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FINAL DRAFT

Background Report: The Status of Oregon Greenhouse Gas Emissions and Analysis

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Prepared for the
Metropolitan Planning Organization
Greenhouse Gas Emissions
Task Force

Prepared by the
Oregon Department of Transportation
Transportation Planning Analysis Unit

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Introduction

House Bill 2186 established a Metropolitan Planning Organization (MPO) Greenhouse Gas (GHG) Emissions Task Force. The charge to the Task Force is to recommend legislation to interim Legislative assembly committees to establish a process for adopting and implementing GHG emissions reductions plans, including a schedule for the planning process and an estimate of necessary funding. The focus is on reducing GHG emissions from light motor vehicles of 10,000 pounds or less and must consider contributions of improved vehicle technologies and fuels. The Task Force must complete its report and recommendations by January 1, 2010. This report was prepared to provide background information to help establish expectations for the GHG emissions reductions that can be achieved by 2035 through MPO planning actions.

Magnitudes of Transportation Emissions

Contributions of the Transportation Sector and Components to GHG Emissions

Light vehicle travel of metropolitan households accounts for about 11 percent of the greenhouse gas emissions of all Oregonians. Reducing the VMT of metropolitan households by 30 percent would reduce the state's GHG emissions by about 3 percent. (Section 2.2.1.)

The transportation sector accounts for about 34 percent of the GHG emissions of Oregonians. All of Oregon's light vehicle travel accounts for about 75 percent of transportation emissions or about 20 percent of total GHG emissions. Light vehicle travel of metropolitan area households accounts for 56 percent of the emissions of all light vehicle travel, or 11.2 percent of all GHG emissions. Portland metropolitan area households account for 65 percent of the metropolitan household light vehicle GHG emissions.

Contribution of Metropolitan Area Travel to Light Vehicle Travel

The effects of metropolitan travel and GHG emissions are not limited to metropolitan areas. For example, about 19 percent of metropolitan jobs are filled by workers who live outside of the metropolitan area where they work, but the GHG emissions from their commutes are about half the total. (Section 2.2.2.)

Unlike other pollutants, CO_2 (the principal GHG) has a life span in the atmosphere of hundreds of years. The effects build up rather than disperse over time because of its long life span. Its effects are global rather than local. Therefore, vehicle travel to or from metropolitan areas have as much adverse effect as vehicle travel occurring wholly within a metropolitan area.

Metropolitan area urban growth boundaries contain about 60 percent of the population of the state. There are three different perspectives for examining metropolitan area travel:

- Travel that occurs within a metropolitan area,
- Travel that is produced by a metropolitan area, and
- Travel that is attracted to a metropolitan area.

An analysis of GHG emissions from commuting shows that the quantity of GHG emissions from travel produced or attracted by metropolitan areas is sizable. Metropolitan residents who commute to locations outside the metropolitan area where they live produce 22 percent of the commute emissions of all metropolitan residents. Commuters who work at jobs in metropolitan areas but live outside the metropolitan area where they work produce almost half of the GHG emissions of commuters who work in metropolitan areas. For the Salem and Corvallis metropolitan areas, the emissions of external commuters make up more than half of the total work commute emissions - about two thirds for Salem and three quarters for Corvallis. External commuters produce disproportionate quantities of GHG emissions because their work trips are three to six times longer.

Analyzing the Effects of Actions to Reduce GHG Emissions

Factors Affecting GHG Emissions from the Transportation Sector

Four types of factors affect GHG emissions from the transportation sector: vehicle efficiency, fuel carbon intensity, transportation network efficiency, amount of vehicle travel. Substantial efforts in all four areas will be needed to reduce GHG emissions sufficiently. (Section 3.1)

Standards for new vehicle fuel efficiency in the U.S. lag substantially behind the standards for other modern industrial countries. The California “Pavley” standards, which Oregon has also adopted, are a significant improvement over federal standards, but are still significantly behind current European Union standards. The large unknown factor for vehicle efficiency is how quickly electric vehicles will replace internal combustion engine vehicles. Electric vehicles produce about a third of the GHG emissions of internal combustion engine vehicles because they are much more efficient at converting energy into motion.

Vehicle fuels produce varying amounts of energy for the amount of GHG produced. The carbon intensity of fuels is measured on a lifecycle basis, and includes the GHG emissions of fuel production and transportation as well as the GHG emissions from using the fuel. Renewable fuels (e.g. ethanol and biodiesel), depending on how they are produced, also have indirect land use effects but there is controversy about how indirect land use effects are calculated. Federal renewable fuels standards require increases in the proportion of the fuel mix that is to be renewable. The 2022 target is for renewables to be approximately equal to 20 percent of the projected gasoline consumption at the time.

Technological advancements are important for renewables to be a substantial share of transportation fuels.

Vehicle fuel efficiency varies with efficiency of the transportation network and operating speed. Efficiency falls off at high speeds greater than about 60 miles per hour (MPH) and at low speeds less than about 25 MPH. The response depends on the vehicle. The amount of vehicle acceleration, deceleration and idling that occurs also affects vehicle fuel efficiency. Actions that help smooth out traffic flow and keep speeds in the best range for fuel efficiency can improve overall fuel efficiency. However, increasing speeds can also increase travel distances and the net amount of GHG emissions.

For more than a decade, the rate of growth of vehicle miles traveled (VMT) in Oregon has been declining. Since 1995, per capita VMT in the Portland metropolitan area (including the portion of the urbanized area in Washington state), has declined and is substantially below the average for large metropolitan areas in the U.S. Per capita VMT on state highways has declined by about 8 percent from 1999 to 2007. The total amount of transportation fuels consumed annually has changed very little since 1999.

The amount of vehicle travel that occurs is a function of land use patterns, transportation services and infrastructure, pricing and demand management. Land use patterns affect how far people travel, how likely they are to own a car, and how likely they are to use their cars or travel by some other mode. The types of transportation infrastructure and services that are available affect the ways and distances that people travel. In general, there is more vehicle travel in metropolitan areas that have a greater freeway supply and less where the transit supply is greater. Prices have a significant effect on the amount that people use their cars. People drive less when it is more costly to do so. How the costs of driving are paid for also have an effect on the amount of driving. Costs that vary directly with the amount of travel have much more effect than lump-sum costs. Demand management actions can also have a significant effect on the amounts that people use their cars. Individualized marketing approaches are particularly successful at reducing household vehicle travel.

Economic Effects of Policies to Reduce Metropolitan VMT

It is possible to plan for and carry out policies to reduce metropolitan vehicle travel intensity without causing prosperity to decline. Differences in the transportation and land use system characteristics of metropolitan areas contribute significantly to differences in vehicle travel intensity. (Section 3.2)

There is a relationship between prosperity and vehicle travel intensity, but it is negative rather than positive. More prosperous metropolitan areas tend to generate less vehicle travel per dollar of income, but this general relationship explains only a small proportion of the differences among the vehicle travel intensities of metropolitan areas.

Metropolitan areas having very similar levels of prosperity have different vehicle travel intensity levels. For example, the Portland and Atlanta metropolitan areas have very similar levels of prosperity, but the Atlanta economy is over 40 percent more vehicle travel intensive than the Portland economy. Lower vehicle travel intensity can have ancillary benefits by reducing the leakage of money from the local economy.

Magnitudes of Reductions Necessary to Reduce GHG Emissions

Reducing on-road vehicle GHG emissions by 75 percent from 1990 levels would be equivalent to reducing Oregonian's per capita annual consumption of petroleum fuels from 567 gallons to 68 gallons. This will not be achievable without transformative changes in vehicle fleets and fuels such as electrification of the light vehicle fleet. Reducing light vehicle VMT will be necessary in order to accommodate transportation that will not be so easily transformed. (Section 3.3.)

The goals for GHG emissions reductions in Oregon Revised Statute 486A.205 are to reduce emissions in 2020 to be 10 percent below 1990 levels and to reduce emissions in 2050 to 75 percent below 1990 values. The statute does not establish a goal for 2035, but a straight-line interpolation yields a value of 42.5 percent below 1990 levels.

A simple, but revealing assessment of the implication of these goals for light and heavy vehicles can be done by analyzing the reduction in fuel consumption that would be necessary to meet these goals. If light and heavy vehicle travel increases according to projections in the Oregon Transportation Plan, per capita annual fuel use would need to decline from the 1990 level of 567 gallons per capita to 68 gallons per capita. If fuel economy improvements alone were to achieve this consumption level, light vehicle fuel economy would need to increase to about 66 MPG in 2035 and 185 MPG in 2050. Heavy vehicle fuel economy would need to increase to about 20 MPG in 2035 and 58 MPG in 2050.

Large improvements in light vehicle fuel efficiency are possible with a fleet composed of electric vehicles. Electric vehicles are much more efficient than internal combustion engine vehicles in converting energy into motion and they emit about a third of the GHG emissions. Larger reductions can be made by increasing the proportion of electricity generated by renewables. It is unlikely that the targets can be met without transitioning the light vehicle fleet to electric vehicles. If this conversion takes place over the next couple of vehicle generations, then it may be possible to use reductions in light vehicle VMT to offset heavy vehicle emissions. A 30 percent reduction in light vehicle VMT in metropolitan areas and a 10 percent reduction in non-metropolitan areas by 2050 would increase the effective allotment of fuel to heavy vehicles by 54 percent in 2035 and 86 percent in 2050. This would substantially lower the required efficiency gains for heavy trucks, but would still pose substantial problems for 2050.

Estimating the Effects of Proposed Policies on GHG Emissions

Estimating the effects of policies on GHG emissions will require the application of several different types of models. While past model development efforts in Oregon give the state a head start on doing the work, a substantial amount of work is required to

deploy and apply the models in all of the metropolitan areas in addition to doing larger scale regional and statewide modeling. The MPOs and ODOT are not adequately resourced to do this work. (Section 4.)

ODOT and the MPOs have the resources to conduct the travel demand modeling work needed to meet current requirements. However, GHG analysis will require several different models that will take additional knowledge, time and resources to deploy, maintain and apply. There are many factors and potential actions for mitigating GHG emissions from the transportation sector. The task of doing the analysis to support GHG mitigation planning is challenging. It requires analytical tools to evaluate the number of factors that affect GHG emissions and the interactions that occur between factors. For example, fuel prices affect where people live and work, where they travel, how they travel and what vehicles they own and use. Models are tools that allow a knowledgeable and experienced person to run virtual experiments to assess the possible effects of policy alternatives to assist decision-makers to develop and analyze the many options and opportunities for addressing GHG emissions.

There are tradeoffs to be made in any model between geographic scope and detail, the number of factors considered and the detail in which they are considered, the level of interactivity between factors, and the amount of time and effort required to model scenarios. No one model can do everything well. Analyzing GHG emissions from the transportation sector will require the application of the several models available to ODOT and Oregon MPOs and consultants. It takes several years to deploy a new model in a metropolitan area and many months to perform a modeling study.

Just as important as using the proper analytical tools for the appropriate level of detail is gathering data and setting up the model for the area being studied. Knowledgeable staff is needed to set up models, run them, and analyze the results. In addition, modeling at different geographic scales needs to be coordinated to ensure that the results are consistent. MPOs and ODOT are not currently staffed to do all of the work that is necessary.

1. Introduction

House Bill 2186 (HB2186) established a Metropolitan Planning Organization (MPO) Greenhouse Gas (GHG) Emissions Task Force. The charge of the Task Force is to:

- Study and evaluate the development of alternative land use and transportation scenarios for MPO areas to accommodate planned population and employment, while reducing GHG emissions from light motor vehicles (10,000 pounds or less) and evaluating reductions by 2035 to meet statutory emissions reductions. The Task Force must consider reductions in vehicle emissions likely to result by 2035 from the use of improved vehicle technologies and fuels.
- Evaluate and identify resources needed and impediments for implementing the land use and transportation scenarios.
- Recommend legislation to interim Legislative assembly committees to establish a process for adopting and implementing GHG emissions reductions plans, including a schedule for the planning process and an estimate of necessary funding.

The Task Force must complete its report and recommendations by January 1, 2010. Given the time line involved, it is likely that the intention of HB2186 is not to look at alternative land use and transportation scenarios in detail. Rather, the intention is to study the process for developing alternative land use and transportation scenarios by MPOs, to identify impediments to implementation, and to provide a structure and funding process to meet GHG emissions targets.

A number of complicated issues and uncertainties affect GHG emissions reductions and the targets that are set. These include:

- How are GHG and vehicle miles travelled (VMT) calculated and attributed to MPOs?
- What are the effects of population growth rate differences on GHG emissions reduction targets for MPOs?
- What is the range of possible vehicle and fuels technologies?
- What is the amount of change required to reduce GHG emissions?
- What tools are needed and what tools are available to estimate GHG emissions?

One of the first steps is to develop information to help establish expectations for the GHG emissions reductions that can be achieved by 2035 through MPO planning actions. The resources needed to develop regional transportation and land use scenarios will depend on the nature of the scenario planning requirements for MPOs.

1.1. Organization of Report

This report is prepared as background to support discussions and deliberations by the Task Force. The report includes the following sections:

- The Magnitude of Transportation Emissions – This includes a description of the proportions of GHG emissions generated by the transportation sector, by light vehicles, and by metropolitan area household travel. It also examines the relative amounts of metropolitan area GHG emissions resulting from intra-metropolitan travel and travel to and from metropolitan areas.

