better manage new equipment added to the system. These strategies would work best combined with signal timing, incident response, and/or ramp metering.

Active Traffic Management. Active traffic management (ATM) involves the use of technology to harmonize speed, warn drivers of back-ups ahead, close and open lanes, and provide for dynamic re-routing.

ATM will be added to parts of I-5, I-90, and SR 520 over the next two years. Reductions to GHG stem from reducing start and stop traffic from congestion.

Roundabouts. The use of roundabouts to replace signals at selected intersections aid in directing traffic flow, often providing a congestion reduction benefit. There are approximately 47 roundabouts currently on the state highway system, with many more on local roads. Roundabouts frequently reduce the need to come to a complete halt, thus reducing the acceleration events that produce higher emissions. A Swedish study calculated that a roundabout put in place of a signalized intersection resulted in an average decrease of 29 percent in CO emissions and 21 percent in NOx emissions (Varhelyi 2002). Another study found a 30 percent decrease in fuel consumption at a roundabout intersection compared to a signalized one (Niittymaki 1999).

Eco-Driving. Eco-Driving involves training people to drive in ways that minimize emissions, for instance, by accelerating gently and by maintaining speeds in the ideal range. This strategy would most likely benefit from leadership by a non-governmental advocacy group.

See Figure H-1 below for more detail on all strategies considered, and the prioritization, cost, and implementation time frame for each strategy.

What sort of impact will system efficiency strategies have on GHG emissions?

We have chosen a conservative estimate one percent for the impact to GHG emissions in the 2050 goal. There are many limitations that affect this estimate (Figure H-1).

The first and most important limitation is that this is an under-researched area with a great need for additional data. When studies of system efficiency and GHG reductions do exist, they often focus on individual locations; for example, the installation of one new ramp meter, or the effects of a single retimed signal. None of these studies consider the impacts to the full transportation system. It is challenging to extrapolate from an individual study to a system-wide improvement. Additionally, no two roadways or networks work exactly alike; it can be difficult to extrapolate from a study to a real-world implementation at a particular intersection or on a particular highway. Despite these issues, WSDOT is confident that targeting strategies to areas that have the highest potential return in reduced GHG emissions will be effective.

Secondly, the only report that has truly attempted a system-wide analysis of system efficiency measures, *Moving Cooler*, has pegged it as a very low contributor to reduction. Often individual strategies such as ramp metering are identified as providing a less than 0.1 percent effect. Based on our own experiences, we think that WSDOT can do better than that, and are still investigating additional resources for system-wide estimations. In addition, the modeling in *Moving Cooler* analyzed national GHG emissions; we're still investigating the degree to which these national assumptions are applicable in Washington. We do feel that, with targeted investments throughout the roadway system, we can achieve a greater impact than *Moving Cooler* estimates.

We have also chosen to not put forward one system-efficiency strategy: we did not suggest reducing the speed limit to 55 or 60 mph because it would be difficult to enforce, and believe that it would cause a speed differential on highways that may reduce safety.

Since most of these GHG-reduction strategies are based on congestion management, they will be most effective in the urban areas where congestion occurs regularly. However, two major strategies signal timing and roundabouts, will be effective in rural areas as well. Those strategies are designed to minimize any type of stopping event, regardless of whether there is congestion or not and therefore will be effective on rural and other types of low-traffic-volume roads.

Finally, the interaction of other societal and commercial forces can change the effect that system efficiency strategies have over time. As the vehicle fleet changes over to low- or no-emission vehicles, the effect system efficiency strategies will decrease. However, as population increases over the next 40 years, these strategies will still have a role to play in managing traffic, and with it, GHG emissions.

System efficiency strategies are practical and proven strategies that can be implemented quickly and easily. WSDOT and local governments have control over their deployment and do not face major policy or technological hurdles to implementation. The only barrier to further reducing GHG emissions using system efficiency strategies is funding for those strategies.

Figure H-1: System Efficiency Strategies for Transportation-Sector Greenhouse Gas Reductions

In Order of Proposed Priority

Strategy [a]	Cost [b]	Effective in rural areas?	Effective with other strategies?	Notes	Time-frame [c]
Signal timing	Medium	Yes	Yes; TMCs, traveler info	WSDOT Environmental Office study estimates show a larger potential for reduction than the amount noted in Moving Cooler.	Short
Incident response/ management	Low	No	Yes; TMCs, traveler info, ATM	Study estimates show a larger potential for reduction than the amount noted in Moving Cooler.	Short
ITS: Ramp-metering	Medium	No	Yes; TMCs, traveler info	Study estimates show a larger potential for reduction than the amount noted in Moving Cooler.	Short
Roundabouts	Low (per roundab out)	Yes	No, generally		Short
HOV Lanes and Direct Access Ramps	High	No	Yes. Ramp metering, TMCs, traveler info, Incident response.		Long, to build out system

[a] **Strategies we are not considering: Green Lanes, Truck-transit only lanes, Limited Access Highways, Express Lanes, Ramp Bypass lanes (all very high cost)**
[b] **Low: <$10 million; Medium: <$100 million; High: >$100 million**
[c] **Short: <5 years ; Medium: 5-10 years; Long: > 10 years**

Strategy [a]	Cost [b]	Effective in rural areas?	Effective with other strategies?	Notes	Time-frame [c]
Active Traffic Management, speed harmonization, Lane control, dynamic re-routing	Medium	No	Yes; Incident response, TMC	I-5, I-90, and SR 520 are all funded for ATM. However, our efforts are not perfectly comparable with similar efforts in Minnesota and the U.K., so we cannot yet evaluate this. Robust evaluation is planned for these efforts and within a couple of years we will have more data.	Short
Traveler Information: 5-1-1, Highway Advisory Radio (HAR), traffic cameras, Variable Message Signs (VMS)	Medium	Yes	Yes; TMCs, incident response, ramp metering, traffic signals	Good traveler information will allow drivers to make informed decisions to avoid congestion and therefore reduce GHG emissions.	Short
IntelliDrive	High	Yes	Yes	Federal government and private sector are driving this effort. WSDOT will need to make sure that our state's ITS equipment can communicate with vehicles in order to get the most GHG-reduction possible.	Long

[a] Strategies we are not considering: Green Lanes, Truck-transit only lanes, Limited Access Highways, Express Lanes, Ramp Bypass lanes (all very high cost)
[b] Low: <$10 million; Medium: <$100 million; High: >$100 million
[c] Short: <5 years ; Medium: 5-10 years; Long: > 10 years

Strategy [a]	Cost [b]	Effective in rural areas?	Effective with other strategies?	Notes	Time-frame [c]
Integrated Corridor Management	Medium	No	Yes		Short
Eco-driving	Low	Yes		This strategy would most likely benefit from leadership by a non-governmental advocacy group.	Short
Road Weather Management	Low	Yes	traveler information	This might not be effective in Washington based on the nature of our weather and congestion patterns (i.e. heavily-congested areas don't get snow very often in Washington)	Short
Lower speed limit	Low	Yes		Reducing and strictly enforcing speed limit. Is this safe? Does WSP have the resources to enforce it? And, how will changes in car technology raise the most-efficient speeds of vehicles?	Short

[a] Strategies we are not considering: Green Lanes, Truck-transit only lanes, Limited Access Highways, Express Lanes, Ramp Bypass lanes (all very high cost)
[b] Low: <$10 million; Medium: <$100 million; High: >$100 million
[c] Short: <5 years ; Medium: 5-10 years; Long: > 10 years

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Appendix I

Greenhouse Gas Emissions Analysis

Greenhouse Gas Emissions Analysis

Contents

Figures

Introduction

WSDOT analyzed greenhouse gas (GHG) emissions to improve understanding of the likely effects of multiple strategies for reducing on-road transportation GHG emissions. This analysis examines likely emission levels over time given various vehicle miles travelled (VMT) reduction assumptions coupled with fuel type and vehicle efficiency assumptions. The scenarios presented here are meant to be illustrative and inform the dialogue on how best to reduce on-road GHG emissions in Washington state. They are not recommendations.

While these analyses were performed with the best information available at this time, any attempt to predict travel demand, vehicle technology, or economic factors out to 2050 is highly uncertain. These calculations are one assessment of a possible future based on the information currently available. Significant differences could result from unanticipated economic conditions, technology breakthroughs, or unforeseen political or regulatory events.

Overview

Four scenarios were analyzed to better understand the contributions of the four major elements that effect on-road transportation GHG emissions in Washington state. Each scenario consists of a package of vehicle and fuel strategies, a bundle of VMT strategies, and assumptions regarding system efficiency improvements.
Before considering individual scenarios a brief discussion provides a common understanding of:

- VMT benchmarks
- VMT forecasting and trends
- Contributions of light- and heavy-duty vehicles to statewide emissions and VMT

A description of historical, existing, and potential future Corporate Average Fuel Economy (CAFE) standards is provided to compare the vehicle and fuel assumptions included in the scenarios evaluated. Finally, the overview concludes with an explanation of miles per gallon gasoline/diesel equivalent as it is used here to compare vehicle efficiency and fuel types between scenarios.

VMT Benchmarks

Washington state has set VMT benchmarks in statute. The benchmarks are percentage reductions based off a 2020 VMT baseline of 75 billion miles. To establish the benchmarks as mile quantities (instead of percentage reductions) 75 billion miles was divided by the population forecast for 2020. Population data for 2007 (prepared by the Washington State Office of Financial Management) is used in Figure I-1 below since it was forecast available at the time the law was written.

These benchmark values can then be compared to any historical year's per capita VMT to determine percentage reductions from that year. Several example years are provided in Figure I-1, along with the benchmark values themselves.

Figure I- 1 – Statewide VMT Reduction Benchmarks and Comparisons to Recent Years

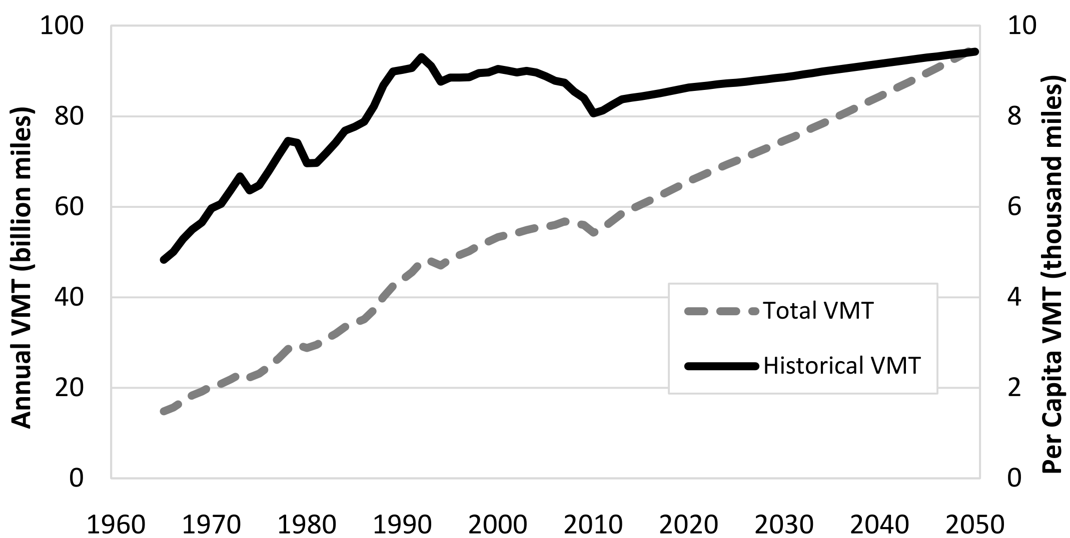
Year	Reduction Percentage	Benchmarks	2000 LD Per Capita	2005 LD Per Capita	2009 LD Per Capita
2000	–	–	8,223	–	–
2005	–	–	–	7,907	–
2009	–	–	–	–	7,496
2020	18%	7,065	14.1%	10.7%	5.8%
2035	30%	6,031	26.7%	23.7%	19.5%
2050	50%	4,308	47.6%	45.5%	42.5%