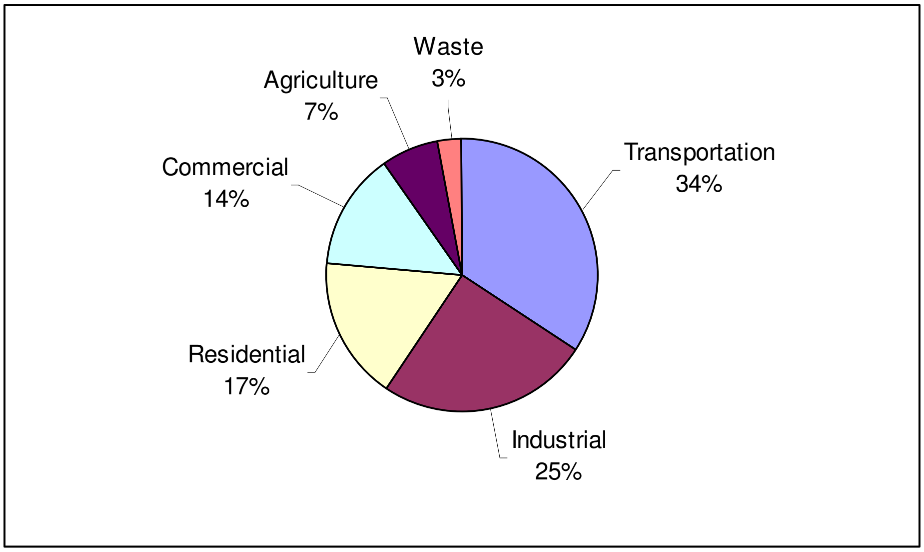
- Analyzing the Effects of Actions to Reduce GHG Emissions - This section identifies factors affecting GHG emissions from the transportation sector and types of policies that may influence those factors. It addresses the question of whether it is possible to reduce metropolitan area GHG emissions without adversely affecting prosperity. It describes the types of models and other tools available to evaluate the potential effects of policies and provides perspective on the magnitudes of change needed to achieve the GHG reductions and the potential role of transportation and land use policies in making the changes.
- Conclusions – This section summarizes the most significant findings presented in the document.

2. Magnitudes of Transportation Emissions

2.1. Contributions of the Transportation Sector and Components to GHG Emissions[1]

Gross total emissions from all sectors of the Oregon economy amount to about 69.9 million metric tons of carbon dioxide (CO_2) equivalent for the year 2005. Figure 1[2] shows the percent of total GHG emissions by major sector of Oregon's economy in 2005. This includes the emissions from Oregonians, regardless of where they occur. For example, the emissions from coal-fired power plants in other states that occur as a result of producing electricity consumed by Oregonians are included in this tabulation. The transportation sector accounts for about 34 percent of the GHG emissions.

Figure 1: Total GHG by Major Oregon Economic Sector



GHG emissions from on-road vehicles (cars, trucks, buses, etc.) account for about 80 percent of transportation sector emissions. Of these, light vehicles (those less than 10,000 pounds) account for 75 percent, as shown in Figure 2.

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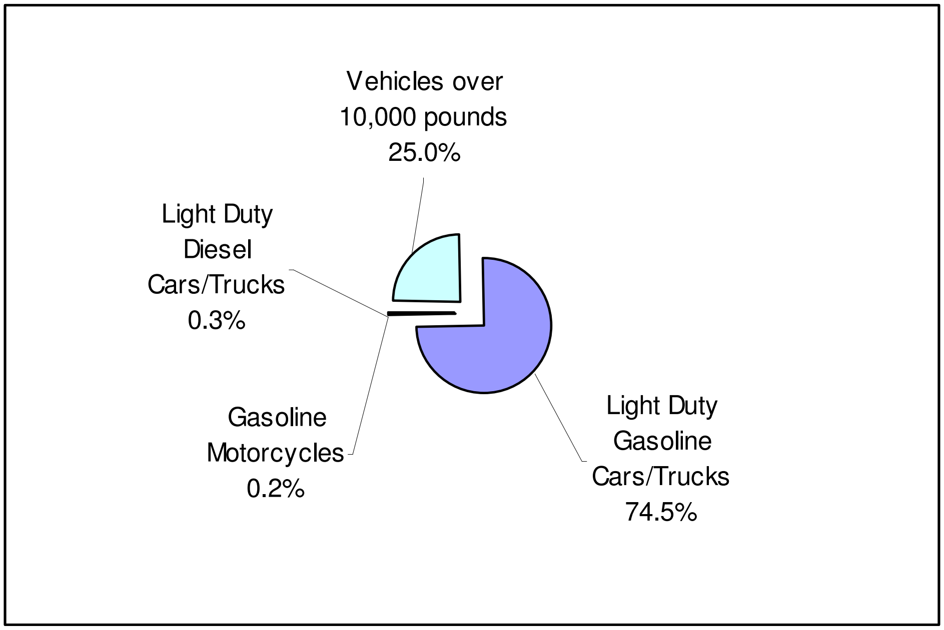
[1] Information in this section comes from several sources.
Proportions of GHG emissions by sector were estimated by the Oregon Department of Energy using the U.S. Environmental Protection Agency's State Inventory Tool.
http://www.deq.state.or.us/aq/climate/docs/inventoryReport.pdf
Proportions of transportation sector GHG emissions from light vehicles come from the Oregon Department of Environmental Quality AMEE database. These proportions were checked against national number reported in Transportation Research Board Special Report 290, *Potential Impacts of Climate Change on U.S. Transportation*, Committee on Climate Change and U.S. Transportation, National Research Council, Washington D.C., 2008, Table B-2.

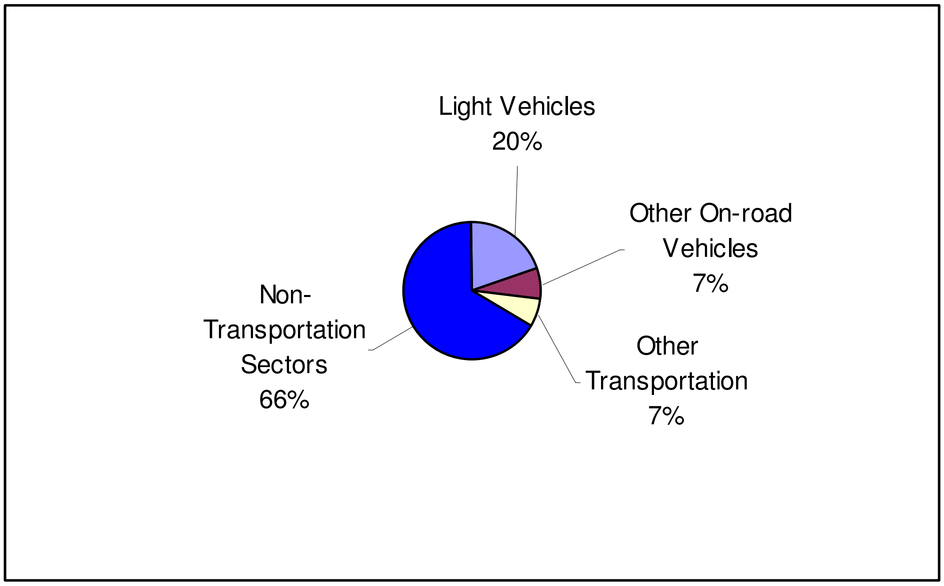
[2] For more detailed on emissions contributions of different sectors and modes, see the Appendix.

Figure 2: On-road Vehicle Contributions to CO_2 Emissions



Since they account for about 75 percent of CO_2 emissions for all on-road vehicles, light vehicles account for 60 percent of all transportation sector emissions and about 20.5 percent of all GHG emissions in Oregon (Figure 3).

Figure 3: Contribution of Transportation to Total Oregon GHG Emissions



2.2. Contribution of Metropolitan Area Travel to Light Vehicle Travel

2.2.1. Metropolitan Proportions of Light Vehicle Travel

ODOT developed the **Green**house Gas **S**tate **T**ransportation **E**missions **P**lanning model (GreenSTEP) to estimate GHG emissions from transportation sources and to estimate how those emissions would change in response to a variety of policy actions. While GreenSTEP was built to assist with forecasting future policy effects on vehicle travel and GHG emissions, it is also capable of being used to estimate present and past travel and emissions levels by county and development type (metropolitan, other urban, rural). Validation of the model included comparing VMT "backcasts" against other estimates of VMT. The results show that the model can do a reasonable job of producing estimates. The estimated proportions of GHG emissions occurring in metropolitan areas come from year 2000 estimates produced by GreenSTEP.

It is important to note that GreenSTEP estimates vehicle travel and the associated GHG emissions at the household level, rather than at the roadway level. In other words, the emissions reported for a particular county or metropolitan area represent the emissions of households who reside in the area, regardless of where they travel.

Metropolitan area urban growth boundaries contain about 60 percent of the population of the state. Households in metropolitan areas contribute an estimated 56 percent of the total household light vehicle GHG emissions of the state. Table 1, Figures 4, and 5 show the estimated split of these emissions among metropolitan areas.

Table 1: Estimated Proportions of Total Metropolitan Household Light Vehicle GHG Emissions by Metropolitan Area

Metropolitan Area	Percent of Metropolitan Area Total	Percent of State Total
Metro	65	36
Eugene-Springfield	11	6
Salem-Keizer	10	6
Rogue Valley	7	4
Bend	4	2
Corvallis	3	2
All	100	56

Figure 4: Total Metro Household Light Vehicle GHG Emissions by Metropolitan Area - Percent of Metropolitan Area Total

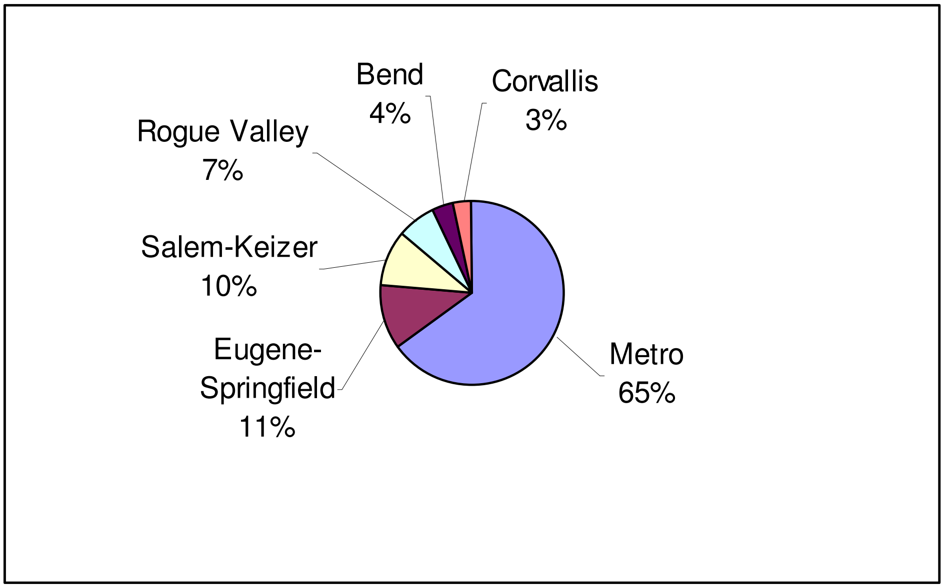
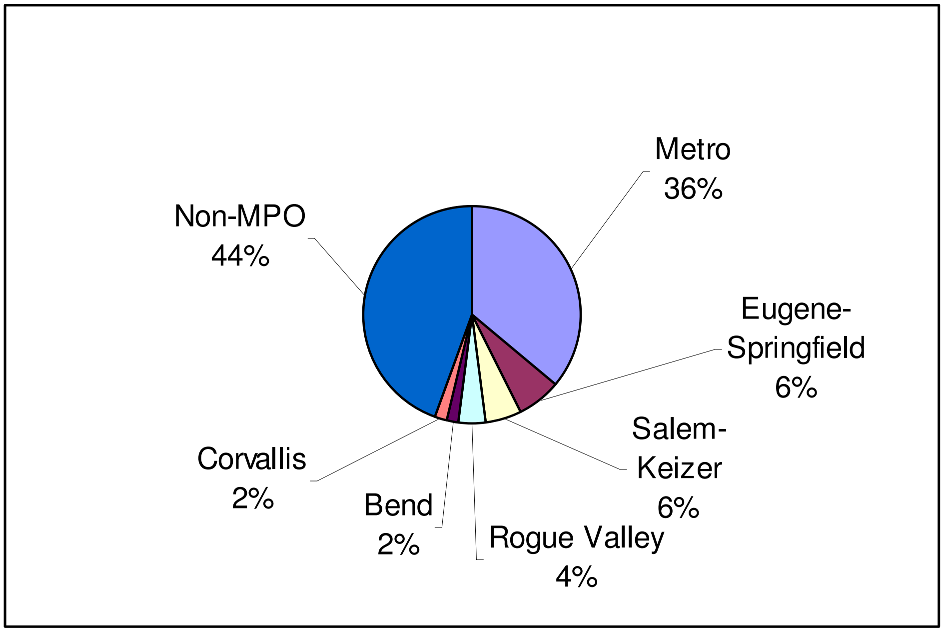


Figure 5: Total Metro Household Light Vehicle GHG Emissions by Metropolitan Area- Percent of State Total



Given that GHG emissions from light vehicles make up 20 percent of all GHG emissions from Oregonians, the emissions from the light vehicle travel of metropolitan households makes up 11.2 percent of all GHG emissions (0.2 * 0.56). If we assume, for the sake of understanding magnitudes, that metropolitan household VMT could be reduced by 30 percent, the net effect on total GHG emissions would be a 3.4 percent reduction in total GHG emissions (0.112 * 0.3).

2.2.2. Implications of Metropolitan Area Travel Definitions

The Oregon Transportation Planning Rule (TPR) addresses passenger vehicle travel on metropolitan roads for MPO planning. The TPR does not consider truck and other commercial VMT, and VMT from trips that do not have origins and destinations within the metropolitan area urban growth boundary. The TPR assumes that MPO policies have little effect on VMT other than passenger vehicle travel to and from places located within the metropolitan area.