Source: Reduction percentages from RCW 47.01.440; Population from Washington State Office of Financial Management

VMT Forecast and Recent Trends

Figure I-2 shows the historical and forecast per capita and total VMT from 1965 to 2050. The steady increase from the mid-1960s to the early 1990s is commonly attributed to more people moving to the suburbs, an increasing number of women in the workforce, and increasing affluence i.e., discretionary time and income.

Figure I-2 – Per Capita and Total VMT



Source: Washington State Department of Transportation (population numbers from Washington State Office of Financial Management)

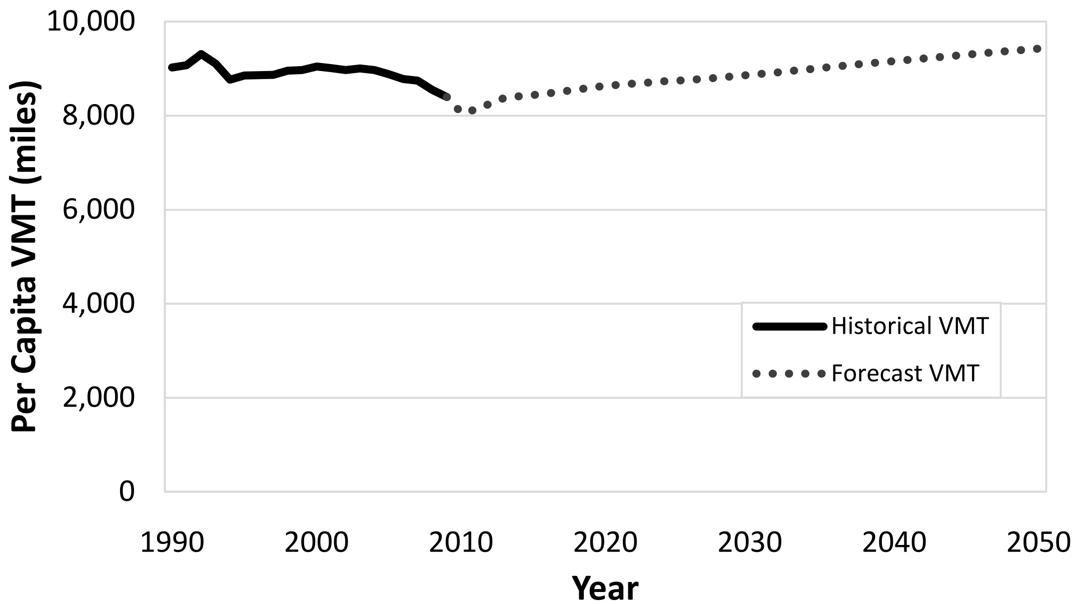
VMT Forecast

The GHG analyses presented in this report use the WSDOT June 2010 as the baseline. This forecast is the first official forecast using the new WSDOT VMT-specific model. For more information on this model and its development, see Appendix E.

Because the official forecast only goes to 2030, for the purposes of this analysis, the forecast extended to 2050 based on rates similar to the last few years of the official forecast:

- Employment growing at 1.1% per year.
- Vehicle registrations increasing at a rate of 110,000 per year.
- Gasoline prices rising each year by $0.08 per gallon, ending at $6.52 in 2050.

Figure I-3 – Per Capita VMT Trends



Source: Washington State Department of Transportation (population numbers from Washington State Office of Financial Management)

Some have questioned the accuracy of the VMT model out to 2050; however, at this time, it is the best indicator available of likely future VMT based on existing trends continuing. If the drivers of VMT change or underlying trends shift, future VMT could vary from the forecast. In particular, questions have been raised about results of the model because it predicts increasing per capita VMT. As both Figures I-2 and I-3 show, over the last decade, per capita VMT has leveled off or declined. Some of the recent decline has been attributed to the current economic downturn, but as the Figure I-4 shows, the trend began in the 1990's.

WSDOT will update the VMT forecast annually. Over time, as travel patterns shift, the VMT forecast will shift as well.

During the VMT model development, a truncated model beginning in 1990 was evaluated to consider the recent flattening of the per capita VMT trend. Currently, the truncated model has only 18 observations which is fewer than is advisable for forecasting models. However, if the flat VMT trend continues, this issue may be re-visited and the forecast may then predict a lower future VMT.

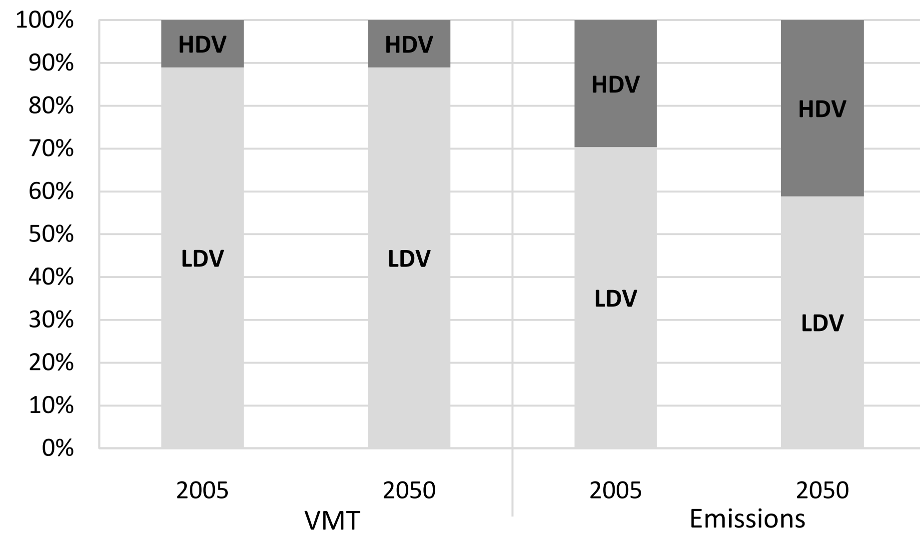
Also noteworthy, while per capita VMT is forecast to increase over the coming years, the primary driver behind the increase in total VMT is increasing population.

Light and Heavy Duty VMT and Greenhouse Gas Emission Contributions

The GHG reduction goals apply to all emission across the state with no exclusions; however, the VMT reduction benchmarks apply only to light duty vehicles. To get a better understanding of the relative contributions of both light- and heavy-duty vehicles to on-road greenhouse gas emissions, their VMT and greenhouse gas emission contributions are compared in Figure I-4.

While the relative contributions of both vehicle classes towards VMT are assumed to remain the same between now and 2050 in the baseline scenario, the portion of emissions from heavy duty vehicles is expected to increase. Vehicle efficiency and fuel carbon content reductions from light-duty are expected to improve due to existing and anticipated standards. However, standards for heavier vehicles are not yet available.

Figure I-4 – Light and Heavy Duty Baseline VMT and GHG Contributions

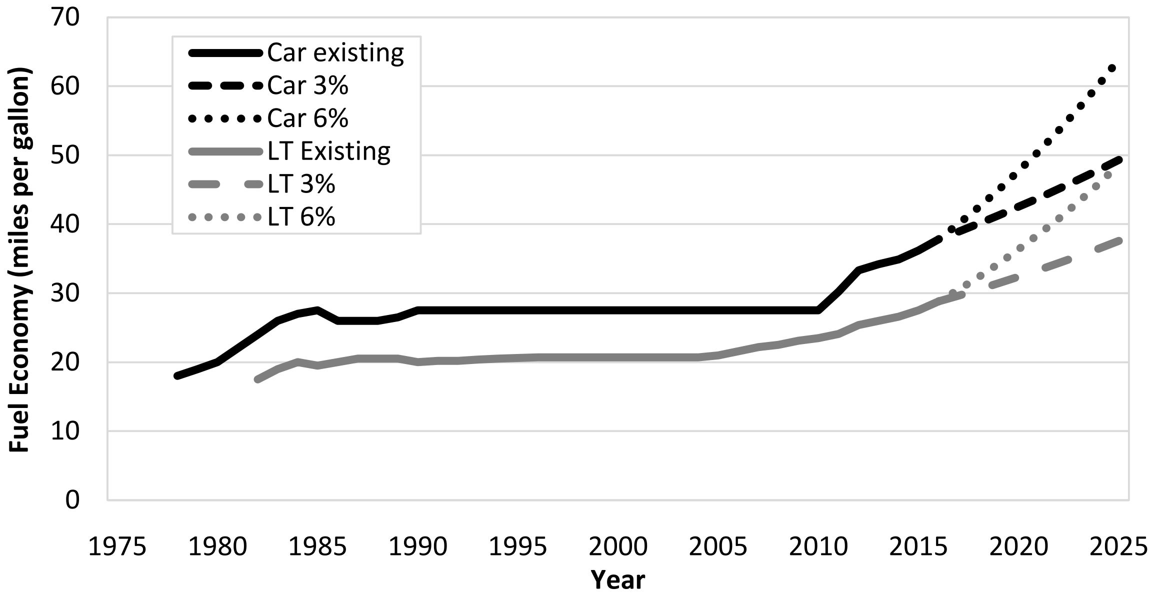


Source: Washington State Department of Transportation (emissions from VISION Model)

CAFE Standards

On September 30, 2010, the Environmental Protection Agency (EPA) and National Highway Traffic Safety Administration (NHTSA) released a Notice of Intent to establish vehicle fuel efficiency and GHG emission standards for light-duty vehicles for 2017 to 2025. The agencies announced that they are considering annual increases in fuel efficiency in the range of 3 to 6 percent. Figure I-5 shows the historical and existing standards (solid lines) and the range of potential future standards (dotted and dashed lines). The final rule is expected by July 31, 2012.

Figure I- 5 – Passenger Car and Light Truck CAFE Standards



Source: *Transportation Energy Data Book*. Oak Ridge National Laboratory and Center for Transportation Analysis. Edition 29. June 30, 2010.

In addition to extending the CAFE standards for light-duty vehicles, President Obama's instructions to the EPA and NHTSA included direction to establish standards for medium- and heavy-duty vehicles for 2014 to 2018. These standards will be the first regulating the fuel efficiency of these vehicle classes. A number of groups have called for 25-35 percent increases in fuel economy for these vehicles. These groups believe improvements in this range will be achievable with existing technology, such as improved aerodynamics, increased engine efficiency, updated transmissions, and weight reductions, among others.[18]

Since this analysis, EPA and NHTSA have announced that they are working on the medium- and heavy-duty vehicle fuel efficiency standards. The standards will cover model years 2014 to 2018 and are expected to reduce GHG emissions by up to 20 percent in 2018, depending on vehicle type.[19]

[18] Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles. Committee to Assess Fuel Economy Technologies for Medium- and Heavy-Duty Vehicles. National Research Council. Transportation Research Board. http://www.nap.edu/catalog/12845.html, accessed on 10/14/2010.