The common practice for analyzing air pollutants from transportation sources in a metropolitan area is to evaluate pollution resulting from vehicle travel on the roads located within the air quality boundary for the metropolitan area. This practice makes sense for most air pollutants of concern, because these emissions have relatively short life spans in the atmosphere and they lose potency to cause adverse health consequences as they disperse. Therefore, the adverse effects of these pollutants are mainly experienced by people who live or work within the air quality boundary.

Unlike other pollutants, CO_2 (the principal GHG) has a life span in the atmosphere of hundreds of years. The effects build up rather than disperse over time because of its long life span. Its effects are global rather than local. Therefore, vehicle travel to or from metropolitan areas have as much adverse effect as vehicle travel occurring wholly within a metropolitan area.

The following information provides some perspective on the relative amounts of vehicle travel and GHG emissions resulting from work travel to and from Oregon's metropolitan areas[3], as compared to work travel occurring just within the metropolitan areas. The ODOT Transportation Planning Analysis Unit prepared estimates of work travel VMT and emissions from the year 2000 U.S. Census journey-to-work data at the Census tract level.[4] The Census reports the modes by which workers travel, which allows estimates to be made of work travel VMT and GHG emissions. This information is presented from the perspective of workers who live in a metropolitan area and from the perspective of workers who work in a metropolitan area.

Workers who live in a metropolitan area and where they go to work

On average, 93 percent of metropolitan area workers residing in Oregon's metropolitan areas work in the same metropolitan area where they reside (Figure 6). The percentages are higher in the Portland Metro and Rogue Valley metropolitan areas and lower in the Corvallis and Salem-Keizer metropolitan areas. Over 20 percent of workers who reside in the Salem-Keizer metropolitan area work outside of the metropolitan area.

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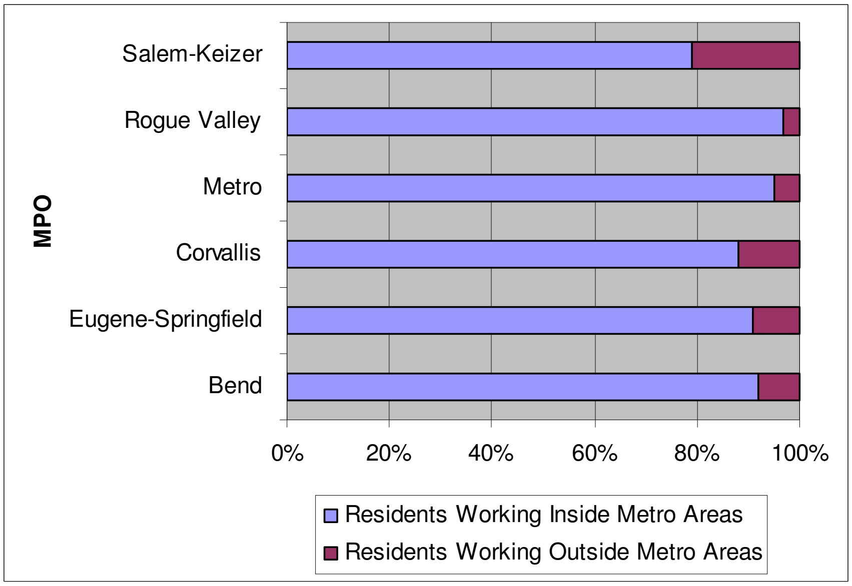
[3] Note that for the purposes of this analysis of commuting, metropolitan areas are defined by metropolitan area urban growth boundaries. Urbanized area boundaries and MPO planning boundaries can extend beyond urban growth boundaries. This is particularly important to note with respect to Vancouver, Washington and other areas in the vicinity. This analysis treats commuting to and from the Vancouver area as being outside of the Portland metropolitan area.

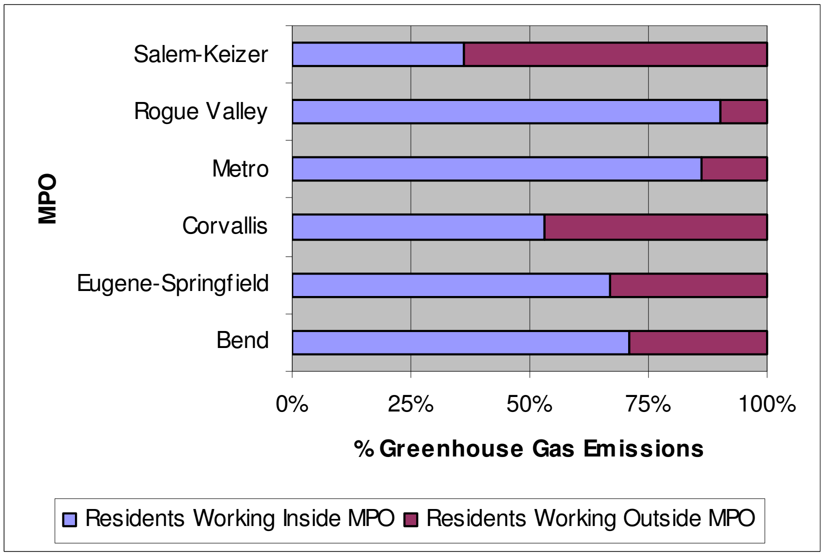
[4] Data and a description of methodology are available on request.

Figure 6: Percent MPO Resident Workers Working Inside and Outside of the Metropolitan Area Where They Live



Metropolitan workers traveling to work destinations located outside of the metropolitan area where they live emit a relatively higher percentage of GHG emissions. On average, the commutes of these workers account for 22 percent of the GHG emissions of workers residing within metropolitan areas. It is notable that the proportion of emissions from workers residing within but working outside the Corvallis metropolitan area is almost half of the total. For the Salem-Keizer metropolitan area, these workers contribute almost two-thirds of the total work commute emissions (Figure 7).

Figure 7: Percent GHG Emissions from MPO Resident Workers Working Inside and Outside of the Metropolitan Area Where They Live



Workers traveling to external workplaces cause a disproportionately large percentage of emissions because their work trips are about three to six times longer than the work trips of commuters who travel to internal workplaces (Figures 8 and 9).

Figure 8: Average Round-trip Commute Distance-Resident Workers Working Inside Their Residence Metropolitan Area

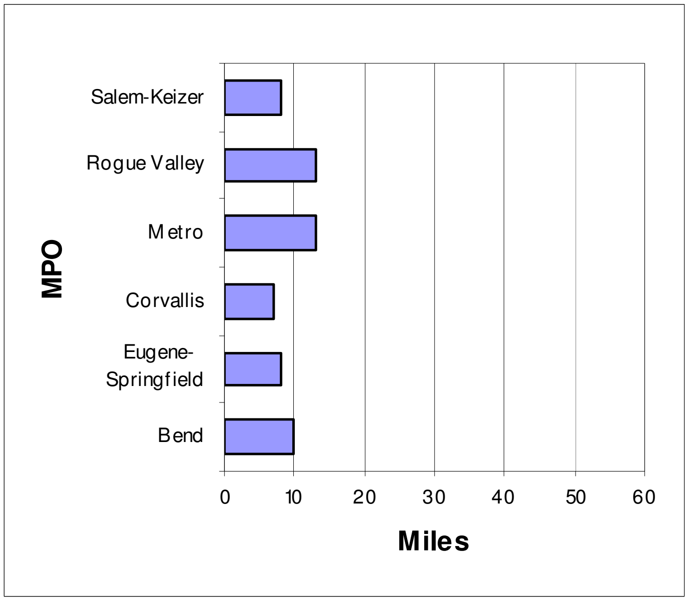
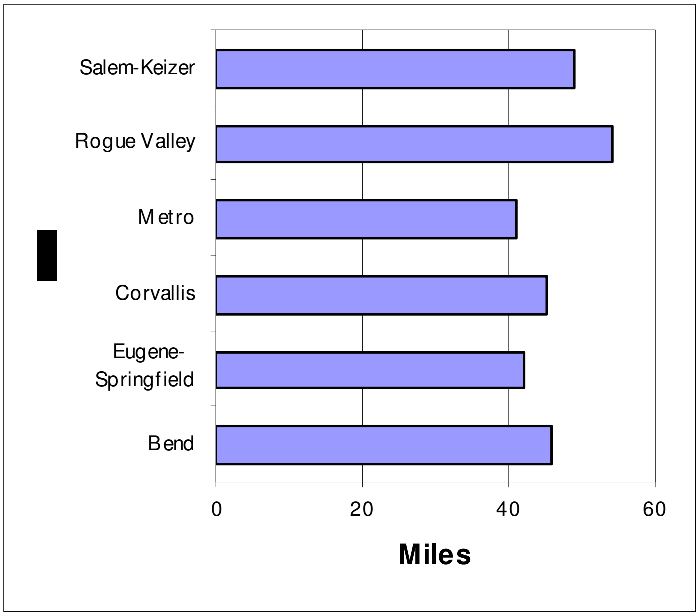


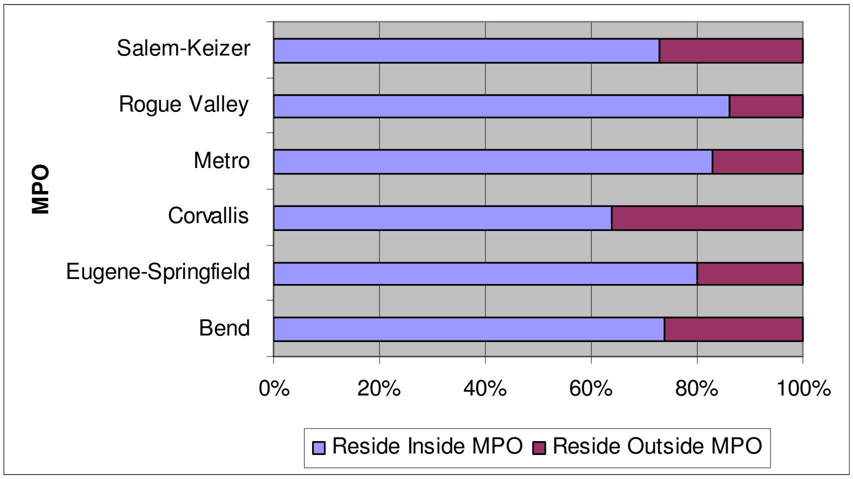
Figure 9: Average Round-trip Commute Distance-Resident Workers Working Outside Their Residence Metropolitan Area



Workplaces located within a metropolitan area and where their workers come from

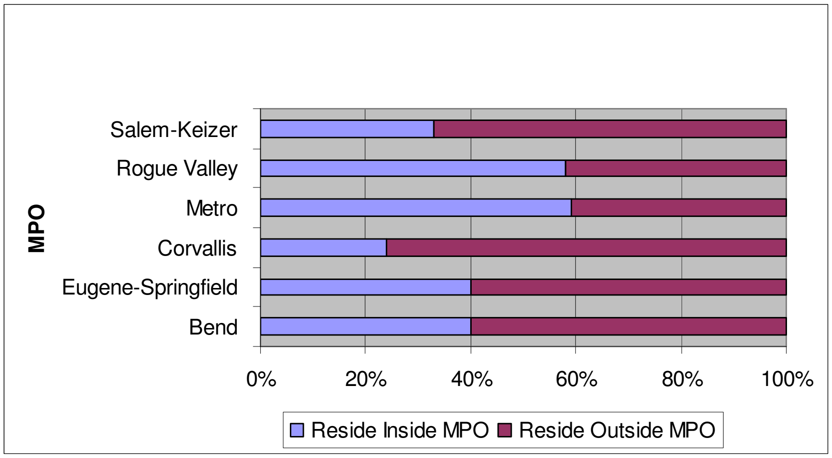
On average, 19 percent of workers who work in metropolitan areas reside in places located outside of the metropolitan area where they work. The Bend, Salem-Keizer and Corvallis metropolitan areas have relatively high percentages of external commuters (Figure 10). In the Corvallis metropolitan area, 36 percent of commuters to work live outside of the metropolitan area.

Figure 10: Percent Workers by Workplace MPO



Commuters to metropolitan area jobs from places outside of the metropolitan area produce almost half of the GHG emissions of work travel to metropolitan areas (Figure 11). Commuters to jobs in the Corvallis metropolitan area from external residences emit about three-quarters of the emissions from those commuting to jobs in the metropolitan area. Commuters to jobs in the Salem-Keizer metropolitan area from external residences emit about two-thirds of all commute emissions to jobs in the metropolitan area.

Figure 11: Percent GHG Emissions by MPO Workplace Workers



Workers traveling from outside the MPO workplaces cause a disproportionately large percentage of emissions because their work trips are from about three to six times longer than the work trips of commuters who travel to internal workplaces (Figures 12 and 13).

Figure 12: Workplace MPO Average Round-trip Commute Distance by Workers Residing Inside MPO

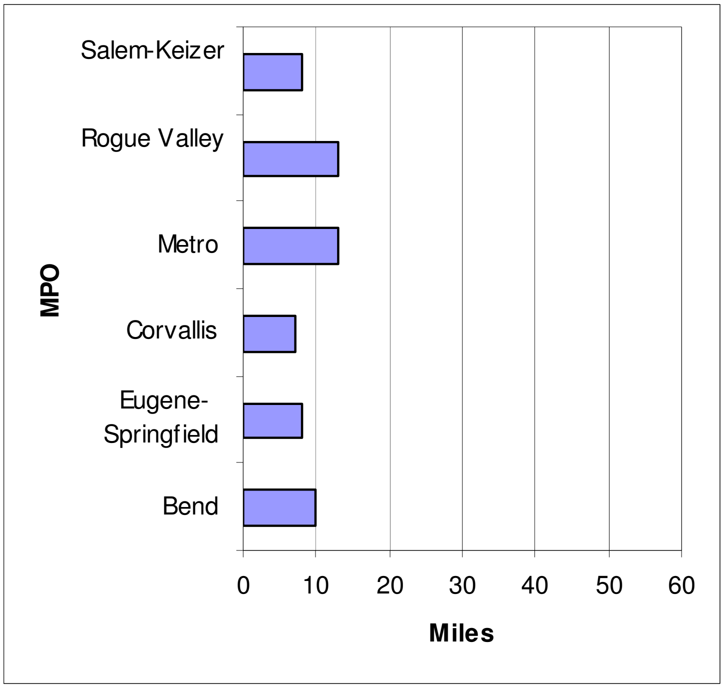
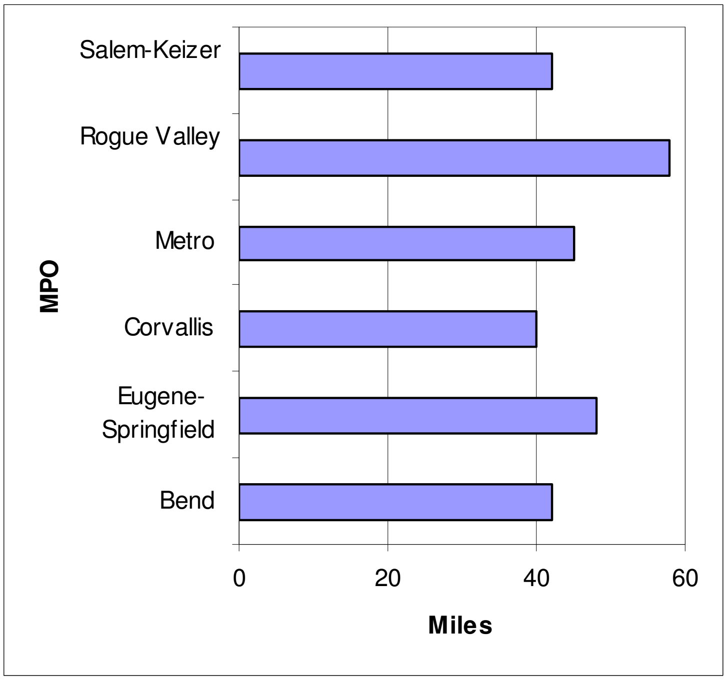


Figure 13: Workplace MPO Average Round-trip Commute Distance by Workers Residing Outside MPO



3. Analyzing the Effects of Actions to Reduce GHG Emissions

3.1. Factors Affecting GHG Emissions from the Transportation Sector

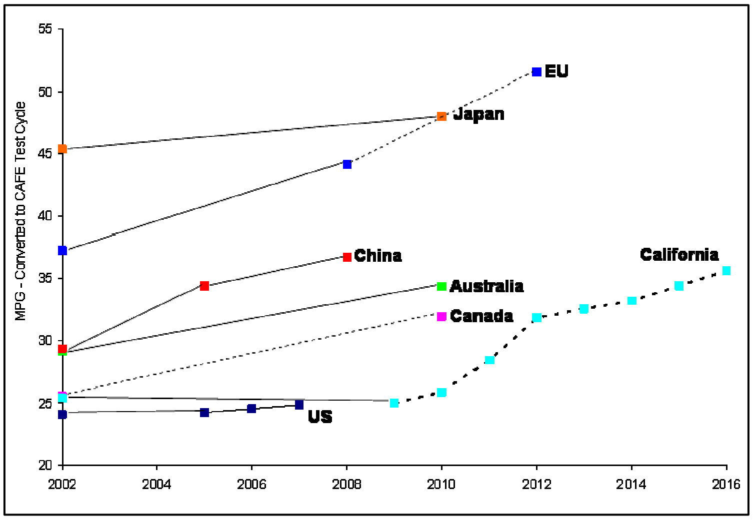
The recent report *Moving Cooler* views transportation CO_2 reduction as a four-legged stool, with one leg related to the energy efficiency of vehicles, a second to the carbon content of the fuels, a third to the efficiency of the transportation network, and a fourth to the amount of vehicle travel.

3.1.1. Vehicle Efficiency

Vehicle efficiency will have a major effect on GHG emissions from light vehicles and the magnitude of other changes needed to reduce GHG emissions from the transportation sector. A high degree of political and technical uncertainty compromises our ability to predict future vehicle efficiency. We know the federal and state fuel economy standards for the next decade but we do not know what those standards will be in the long term. We also do not know how rapidly electric vehicle technology will advance and how quickly electric vehicles can replace internal combustion engines in the vehicle fleet.

Vehicle fuel economy and improvement standards in the U.S. have been low compared to the standards of other industrialized countries, as shown in Figure 14. In 2007, the Energy Independence and Security Act (EISA) mandated that the fleet average fuel economy of new passenger vehicles be 35 miles per gallon (MPG) by 2020. This is 32 percent below the 2012 standard for the European Union (EU) of 51.5 MPG[5].

Figure 14: Comparison of Passenger Vehicle Fuel Economy and GHG Emissions Standards around the World



Source: *Comparison of Passenger Vehicle Fuel Economy and GHG Emission Standards Around the World*. Pew Center on Global Climate Change, Figure ES, p.1.

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[5] Feng An and Amanda Sauer, *Comparison of Passenger Vehicle Fuel Economy and Greenhouse Gas Emission Standards Around the World*. Pew Center on Global Climate Change. December 2004. Table 12.

Two recent studies of transportation and land use policies to reduce GHG emissions, *Growing Cooler* and *Moving Cooler*, used projections of vehicle fuel efficiency derived from the EISA standard as the basis of evaluating land use and transportation policies. These projections assume that the average fuel economy for light vehicles in 2030 will be between 35 and 40 MPG with small subsequent improvement.[6]

The California Air Resources board adopted more stringent standards affecting light vehicle fuel economy to carry out the Pavley Bill enacted in 2002. Oregon and 11 other states followed suit in adopting these standards. The federal government at first rejected California's request for a waiver to allow the state to implement its rules, but the current administration is now attempting to harmonize the federal fuel economy standards with the California standards. The Pavley standards are estimated to increase new vehicle fleet fuel efficiency to 43 MPG by 2020.[7] This efficiency level is 23 percent above the EISA standard but still about 16 percent below the EU 2012 standard. The differences in vehicle efficiency standards show that the standards and forecasts based on them are as much politically driven as they are technically driven.

The possibilities for electric vehicle use offer great hope for reducing GHG emissions from light vehicles, but also pose large uncertainties about the future. Electric vehicle drive trains are several times more efficient at converting energy into movement. As a result, they have a fraction of the carbon emissions per mile of travel.[8]

Rapid advances are occurring in electric vehicles. Batteries are becoming more powerful and the distance that vehicles drive between charges has increased significantly[9]. Large sums are spent on battery research as companies and countries compete for market position in the future of personal vehicle travel. The federal government recently awarded $2.4 billion in grants for battery and electric drive development and Oregon has been aggressively pursuing the development of electric vehicles and infrastructure. This year the state formed a partnership with Mitsubishi and Portland General Electric to develop an electric vehicle charging network. ReVolt Technologies recently decided to locate its headquarters in Portland, and the 2009 Legislature passed a bill to allow the licensing of medium speed electric vehicles in Oregon.

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[6] *Growing Cooler* assumes the forecast in the Energy Information Agency's (EIA) Annual Energy Outlook 2008. *Moving Cooler* assumes the forecast in the EIA's Annual Energy Outlook 2009. Figure 6 (p. 14) in the 2009 Outlook compares the 2030 forecasts of the two reports.

[7] California Air Resources Board, *Comparison of Greenhouse Gas Reductions for the United States and Canada Under U.S. CAFÉ Standards and California Air Resources Board Greenhouse Gas Regulations*. February 25, 2008.

[8] For example, a 50 MPG gas-powered vehicle will travel 0.62 kilometers per mega joule of energy. In comparison, the efficiency of the Tesla Roadster electric vehicle at converting power to movement is 2.18 kilometers per mega joule[8]. Since the carbon intensity of gasoline is 95.86 grams of GHG emissions per mega joule and of electricity is 124.1 (California average mix), that means the GHG emissions for the gas-powered vehicle (154.6 gm/km) are 2.7 times the emissions for the electric vehicle (56.9 gm/km).

[9] Examples of electric vehicles on the market include the Honda Clarity (300+ mile range), Tesla Roadster (200+ mile range), and the BMW Mini E (100+ mile range). Electric vehicles to be released soon include the Chevrolet Volt (40 mile range) and Mitsubishi iMiev (75 mile range).

Finally, how people maintain and operate their vehicles affects vehicle fuel efficiency. Some of the many practical actions that a driver can take to reduce emissions include:

- Drive at more constant speeds to minimize acceleration and braking.
- Shift into higher gears sooner.
- Avoid driving at higher speeds that are less efficient.
- Properly inflate tires.
- Use lower rolling resistance tires.
- Reduce wind drag from car-top carriers.
- Remove heavy objects from the car.
- Properly maintain and repair the car's drive train.
- Avoid situations of extended idling (e.g. waiting in line at a drive-up service window).

3.1.2. Carbon Content of Fuel

Motor vehicle fuels vary in the amounts of GHG they produce for the amount of energy they contain, especially when emissions for producing and transporting the fuels to the end user are included in the calculation. The GHG production of different fuels is known as the carbon intensity of the fuel. It is measured as the grams of GHG, expressed as CO_2 equivalents, per mega joule of energy contained in the fuel. For example, the California Air Resources Board has calculated that gasoline emits about 96 grams of GHG per mega joule. In comparison, the emissions from biodiesel produced from waste cooking oil (such as that produced by SeQuential-Pacific Biodiesel in Salem) are about 14 grams of GHG per mega joule. Therefore, GHG emissions can be reduced by lowering the carbon intensity of transport fuels.

Federal and state governments have adopted various standards for including renewable fuels in the fuel mix. This has not been solely for reducing GHG emissions. Ethanol must be added to fuels as an oxygenator to replace Methyl Tertiary-Butyl Ether (MBTE), which causes ground water contamination.[10] The renewable fuel standard included in the EISA is intended to increase U.S. energy independence as well as reducing pollution. The EISA mandates increasing quantities of renewable fuels in the fuel mix over time. The 2022 target is 36 billion gallons, an estimated 20 percent of projected gasoline consumption at that time[11]. It has been estimated that the federal standards would have the effect of lowering GHG emissions by 6.3 percent from what they otherwise would be[12]. In 2007, Oregon House Bill 2210 established a renewable fuel standard mandate, which was modified by the 2009 legislature.

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[10] Ethanol was used as an oxygenate in Oregon from the early 1990s to the middle of this decade to reduce the wintertime carbon monoxide concentrations in areas that failed to meet carbon monoxide air quality standards. When vehicles with computerized engine controls became prevalent, the oxygenating agent was no longer needed and the requirement was lifted. States such as California and Arizona that use reformulated gasoline to control ground level ozone still need to oxygenate their fuel. Ethanol replaced MBTE in reformulated gasoline.

[11] *Reducing Greenhouse Gas Emissions from Transportation Sources in Minnesota*, Center for Transportation Studies, University of Minnesota, June 2008, p. 15.

[12] Ibid p.16.

The more recent direction of policy to reduce the carbon intensity of fuels has been to set standards for reducing the carbon intensity of fuels. California pioneered this in 2007 with the adoption of the first low carbon fuel standard. The standard requires that the carbon intensity of fuels sold in California be reduced 10 percent from the level in 2010 by the year 2020. Oregon enacted a similar requirement into law in 2009 that authorizes the Environmental Quality Commission to adopt a low carbon fuel standard (HB2186).

The production of renewable fuels can be controversial. Ethanol and biodiesel, the most prevalent renewable fuels, are made primarily from food crops. Ethanol is made from corn and biodiesel from soybeans. Concerns have been raised that increased demand for these fuels may be driving up food prices. There are also concerns that production of these fuels has indirect land use effects on GHG emissions by causing the conversion of forests to agricultural land in other countries in order to replace lost food production. The California Air Resources Board (CARB) has included this indirect land use effect in the carbon content estimate of ethanol, but the decision to do so is controversial. Current ethanol production methods are also fairly energy intensive. The net result is that the ethanol produced by some methods are estimated by CARB to be more carbon intensive than gasoline, when estimated indirect land use effects and production energy requirements are added. However, ethanol produced by other methods has significantly lower carbon intensity than gasoline even when the indirect land use effects are considered. The energy required to produce biodiesel is less than that required to produce ethanol, but CARB is still conducting this analysis.

Large amounts of production of biofuels will require technological improvements. There is only enough farmland in the U.S. to produce enough biofuels to replace a small portion of petroleum fuels. The future for producing large supplies of ethanol is the production of ethanol from the inedible cellulosic parts of plants such as wood residues, corn stalks, wheat straw, and grasses. It is estimated that the U.S. could produce 1.3 billion tons annually of cellulosic biomass for fuel without adversely affecting the production of other agricultural products. This amount of biomass could produce at least 100 billion gallons of fuel annually.[13] The processing of cellulosic material can produce oil fuels as well as ethanol.[14] Algae crops are also being researched as high yield sources of bio-oil. They yield about 250 times the amount of oil per acre as soybeans because of their very high oil content (some exceed 50 percent).[15]

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[13] George W. Huber and Bruce E. Dale, Grassoline at the Pump, Scientific American, July 2009, Volume 301, No. 1, p. 54.