[19] Administration Proposes 20 Percent Cut in Fuel Use, Emissions for Heavy-Duty Trucks. AASHTO Climate Change Weekly Briefing, Volume 1, Issue No 35, October 28, 2010.

Miles per gallon equivalent (mpgge/mpgde)

To get a better sense of the magnitude of vehicle and fuel improvements evaluated for this report, average on-road fleet fuel efficiency is presented in terms of mile per gallon gasoline/diesel equivalents (mpgge/mpgde) based on GHGs emitted. To calculate this value, total GHG emissions were divided by total VMT to determine grams of CO_2e per mile. Light duty and medium/heavy duty vehicle classes were calculated separately. These GHG efficiency values were then converted to equivalent fuel economies using 8.81 kg CO_2e/gallon gasoline and 10.15 kg CO_2e/gallon diesel and a factor of 1.05 to include non-CO_2 GHGs.

Scenario Inputs

In order to understand the effects of multiple strategies on the state's on-road greenhouse gas emissions, four scenarios of vehicle and fuel strategies, VMT reductions, and system efficiency improvements were evaluated. To evaluate the scenarios, annual VMT values for both light- and heavy-duty vehicles were input into the VISION model that Ecology's consultant had modified for Washington state as part of the their work on the Low Carbon Fuel Standard (LCFS). Vehicle and fuel inputs were adjusted within the model and the VISION results were adjusted "off model" to account for system efficiency improvements.

An overview of the scenarios evaluated is provided in Figure I-6. Figure I-11 details the inputs for each scenario.

Figure I-6 – Scenario Overview

Scenario	Vehicles and Fuels	VMT	System Efficiency
Baseline	Ecology's Low case (45 mpgge in 2050)[20]	WSDOT June 2010 forecast (8,350 mi/person in 2050)	Nothing beyond projects currently programmed
Mid	Ecology's Mid/Most Likely case (49 mpgge in 2050)	Low bundle, 10% below forecast in 2050 (7,550 mi/person in 2050)	1% GHG reduction from additional improvements
High	Ecology's High/Aggressive case (66 mpgge in 2050)	High bundle, 28% below forecast in 2050 (6,010 mi/person in 2050)	1% GHG reduction from additional improvements
High Extended	Ecology's High/Aggressive case + fuel economy improvements beyond 2025 (69 mpgge in 2050)	High bundle, 28 % below forecast in 2050 (6,010 mi/person in 2050)	1% GHG reduction from additional improvements

Vehicles and Fuels

The Department of Ecology developed three scenarios of vehicle and fuel inputs as part of their evaluation of a low carbon fuel standard (LCFS). These three scenarios represent changes in the vehicle fleet and fuels that Ecology's research indicates are achievable. Because these scenarios come out of Ecology's work on the LCFS, the improvements remain constant after 2023. To get a better understanding of potential longer-term vehicle and fuel improvements, WSDOT added a fourth scenario:

- Low/Business as Usual
- Medium/Likely
- High/Aggressive
- High Extended (added by WSDOT)

All modeling results out to 2050 remain highly uncertain.

[20] Miles per gallon gasoline equivalent is used here to represent the carbon efficiency of the vehicles in terms most people are more familiar with.

VMT Reductions

WSDOT staff researched and prepared two VMT bundles for inclusion in this analysis:

- The Low bundle has moderate implementation costs, is relatively non-controversial, and is expected to provide about a 10% reduction in light-duty VMT over baseline values in 2050.
- The High VMT bundle is anticipated to provide about a 28% reduction over baseline light-duty VMT in 2050. This bundle builds on the Low bundle with additional programs and projects intended to shift personal travel from the private automobile to alternative modes and fund the implementation and operation of alternate modes.

See Appendix F for a list of the strategies included in each bundle and additional detail on the development of the VMT bundles.

System Efficiency Improvements

System efficiency improvements were applied outside the VISION model to the final results. A one percent reduction in statewide GHG reductions was assumed to be provided by additional system efficiency strategies. For additional information on these strategies, please refer to Appendix H.