[14] Ibid, p. 56

[15] Michael Briggs, University of New Hampshire Biodiesel Group, August 2004, http://www.unh.edu/p2/biodiesel/article_alge.html.
A.B.M. Sharif Hosssain et. al. Biodiesel Fuel Production from Algae as Renewable Energy. American Journal of Biochemistry and Biotechnology 4(3):250-254, 2008.

3.1.3. Efficiency of the Transportation Network

The operational efficiency of the transportation network affects the efficiency of vehicles. Vehicle travel speeds affect light vehicle fuel efficiency. Figure 15 shows that vehicle fuel efficiency and the speed at which maximum efficiency is achieved vary among different models of vehicles. There is more variation between vehicles at slower speeds than at higher speeds. In general, fuel efficiency declines at speeds below 25 MPH and over 60 MPH.

Fuel economy is also adversely affected by vehicle deceleration and acceleration. Deceleration wastes energy as the vehicle slows down; acceleration uses more energy per mile than constant speed travel of the same distance; stopping wastes fuel in idling. The design and operation of roads affects vehicle speeds and the amount of acceleration, deceleration and stopping of cars. Optimization of traffic signal spacing and coordination of traffic signals allows for optimization of traffic progression and minimizes stopping at traffic signals. Freeway management strategies, such as incident management and ramp metering, also smooth out traffic flow and improve vehicle fuel efficiency.

While increasing speeds can improve vehicle fuel efficiency, it can also increase the amount of vehicle travel. The distances that people travel are affected by travel speeds and times. In the absence of other influences, travel distances increase as travel speeds increase and travel times decrease. The net effect on GHG emissions will be the result of complex interactions and cannot be determined without modeling the specific situation.

Improving system efficiency can also be important for reducing GHG emissions from public transportation. Urban transit buses running with low occupancies produce more GHG emissions per passenger mile of travel than a high efficiency single-occupant automobile.[16] GHG emissions from urban transit buses can be improved by increasing bus ridership levels.[17]

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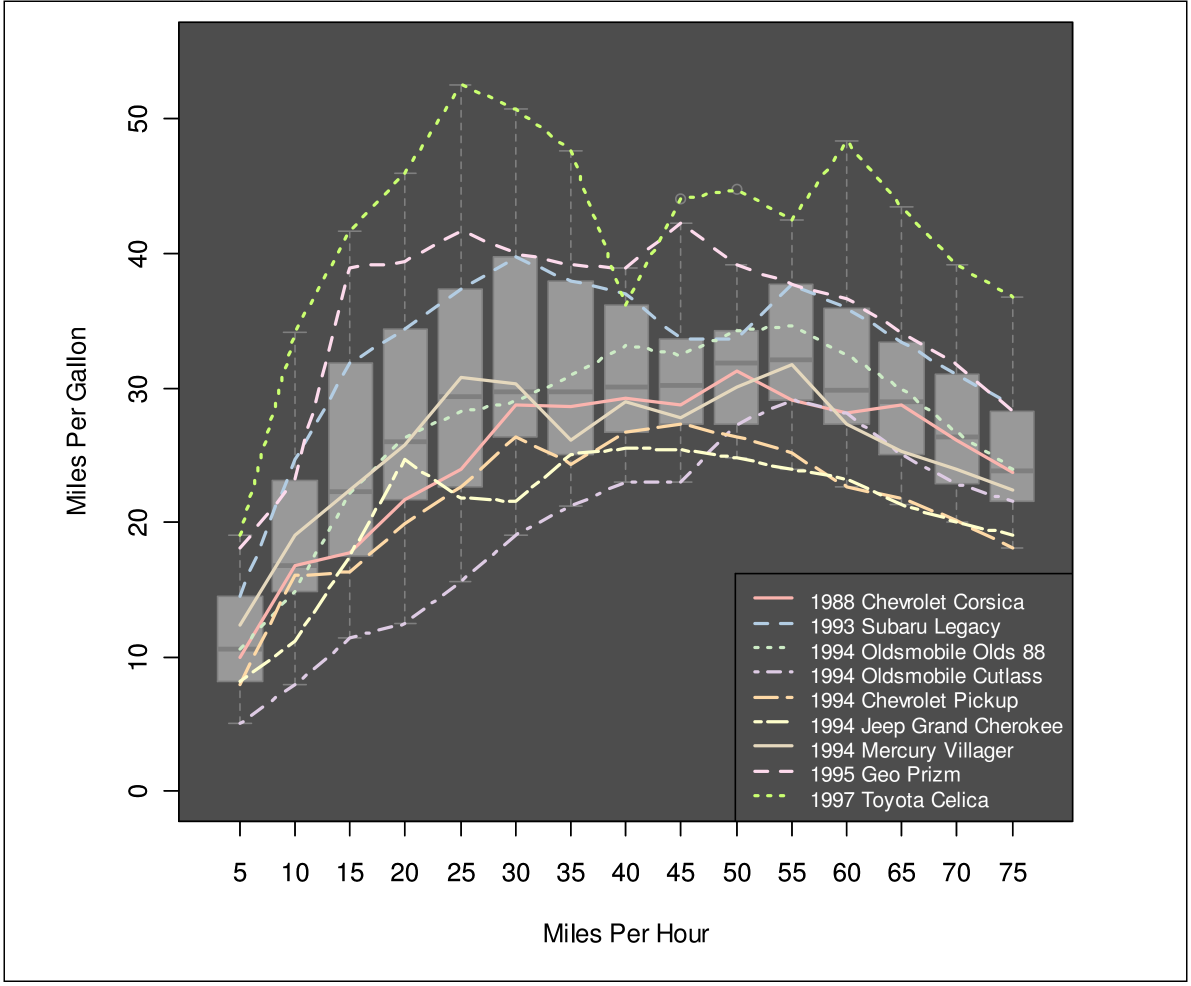
[16] M.J. Bradley & Associates, Comparison of Energy Use & CO_2 Emissions from Different Transportation Modes, May 2007, American Bus Association, Washington, D.C. The urban transit bus average is 299 grams per passenger mile. The single occupant auto average is 371 grams per passenger mile for automobiles having an average fuel economy of 22.9 mpg. However the average for a high mpg auto like the Prius is 184 grams per passenger mile.

[17] University of Minnesota Center for Transportation Studies, Reducing Greenhouse Gas Emissions from Transportation Sources in Minnesota, June 2008, p.22

Figure 15: Light Vehicle Fuel Economy vs. Steady State Speed



Source: Davis, Stacy C., Susan W. Diegel, Robert G. Boundy. Transportation Energy Data Book: Edition 28. Oak Ridge National Laboratory, 2009, Table 4.28

3.1.4. Amount of Driving (VMT)

Growing Cooler cites a forecast from the U.S. Department of Energy that VMT will increase by 59 percent between 2005 and 2030. VMT has been growing at a slower rate in Oregon, and the Oregon Transportation Plan (OTP) forecasts an increase of 40 percent over that time. The growth of VMT in Oregon began to level off and per capita VMT began declining even before fuel prices began their rapid rise in recent years.

VMT per capita in the Portland metropolitan area started leveling off and declining in the mid-1990s[18] (Figure 16). Meanwhile the per capita VMT average for other large metropolitan areas continued to grow.

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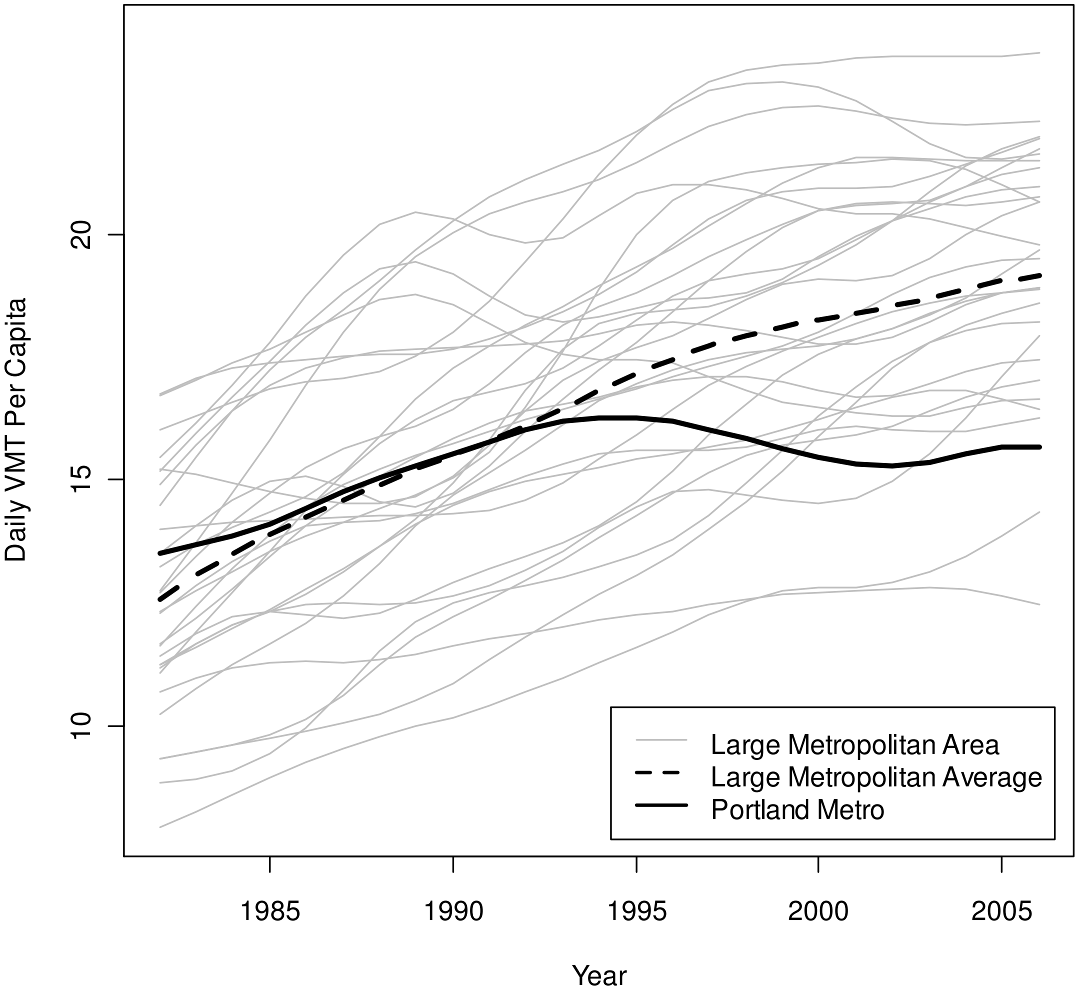
[18] Texas Transportation Institute, database for the Urban Mobility Report. Note that the Portland metropolitan area includes Vancouver, WA and other portions of Clark County.

Figure 16: Daily VMT Per Capita on Major Roads in Large Metropolitan Areas: 1982 - 2006



Source: ODOT Transportation Planning Analysis Unit analysis of Texas Transportation Institute Urban Mobility Report database.

State highway VMT has produced a similar trend of flattening out in recent years (Figure 17), while state highway VMT per capita has dropped by 8 percent over that time (Figure 18).[19]

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[19] Source: ODOT

Figure 17: Oregon Highway Vehicle Miles Travelled – 1990-2007

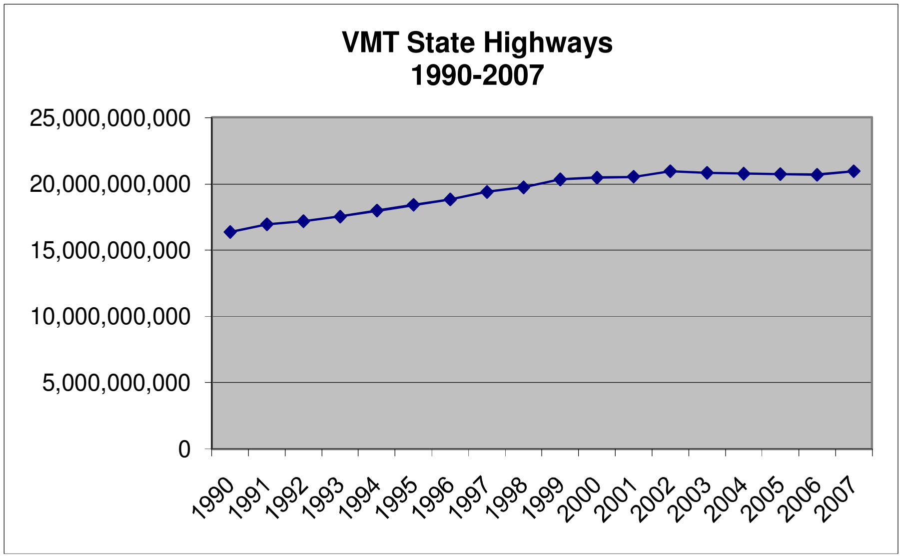
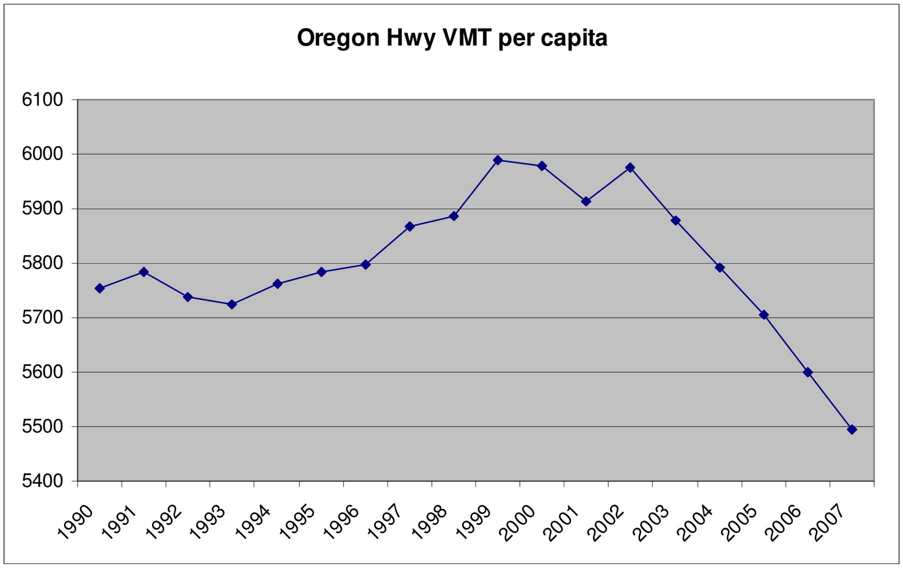


Figure 18: Oregon Highway Vehicle Miles Traveled Per Capita 1990-2007



Total motor fuel consumption in the state has increased by only 0.25 percent from 1999 to 2007 (Figure 19) while the population of the state increased by 10.4 percent. The net effect has been a 9.2 percent decrease in consumption per capita.[20]

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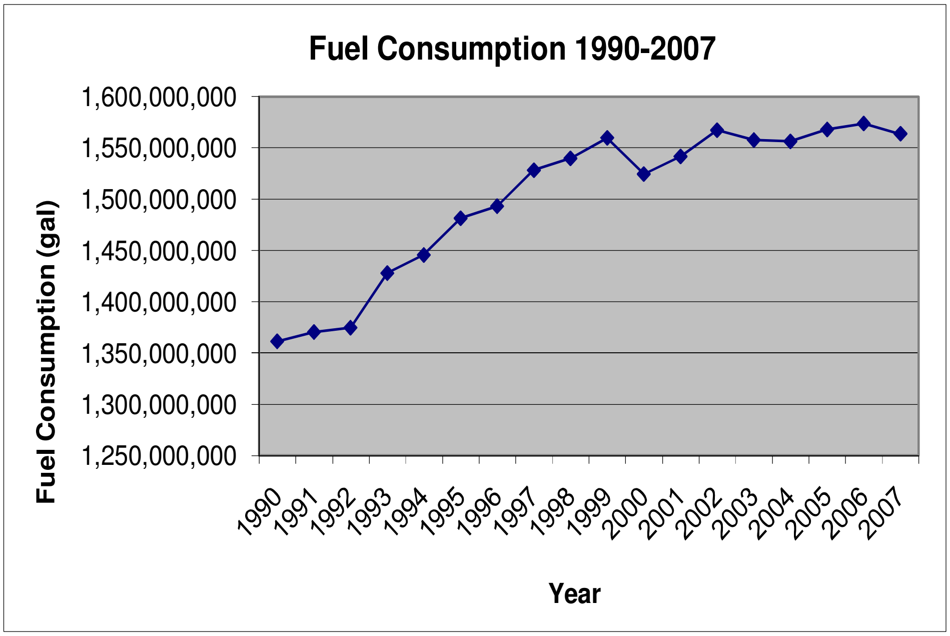
[20] Source: ODOT

Figure 19: Oregon Fuel Consumption 1990-2007



Some of the flattening in state highway VMT may be due to the shifting of a portion of traffic from state highways to local roads as a result of rising congestion. However, the flattening of fuel consumption indicates that total travel is probably leveling off as well.

Several factors affect the amount of travel and total VMT:

- ***Land use patterns*** affect how far people travel and the modes by which they travel. People will do more of their travel by automobile and will drive farther if activities are dispersed. The distribution and mixing of land uses has similar effects. The design of land uses affects the ease and amounts of travel by walking, bicycling and using public transportation. Land use patterns also are likely to affect newer transportation modes and services. For example, the density of development influences the practicality of car sharing, and shorter-range electric vehicles are a more viable option at higher densities where journeys are shorter.
- ***Transportation services and infrastructure*** also affect travel distances and modes of travel. People choose their mode of travel based on the relative performance and cost of each modal option. If public transit performance is poor compared to highway performance, then fewer people will travel by public transit. Transportation systems interact with land use to affect the amount of vehicle travel that occurs. For example, more public transit ridership occurs where more activities cluster around transit lines, and new major roads can alter land development patterns and increase vehicle travel as a result. The speed of travel also affects travel distance, e.g., VMT is higher for people who live in metropolitan areas that have more extensive freeway systems.
- ***Pricing*** affects decisions on travel, as the higher the cost of fuel, the less people travel. Part of pricing is the issue of what people are willing to pay as a lump sum (e.g. yearly insurance policy) vs. on a usage basis (e.g. fuel or mileage charge).

- ***Demand management*** is a tool to help people understand how to maximize their options. It is becoming clear that how people decide to travel is affected by the approaches taken to communication and involvement. Individualized marketing has been shown to significantly reduce VMT in neighborhoods when options for alternative travel opportunities are clearly defined and offered.

3.2. Economic Effects of Policies to Reduce Metropolitan VMT

For over thirty years, per capita VMT and income for Oregon have grown at similar rates, as shown in Figure 20. This relationship raises the question of whether an economy can be prosperous without rising VMT. The link between VMT and income is intertwined with land use patterns, transportation infrastructure, energy costs, and economic diversity. All these factors play into how a metropolitan area grows over time.

Figure 20: Indexed Trends in Per Capita VMT and Income for Oregon: 1970 to 2006

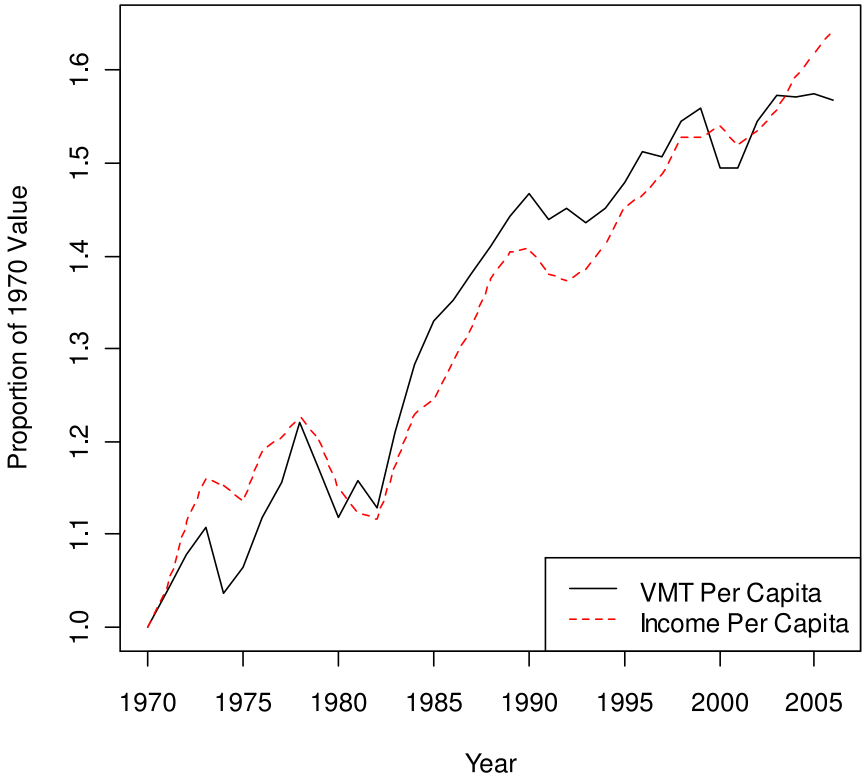
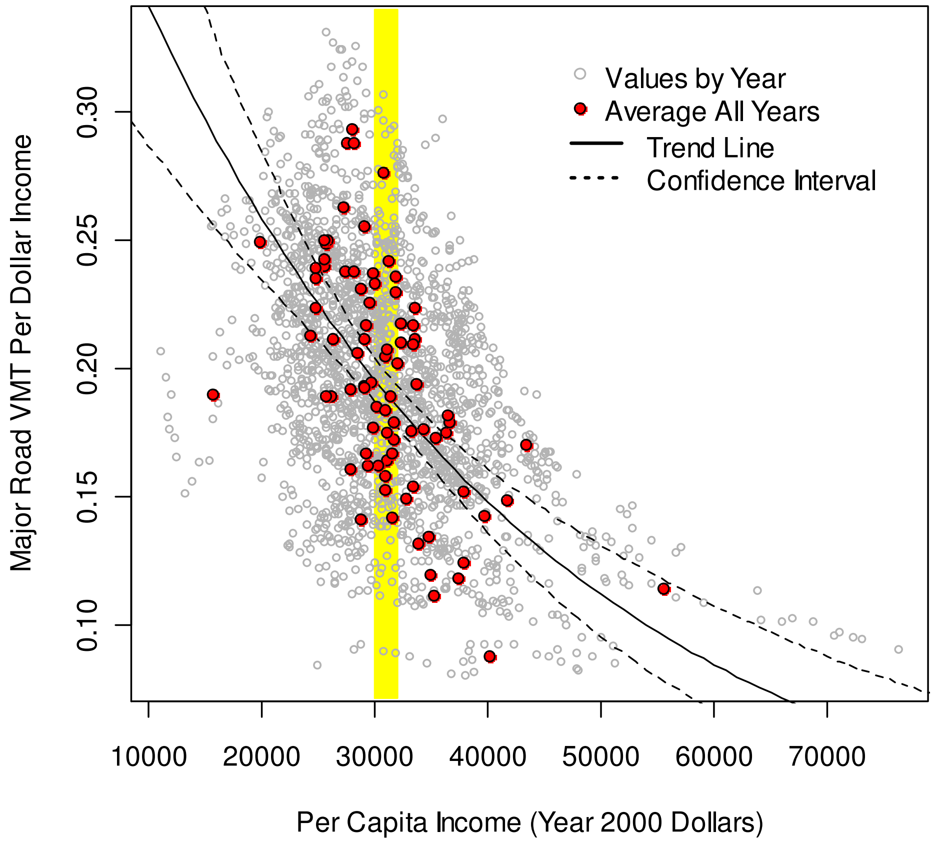


Figure 21 illustrates the variation among U.S. metropolitan areas in travel intensity and economic prosperity over time. Prosperity is measured as the per capita income of the metropolitan area.[21] All dollar values are deflated to be equivalent to year 2000 dollars. The vehicle travel intensity of metropolitan areas is measured as the ratio of annual VMT on major roadways in the metropolitan area (e.g. freeways and arterials) to the metropolitan area gross domestic product (GDP).[22]

Figure 21: Vehicle Travel Intensity vs. Prosperity for U.S. Metropolitan Areas 1982 to 2006



The open gray dots in the figure show the values for all the metropolitan areas and all the years from 1982 to 2006. The red dots show the averages over time for each metropolitan area. The solid black line shows the average relationship between metropolitan area

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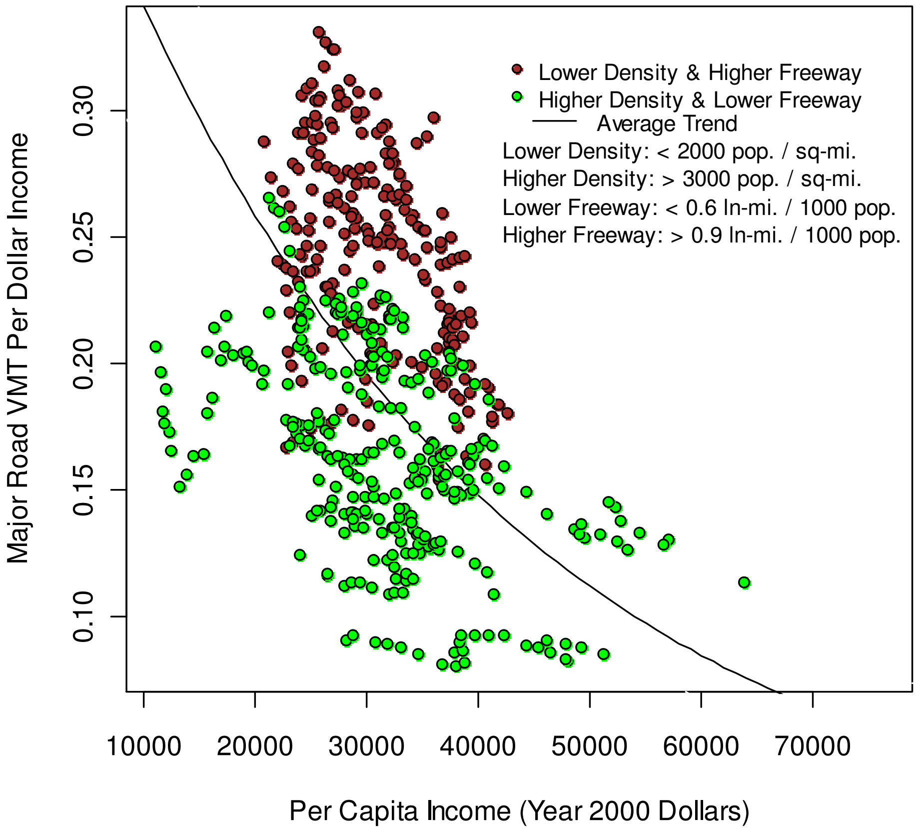
[21] Data on metropolitan income comes from the Bureau of Economic Analysis regional economic accounts database. http://www.bea.gov/regional/

[22] Data on metropolitan VMT and transportation system characteristics comes from the database used by the Texas Transportation Institute to compile the 2009 Urban Mobility Report. http://mobility.tamu.edu/ums/. The Urban Mobility Report provides information only on major roads (freeways and arterials) because data on VMT on other roads is not very reliable. Major roads in metropolitan areas typically carry the large majority of VMT (~ 75% in Oregon).

prosperity and vehicle travel intensity. The narrow vertical yellow band shows a range of $1,000 on either side of the average per capita income for all metropolitan areas and years. Clearly, metropolitan areas having the same level of prosperity can have greatly different vehicle travel intensities.