Results

Scenario Analysis of Greenhouse Gas Emissions

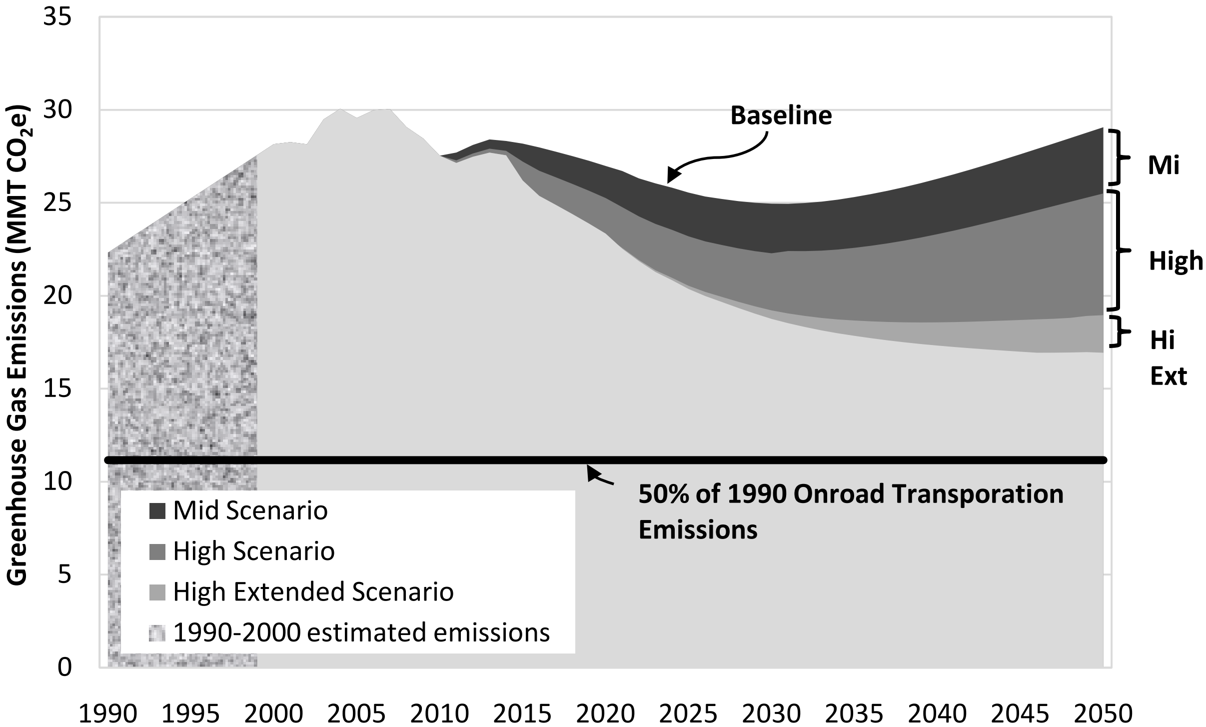
The expected GHG from the four scenarios are shown in Figure I-7. For illustrative purposes only, Figure I- 7 includes a line indicating 50 percent of the on-road transportation's 1990 emissions. It is important to note that statewide GHG reduction goals apply to all sectors as a whole, not just transportation. [21]

The shaded area in the chart indicates emissions estimated; the model used for this analysis does not include the years 1990 to 1999.

The High Extended scenario's reductions shown in this chart correspond to roughly a ten percent reduction in total state emissions in 2050. The scenario analysis suggests that actively pursuing each and every GHG reduction strategy from transportation will be critical to significantly reduce the state's emissions. There is no silver bullet.

[21] See Technical Appendix C: Revised Code of Washington 70.235.020

Figure I- 7 – On-Road Greenhouse Gas Emissions



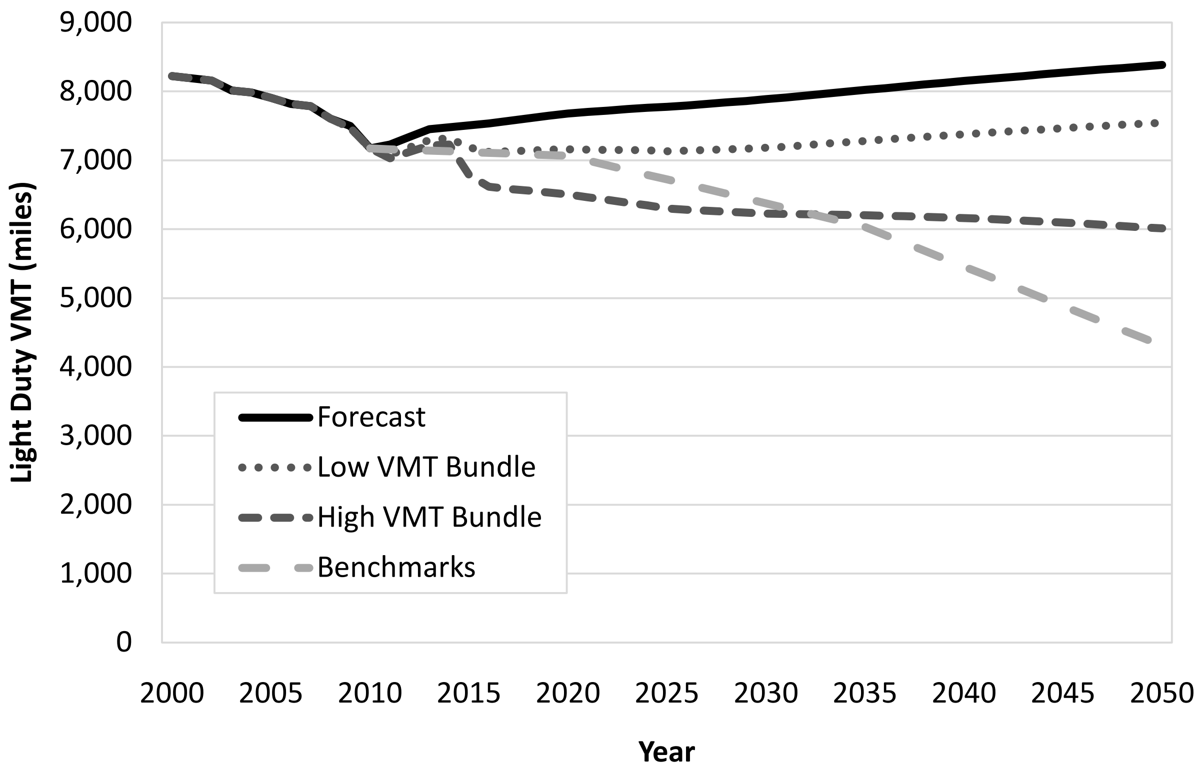
Source: VISION Model

WSDOT's analysis suggests that implementing combinations of aggressive transportation strategies could achieve roughly a ten percent reduction in total state GHG emissions compared to 2050 baseline. Implementing many of these strategies would require changes in policy, funding, and authority, and also assumes ambitious improvements in vehicles and fuels. WSDOT did not assess the political or financial feasibility of implementing the strategies.