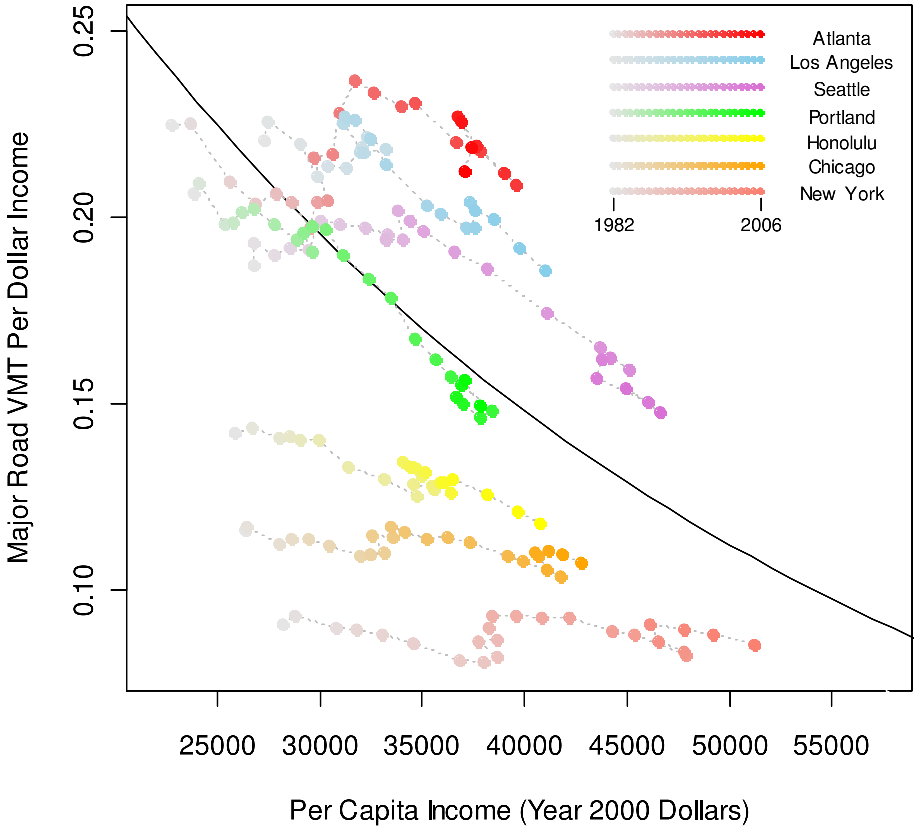
As previously mentioned, other factors influence this relationship, such as metropolitan area density. Figure 22 illustrates the joint effects of metropolitan area density and freeway supply on vehicle travel intensity. Metropolitan areas that have lower population densities and more expansive freeway systems tend to have higher than average vehicle travel intensities. The reverse is true for metropolitan areas that have higher population densities and less expansive freeway systems.

Figure 22: Metropolitan Vehicle Travel Intensity vs. Per Capita GDP by Density and Freeway Supply Characteristics



The previous two figures examined the overall relationship between metropolitan area prosperity and vehicle travel intensity. It is also helpful to examine how these characteristics have changed over time for individual metropolitan areas. Figure 23 presents this information for Portland and six other metropolitan areas: Atlanta, Los Angeles, Seattle, Honolulu, Chicago and New York. These metropolitan areas cover most of the range of vehicle travel intensity values.

Figure 23: Vehicle Travel Intensity vs. Prosperity for Selected Metropolitan Areas - 1982 - 2006



The vehicle travel intensity of all of these metropolitan areas has declined as their prosperity has increased, but some have declined much more than others. The Portland area experienced the biggest decline as its prosperity increased. The Atlanta area experienced a very small decline in the long term. The Chicago and New York areas also experienced relatively small declines but they started out from much lower baselines.

It is instructive to compare the Portland and Atlanta trends. The occupants of both metropolitan areas had very similar levels of prosperity through the entire time period. At the beginning of the period, they also had roughly similar vehicle travel intensity levels. In 1987, these values were almost identical, but then their paths diverged. The vehicle travel intensity of the Portland area changed little until 1992, but then entered a long period of decline as metropolitan prosperity continued to grow. Meanwhile, as the prosperity of the Atlanta metropolitan area grew in the late 1980s and early 1990s, so did the vehicle travel intensity. Starting in the mid-1990s, the trend in Atlanta reversed and the vehicle travel intensity declined as the area became more prosperous. The net result of these divergent trends was that by 2006, the vehicle travel intensity of the Atlanta economy was about 42 percent higher than that of Portland's economy.

Patterns of growth observed for U.S. metropolitan areas illustrate the variety of possibilities for how growth can occur. Lower vehicle travel intensity does not necessarily result in lower prosperity. Several factors, such as the density and arrangement of land uses, transportation system characteristics, and economic diversity, play integral roles in determining vehicle travel intensity.

It is possible to plan for and carry out policies to reduce metropolitan vehicle travel intensity without causing prosperity to decline. It is also important to note that there are potential positive economic effects as well. For example, reducing Oregon's reliance on imported fuel will reduce the Oregon dollars leaving the state. That spending could go toward purchasing Oregon goods and services, further stimulating economic activity through the multiplier effect.

3.3. Magnitudes of Reductions Necessary to Reduce GHG Emissions

HB2186 directs the task force to "take into account the amount of GHG emissions caused by motor vehicles with a gross vehicle weight rating of 10,000 pounds or less that need to be reduced by 2035 in order to meet the goals stated in ORS 468A.205". Those goals are to reduce total GHG emissions in Oregon to 10 percent below 1990 levels by 2020 and 75 percent below 1990 levels by 2050. A straight-line interpolation between these two targets results in a 2035 target of 42.5 percent below 1990 levels.

ORS 468A.205 and HB2186 do not identify how to divide the goals among different use sectors or how to divide transportation use reductions among portions of the transportation sector. The major allocation issues for on-road transportation is how to divide emissions reductions between light and heavy vehicles and how then to split them between metropolitan areas and non-metropolitan areas. This discussion provides a high-level overview of implications of the GHG reduction targets on light and heavy vehicles and on metropolitan and non-metropolitan areas, assuming that the on-road transportation section will meet the targets in the law.

Fuel consumption is used as a proxy in this general analysis because GHG emissions directly relate to the amount of fuel consumed and the quantities are easy to understand. Table 2 shows amounts of fuel consumption that would be consistent with the GHG emission reduction targets. Note that this assumes no reduction in fuel carbon intensity.

Table 2: Statewide Fuel Consumption Amounts Consistent with GHG Reduction Targets

Year	Light Vehicle Fuels (million gallons)	Heavy Vehicle Fuels (million gallons)	Combined Fuels (million gallons)
1990	1,294	319	1,613
2010	1,540	399	1,939
2020	1,165	287	1,452
2035	744	184	928
2050	324	80	404

Both the state population and VMT are projected to grow, so the amount of fuel consumed per person and per mile of travel must decline at a faster rate than the decline in the total amount of fuel consumed. Oregon's population is projected to grow at a rate of 1.2 percent annually. The OTP projects light vehicle VMT to grow at a rate of 1.35 percent per year and heavy vehicle VMT to grow at a rate of 1.4 percent per year. These projections are shown in Table 3 and are lower than national projections that have been used in other studies like *Growing Cooler* and *Moving Cooler*.

Table 3: Statewide VMT and Population Given Assumed Growth Rates

Year	Light Vehicle VMT (millions)	Heavy Vehicle VMT (millions)	Population (thousands)
1990	25,110	1,893	2,847
2010	35,070	2,665	3,844
2020	40,103	3,063	4,359
2035	49,038	3,773	5,158
2050	59,964	4,647	5,921

Table 4 shows the combined effects of the targets and population growth as per capita rates of fuel consumption.

Table 4: Per Capita Fuel Consumption Given Assumed Fuel Consumption Targets and Population Growth

Year	Light Vehicle Fuel Per Capita (gallons)	Heavy Vehicle Fuel Per Capita (gallons)	Combined Fuel Per Capita (gallons)
1990	455	112	567
2010	400	104	504
2020	267	66	333
2035	144	36	180
2050	55	13	68

To meet the targets through fuel efficiency alone and if VMT grows according to the projections in Table 4, the fleet average fuel economy levels shown in Table 5 would be necessary.

Table 5: Fleet Average Fuel Economy to Meet Targets

Year	Light Vehicle (miles per gallon)	Heavy Vehicle (miles per gallon)	Adj. Heavy Vehicle *See text below
1990	19.4	5.9	5.9
2010	22.8	6.7	6.7
2020	34.4	10.7	8.8
2035	65.9	20.5	13.4
2050	185.1	58.1	31.2

Given the VMT growth assumptions, fuel economy for light and heavy vehicle fleets would have to triple in order to reduce fuel consumption to the 2035 levels in Table 2. For light vehicles, this amount of growth equates to an annual increase of 4.3 percent. Fuel economy would have to increase eight-fold in order to achieve the 2050 targets. Clearly, such changes could not occur without transformation of vehicles and energy sources.

It is important to note that the numbers in Table 5 are the averages for vehicles on the road, not the averages for new vehicles. Because the turnover rate of vehicles is low - the median age of passenger cars was over nine years in 2008 – the on-the-road average fuel economy is significantly less than the new vehicle average. To meet the averages in Table 5, the fuel economy of new vehicles would have to grow at an even faster rate. The entire light vehicle fleet will turn over at least two times by 2050, so if there were a complete transition to electric vehicles by then, perhaps we could achieve the needed reductions. Electric vehicles are much more efficient than internal combustion vehicles in converting the energy in fuel into motion. The California Air Resources Board has found that electric vehicles produce about one-third of the emissions of internal combustion vehicles given the current electric power mix in California, which includes power from coal and natural gas-fired power plants.

Making such large improvements in heavy vehicle fuel economy is much more problematical because of the weights and distances traveled. However, if the light vehicle efficiency gains can be achieved and light vehicle VMT can be reduced from the projected amounts, it may become more feasible to accommodate projected growth in heavy vehicle VMT. Light vehicle VMT could decline on a per capita basis in response to the development of more compact land use patterns and the creation of new price signals and demand management measures. For example, the *Growing Cooler* study estimates that GHG emissions could be reduced from what they otherwise might be by 7-10 percent in 2050.[23] Universal pay-as-you-drive insurance could reduce VMT by the same amount. Universal implementation of individualized marketing approaches to demand management might reduce VMT in metropolitan areas by about 10 percent as well. These are not policy recommendations or the only potential strategies. They simply provide an approximation of VMT reduction to evaluate the implications on light vehicle fuel consumption.

Following is one of many scenarios that could achieve the targeted reduction in GHG:

- By 2050, reduce VMT by 30 percent in metropolitan areas from what it otherwise would be to reflect land use policies, demand management and pricing changes.
- By 2050, reduce VMT by 10 percent in non-metropolitan areas to reflect pricing changes.
- Metropolitan households account for 56 percent of the GHG emissions and VMT.
- The entire light vehicle fleet will transition to electrics, and power generation by renewable energy sources will increase to achieve the efficiencies shown in Table 5.

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[23] Ewing, Reid. K Bartholomew, S. Winkelman, J. Walters, D. Chen. Growing Cooler: The Evidence on Urban Development and Climate Change, Urban Land Institute, 2008, p. 9.

The combined result of the metropolitan and non-metropolitan VMT reductions would be statewide reductions in light vehicle VMT and fuel consumption of 13 percent in 2035 and 22 percent in 2050. This would increase the effective allotment of fuel to heavy vehicles by 54 percent in 2035 and 86 percent in 2050. This would substantially lower the required efficiency gains for heavy trucks, but would still pose substantial problems for 2050. Other actions, such as the development of lower carbon fuels, would be needed.

This example simplifies many things, but it shows that the challenges for reducing GHG emissions from the transportation sector are great, major changes of many types will be required to meet the challenges, and measures to reduce VMT are important. More involved modeling is needed to provide more robust analysis. The tools available for doing this modeling are described in the next section.

4. Estimating the Effects of Proposed Policies on GHG Emissions

There are many factors and potential actions for mitigating GHG emissions from the transportation sector. The task of doing the analysis to support GHG mitigation planning is challenging and requires analytical tools. Many factors interact with one-another – for example, fuel prices affect where people live and work, where they travel, how they travel and what vehicles they own and use – so models must do a reasonable job of accounting for the interactions.

Models are analytical tools that provide data on possible outcomes of different policy actions. However, they do not tell decision-makers what to do to solve a problem and are not substitutes for good analytical knowledge and judgment. Models enable people to test actions to gain an understanding of potential effects before making decisions and taking action. Just as a scientific experiment requires a person with subject area knowledge to set up the experiment and conduct analysis, so does a modeling task require knowledge to properly run the model and analyze results.

There is no single model that can address all GHG emission factors and the interactions between factors for all of the prospective actions that might be implemented. Practically, every model has certain limitations, and not all interactions can be accounted for, but a reasonable analysis can be done and many scenarios can be analyzed in the available time and budget if the analyst combines the results of different models that together meet the analytical needs.

Approaches to modeling GHG emissions vary along four dimensions: geography, factors, interactions, and scenarios. There are trade-offs within and between these dimensions.

- The geographic scale describes the geographic breadth and detail of the model. A large-scale model addresses large areas such as the Willamette Valley or the entire state, but cannot address neighborhood level interactions.
- The factor scale addresses the number of factors addressed in the model and the level of detail with which each factor is addressed. There is a tradeoff between the number of factors analyzed and the detail in which they are analyzed.
- The interaction scale addresses the degree of interactions between factors that are modeled. A highly interactive model addresses multiple interactions between factors over time, but is limited in the number of factors that are modeled.
- The scenarios scale addresses the variety of scenarios that may be modeled vs. the detail with which those scenarios are modeled. If a large number of scenarios are modeled to find the "best" combination of actions, then simplifications are needed in geographic detail, factor detail, and/or interactivity. So-called "sketch planning models" address many factors but have little detail and interactivity between factors. This enables them to be used to evaluate many scenarios in a relatively short period of time.

Following is a summary of Oregon models and their attributes at each of these scales.

- The GreenSTEP model was developed to evaluate GHG emissions from the transportation sector. It is oriented to modeling a large number of factors that affect

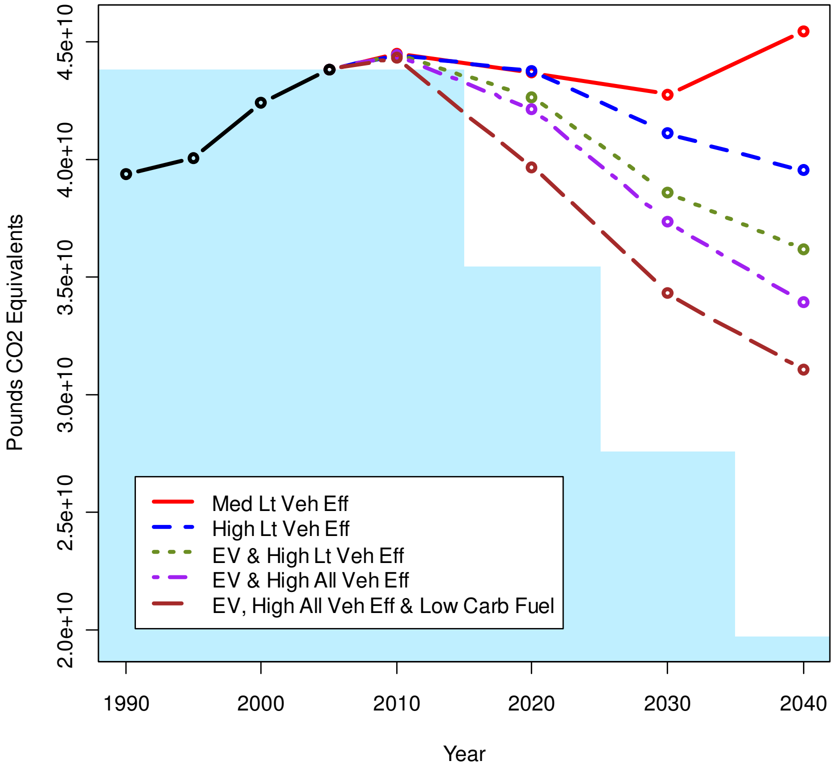
GHG emissions at a statewide level with detail to the county level. The level of interactivity is moderately low. It was built to evaluate many scenarios.

- The Statewide Integrated Model (SWIM) is a large-scale economic, land use and transportation model. It focuses on modeling a high degree of interactivity between economic, land use and transportation factors at a statewide level with detail to the sub-community level. It can be used to analyze many factors at a moderate level of detail. It is a complicated model with long run times so relatively few scenarios can be evaluated.
- Metroscope is a residential and commercial real estate model developed for the greater Portland metropolitan area. It is linked to regional transportation and economic/demographic models. Its focus is on modeling the interactions of a variety of metropolitan growth management and transportation policies at the metropolitan level with detail to the sub-community level. It can be used to analyze many factors at a moderate level of detail. It has relatively short run times, so many scenarios can be evaluated.
- The Metro regional transportation model and the derivative JEMnR model are metropolitan transportation models that model vehicle ownership and travel interactions in response to land use and transportation systems. The JEMnR model is used in the Salem-Keizer, Corvallis, Rogue Valley, and Bend MPOs. The Eugene-Springfield MPO travel model has similar functionality. The focus of these models is to evaluate the response of travel distances, modes and routes to transportation infrastructure and land use decisions in metropolitan areas with detail at the sub-neighborhood level. These models can analyze a moderate number of scenarios.
- The LUSDR model (Land Use Scenario DevelopeR) models metropolitan land use in response to transportation and land use policies. Its focus is on showing the uncertainty in how land may develop in response to policy and can be used for risk assessment and identifying patterns that may have more or less desirable outcomes. It operates at a metropolitan or urban level with detail to the sub-neighborhood level. It was built to analyze a large number of scenarios.
- Urban sketch planning models such as METROQUEST (used in a scenario planning process in the Rogue Valley MPO), PLACES3 (used in Sacramento area Blueprint Planning process), and Coolspots, assess GHG emissions from many urban design factors. These models run quickly, which enables them to be used in real time in public settings. These models address many factors at a low level of detail and very limited interactivity.
- MOVES and its predecessor, MOBILE 6, are air quality models that use the outputs of regional transportation models to calculate emissions. MOVES calculates GHG emissions and is more responsive to vehicle speeds than MOBILE 6. It will become the official model for air quality conformity analysis once the U.S.EPA releases the final version. It can be used at a variety of geographic levels. These models are limited to addressing vehicle emissions and do so at a high level of detail.

Scenario planning for GHG emissions reduction will need to involve several different models operating at different scales. GreenSTEP is useful for developing an overall strategy that identifies relative contributions of vehicles, fuels, system efficiency and VMT reduction to achieve GHG reduction targets. SWIM is useful for evaluating potential pricing, growth management and transportation policies that could affect the amount of GHG emissions from intercity travel. Sketch planning models are useful within metropolitan areas and other communities to do a rapid assessment of many different scenarios.

An example of model output from the GreenSTEP model is shown in Figure 24. This information was developed for the Land Use and Transportation Subcommittee of Oregon's Global Warming Commission (GWC) to inform their discussions on a statewide strategy for managing GHG emissions from transportation sources.

Figure 24: Example of GreenSTEP Model Output



Another example of using models for high-level analysis is the Willamette Valley Livability Forum study *Choices for the Future: The Willamette Valley.*[24] The SWIM model was used to analyze how alternative land use and transportation policies in the Willamette Valley would likely affect land use patterns and state highway congestion. Using this information, the Forum identified the desired and undesired outcomes of possible land use and transportation alternatives and the reasons for those outcomes. The SWIM analysis also helped Forum members gain a better understanding of the sensitivities of growth patterns and highway congestion to various land use and transportation policies. The Forum used this information as they developed expectations, goals and plans for the future of the Willamette Valley.

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[24] http://www.oregon.gov/ODOT/TD/TP/docs/TMR/GEN1/SMAPfinal.pdf

Higher level modeling can be used to evaluate many scenarios to help reduce them to the most promising few, which can then be modeled in more detail. Metropolitan travel demand modeling is needed for all scenarios because these models are the most capable of addressing the interactions that affect travel distances and modes. Integrated land use and transportation modeling may be used as well to evaluate the types of land use and transportation policies that are needed for a desired scenario to occur. Finally, detailed emissions modeling will provide the best estimates of GHG emissions.

Modeling for GHG emission reduction poses substantial timing and resourcing issues. In past years, the focus of the MPOs and ODOT has been to develop and apply travel demand models. Budgets and staffing were developed to be adequate for these purposes. Over the years, expectations for using these models increased, but by working together on data gathering and model and software creation, modelers have been able to develop efficiencies that have enabled them to accommodate increased work loads. For example, ODOT was able to develop models for two new MPOs (Bend and Corvallis), update the model for the Rogue Valley MPO, and build models for about a dozen smaller urban areas without any increase in staff. However, even with the productivity improvements that have been made, it requires a significant amount of time and resources to develop or update a single MPO travel demand model. It took ODOT five years to develop travel demand models for Bend, Corvallis and the Rogue Valley using existing ODOT and consultant staff. The work is not limited to that of the modelers. The efforts of other MPO staff and consultants are required to gather needed data and to work with local stakeholders to make sure that the model reasonably reflects conditions in the area. It takes more time to complete model development for all areas, because there are not enough staff resources to do all of the work concurrently.

Planning for GHG emission reduction increases substantially the amount of modeling required to develop plans. Large scale models, land use models and sketch planning models all need to be applied in a coordinated fashion to address the issues and interactions. All of this work will take a significant amount of time, resources and expertise and the MPOs and ODOT are not currently staffed to do it. Although much work has already been done to develop the needed modeling tools, a substantial amount of work will be necessary to:

1. Apply large scale models to help determine:
    - What proportions of reduction in GHG should be expected from VMT reduction vs. other factors;
    - What proportions of VMT reduction should be expected from actions that affect intraurban travel vs. interurban travel;
    - What proportions of VMT reduction should be expected from metropolitan areas vs. other areas;
    - What proportions of VMT reduction should be expected from metropolitan and local transportation and land use actions vs. state actions; and
    - What set or sets of actions statewide would be best to pursue.
2. Deploy land use models in metropolitan areas so that the interactions of transportation and land use policies can be modeled.

3. Modify transportation models to enable modeling of new policy considerations such as pricing.[25]
4. Assist in the development of alternative land use and transportation scenarios to be evaluated.
5. Evaluate alternative scenarios using land use, transportation and emissions models.

Experience with previous studies provides some examples of the amount of work that would be required. Large scale statewide and regional modeling studies (e.g. Willamette Valley study, bridge options study, Oregon Transportation Plan update) have required from half a year to over a year of concentrated modeling staff effort. The time and effort required to apply metropolitan transportation and land use models to analyze policy scenarios is comparable. The effort required to deploy a metropolitan land use model, based on the experience with developing the LUSDR model for the Greater Bear Creek Valley Regional Problem Solving Process and subsequent experience with deploying LUSDR in the Salem-Keizer MPO, is comparable to the effort required to develop or update a metropolitan area travel demand model (approximately two years). Even more time is required to develop the more complex land use models that are being deployed in some of the larger metropolitan areas (e.g. UrbanSim, PECAS). It should be noted that these times are only what is required to do modeling. Planning studies that use models also require time for organization, objective setting, data gathering, scenario development, and public involvement.

All this assumes that people with sufficient expertise are available to do the work. Much of the required modeling work is still fairly new and there are not many people available with the requisite knowledge (although Oregon is better positioned than almost every other state in this regard). Therefore, it would not be possible to do the work for all areas at the same time. Phasing would be required. Moreover, how the work is organized and coordinated would have significant effects on the amount of work. Less modeling work is required to support a well-organized planning process that addresses issues at the appropriate scale with a logical sequencing of decisions. One important issue in this regard is how intercity travel in the Willamette Valley will be addressed. Intercity travel, such as commute travel, is not confined to well-defined “travelsheds” around metropolitan areas. Rather it is the result of a complex pattern of overlapping labor and housing markets. Addressing and modeling this travel on an individual metropolitan area level will be challenging to determine modeling boundaries, avoid duplication of modeling effort, and coordinating metropolitan area assumptions and plans.

The amount of time and effort to do modeling for metropolitan area GHG mitigation should not be underestimated. The time and resources will be significant. The expertise and resources available to do the work are limited. Careful planning and phasing of the work will be necessary in order to be successful.

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[25] http://www.oregon.gov/ODOT/TD/TP/docs/LRPU/twp3.pdf

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US EPA 2005, Table 3-7 (representing the CO_2 component of GHG Emissions).

APPENDIX A: Magnitudes of Transportation Emissions

GHG emissions from on-road vehicles (cars, trucks, buses, etc.) account for about 80 percent of transportation sector emissions. Of these, light vehicles (those less than 10,000 pounds) account for 75 percent, as shown in Table A1.

Table A1. Contribution to Transport Sector CO_2 Emissions for On-road Vehicles

On-road Vehicle	CO_2 **Emissions (tons/year)**
All On-Road Vehicles	**19,803,784**
Light Vehicles	
Light Duty Gasoline Vehicles	6,374,154
Light Duty Gasoline Trucks 1 & 2	5,591,670
Light Duty Gasoline Trucks 3 & 4	2,799,153
Gasoline Motorcycles	31,436
Light Duty Diesel Vehicles	15,266
Light Duty Diesel Trucks 1-4	43,361
Subtotal for Light Vehicles	**14,855,039**
Contribution of Light Vehicles	75%

It is assumed that light on-road vehicles produce the full range of GHG emissions (CO_2, CH4, N2O, HFC, PFC and SF6) proportional to mode share. As shown in Table A2, GHG emissions from all on-road vehicles, including cars, trucks, buses, etc., account for about 80 percent of transportation emissions.

Table A2: GHG Emissions from All On-Road Vehicles

Mode share of On-road vehicles by CO_2 Direct Combustion Emissions	Million Metric Tons of CO_2 Equivalent
On-road Gasoline	13,295
On-road Diesel	5,466
Subtotal for On-road Vehicles	18,761
Total gross emissions from all sources	69,951
Total transportation related Direct Combustion Emissions	23,387

On-road vehicle contribution to GHG as a percent of transportation sector total	18,761/23,387 X 100% = **80.2%**
Light vehicle contribution to GHG as a percent of transportation sector total	18,761 X 75% = 14,070 14,070/23,387 X 100% = **60.1%**
Light vehicle contribution to GHG as a percent of total GHG emissions in OR	14,070/69,951 X 100 = **20.1%**