Light Duty VMT Reductions

Figure I-8 shows the various levels of per capita light-duty VMT reductions that each of the scenarios uses. The Low and High bundles reach 10 and 28 percent reductions in 2050 from the future year baseline, respectively.

Figure I-8 – Scenario Per Capita Light-Duty VMT



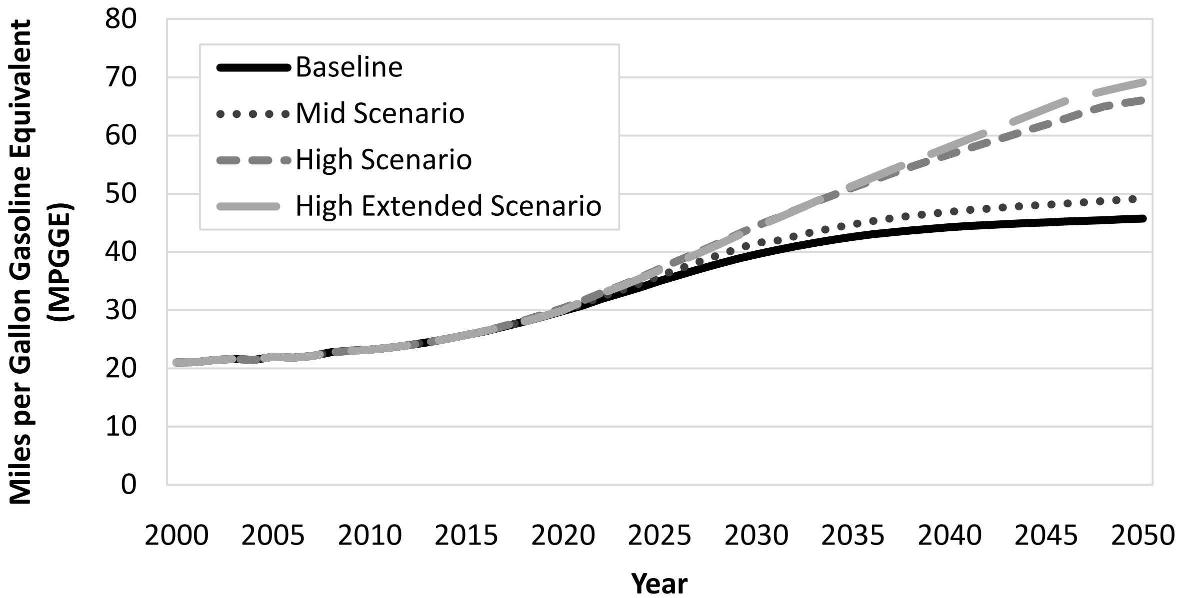
Source: Washington State Department of Transportation

Vehicle Fuel Efficiency

Several different vehicle and fuel scenarios were evaluated. Fleet average vehicle efficiency[22] was calculated as grams CO_2e per mile and converted to miles per gallon for ease of comparison. Alternatives for both the light- and heavy-duty vehicles are shown in Figures I-9 and I-10.

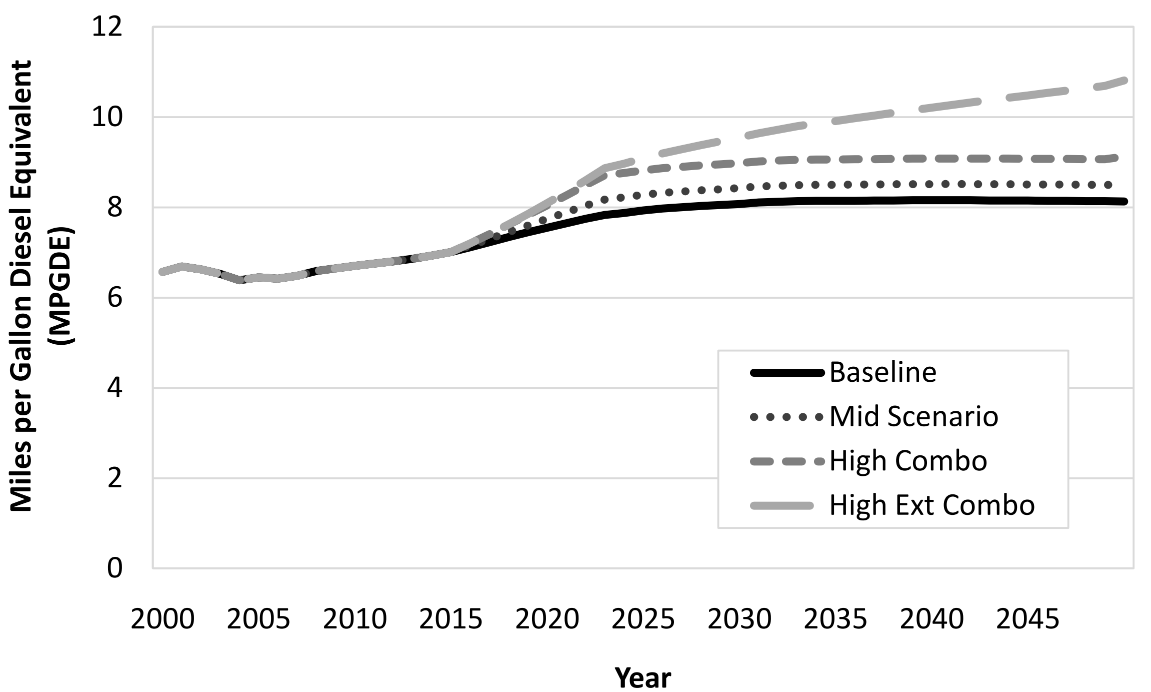
[22] Fleet average fuel efficiency is the average of all cars currently being driven. This is lower than the CAFE standards set by NHTSA for new cars. As older cars are removed from the fleet and newer cars replace them, the overall fleet average will increase.

Figure I-9 – Scenario Light-Duty Fuel Economy



Source: VISION Model

Figure I-10 – Scenario Heavy-Duty Vehicle Efficiency



Source: VISION Model

Input Tables

Figure I-11 – On-Road Vehicle and Fuel Assumptions

Parameter	Base	Mid	High	High Extended
Electric Vehicle Sales	2X Current EIA projection	4X Current EIA projection	8X Current EIA projection	8X Current EIA projection
EV:PHEV split	1 to 6	1 to 6	1 to 6	1 to 6
Ethanol	15% blend beginning in 2015	RFS2 proportionate share (375 million gallons by 2022)	RFS2 proportionate share (375 million gallons by 2022)	RFS2 proportionate share (375 million gallons by 2022)
FFV Miles on E85		Reaches a maximum of 25% in 2040	• By 2035 26% of FFV miles on E85 • By 2050, 45% of FFV miles on E85	• By 2035 65% of FFV miles on E85 • By 2046, 100% of FFV miles on E85
Biodiesel	B5 blend in 2022	B10 blend in 2022	B17 Blend in 2023 (LCFS high scenario)	• B17 Blend in 2023 (LCFS high scenario)
Light Duty Fuel Efficiency	2017-2025 fuel efficiency ↑2.5% per year	2017-2025 fuel efficiency ↑2.5% per year	2017-2025 fuel efficiency ↑2.5% per year	• 2017-2025 fuel efficiency ↑ 2.5% per year • From 2026-2050 ↑by 1% per year
2050 LD Ave. Efficiency[23]	202 g/mile (46 mpgge)	188 g/mile (49 mpgge)	140 g/mile (66 mpgge)	134 g/mile (69 mpgge)
Mid/Heavy Duty Fuel Efficiency	EIA estimates	EIA estimates	EIA estimates	• 2017-2025 ↑ 10% • 2026-2050 ↑ 0.5% per year
2050 Mid/Heavy Duty Average Efficiency[24]	1,134 g/mile (8 mpgde)	1,089 g/mile (8 mpgde)	1,014 g/mile (9 mpgde)	855 g/mile (11 mpgde)
Electricity Emission Factors 2010 to 2020	To 2020, 2005 inventory emissions rate; 2020 to 2050 assume currently law renewable portfolio standard, conservation, energy codes, etc. are met.			

Table Notes:
EIA = Energy Information Administration
EV = electric vehicle
FFV = flex fuel vehicles
LCFS = low carbon fuel standard
mpgge = miles per gallon gasoline equivalent
mpgde = miles per gallon diesel equivalent
PHEV = plug-in hybrid electric vehicle
RFS2 = Renewable Portfolio Standard 2

[23] Vehicle efficiency is provided in both grams of CO_2e per mile and the equivalent miles per gallon that would produce that level of GHG emissions.
[24] Although mid/heavy duty vehicle improvements do not change between the base, mid, and high scenarios, their carbon efficiency is affected by the carbon content of the fuel supply.

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Appendix J

Abbreviations

Abbreviations

AADT	Annual average daily traffic
AIC	Akaike information criterion
AR	Autoregressive
ARMA	Autoregressive moving average
ATM	Active traffic management
AVMT	Annual vehicle miles traveled
AVS	Advanced vehicle systems
B10	Diesel blended with 10% biodiesel (blending values vary e.g. B20)
BRT	Bus rapid transit
CAFE	Corporate average fuel economy
CARB	California air resources board
CAT	Climate action team
CBD	Central business district
CMAQ	Congestion mitigation and air quality
CO2	Carbon dioxide
CO2e	Carbon dioxide equivalent
CRAB	County roads administration board
CTOD	Compact and transit oriented development
CTR	Commute trip reduction
CWPP	County wide planning policy
E85	Petroleum blended with 85% ethanol (blending values vary e.g., E10)
EO	Executive order
EIA	Energy information administration
EPA	Environmental protection agency
EV	Electric vehicle
FFV	Flex fuel vehicles
FHWA	Federal highway administration
GHG	Greenhouse gas
GMA	Growth management act
HAR	Highway advisory radio
HDV	Heavy duty vehicle
HERS	Highway economic requirement system
HOT	High occupancy toll
HOV	High occupancy vehicle
HPMS	Highway performance monitoring system

IR	Incident response
ITS	Intelligent transport system
LCFS	Low carbon fuel standard
LDV	Light duty vehicle
LOS	Level of service
LT	Light trucks
LUCC	Land use and climate change advisory committee
MA	Moving average
MPGGE	Miles per gallon gasoline equivalent
MPGDE	Miles per gallon diesel equivalent
MPO	Metropolitan planning organization
NEMS	National energy modeling system
NHS	National highway system
NHTSA	National highway traffic safety administration
OFM	Washington state office of financial management
PAYD	Pay as you drive
PERF	Planning environmental review fund
PHEV	Plug in hybrid vehicle
PSRC	Puget sound regional council
RCW	Revised code of Washington
RFS2	Renewable portfolio standard 2
RMSE	Root mean square error
RTPO	Regional transportation planning organization
SEPA	State environmental protection act
SIACF	Sample inverse autocorrelation function
TDO	Transportation data office
TDR	Transfer of development rights
TIWG	Transportation implementation working group
TMC	Travel management center
TOD	Transit oriented development
TRB	Transportation research board
TRFC	Transportation revenue forecast council
USGCRP	U.S. global change research program
USDOT	U.S. department of transportation
VMS	Variable message sign
VMT	Vehicle miles traveled

WA	Washington
WCI	Western climate initiative
WSDOT	Washington state department of transportation
WSP	Washington state patrol

Appendix K

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