GHG Target Rules Technical Memo 2

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To: Oregon Department of Land Conservation and Development

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1. Purpose

The purpose of this memo is to develop a technical basis for establishing a series of annual targets for the years 2040 through 2050. Section 2 of this memo provides an explanation of how the targets are calculated and describes changes in circumstances since the target rules were adopted which affect the calculations. The section explains the basic mathematical relationship between the ***goal*** for reducing per capita greenhouse gas (GHG) emissions from light-duty vehicles in metropolitan areas, the forecast for the change in the vehicle emissions ***rate*** due to improvements to vehicle technologies and fuels, and the corresponding ***target*** for reducing per capita vehicle miles traveled (VMT).[1] Section 3 focuses on how the ***goal*** for reducing per capita GHG emissions is calculated and compares the result of the calculations with the result from the original target rule calculations. The section also evaluates the relative effects of updated population projections, different metropolitan area aggregations, and inclusion of the Albany and Grants Pass metropolitan areas on the results. Section 4 focuses on updating the forecasts of vehicle emissions ***rates*** based on the Oregon Department of Transportation's adopted Statewide Transportation Strategy (STS) for reducing greenhouse gas emissions from the transportation sector, updated federal CAFE standards, and the multi-state Zero Emissions Vehicle standards that have been adopted by Oregon.[2] Section 5 develops several alternative sets of annual goals and ***targets*** for metropolitan areas as a whole and separated between the Portland metropolitan area and the smaller metropolitan areas using outputs from the GreenSTEP model runs for the STS preferred alternative.[3] Finally, Section 6 explores issues relating to how the targets are expressed in the rules given that in practice many actions which affect the ***target*** for reducing per capita VMT also affect the vehicle emissions ***rate*** and vice versa.

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[1] Section 5 of Chapter 85 of Oregon Laws 2010 directed the Departments of Transportation, Environmental Quality, and Energy to jointly develop technical information that the LCDC would use to establish GHG reduction targets. The laws established the methodological steps the agencies were to use in developing the information. Those steps can be summarized as establishing goals for reducing metropolitan area emissions, forecasting future changes in future vehicle emissions rates, and computing the reduction in VMT that must be achieved in order to meet the goal given the forecasted vehicle emissions rates.

[2] The STS was developed in response to Oregon legislation (Chapter 85, Oregon Laws 2010). The National Highway Traffic Safety Administration (NHTSA) in cooperation with the Environmental Protection Agency (EPA) and the State of California have developed CAFE (Corporate Average Fuel Economy) standards for model year vehicles out to the year 2025 with the objective of reducing GHG emissions (http://www.nhtsa.gov/fuel-economy). Oregon has adopted California's program for zero-emission vehicles (http://www.deq.state.or.us/aq/orlev/).

[3] The GreenSTEP model was developed by the Oregon Department of Transportation to evaluate the potential effects of a variety of trends and actions on GHG emissions. The GreenSTEP model was used developing the target rules and the STS (https://www.oregon.gov/ODOT/TD/TP/pages/greenstep.aspx).

2. Background on Calculating Targets

2.1. Overview

It is important to understand how the targets are calculated in order to understand their meaning. This section starts with a simple visual presentation. It then presents a slightly more complicated mathematical equation.

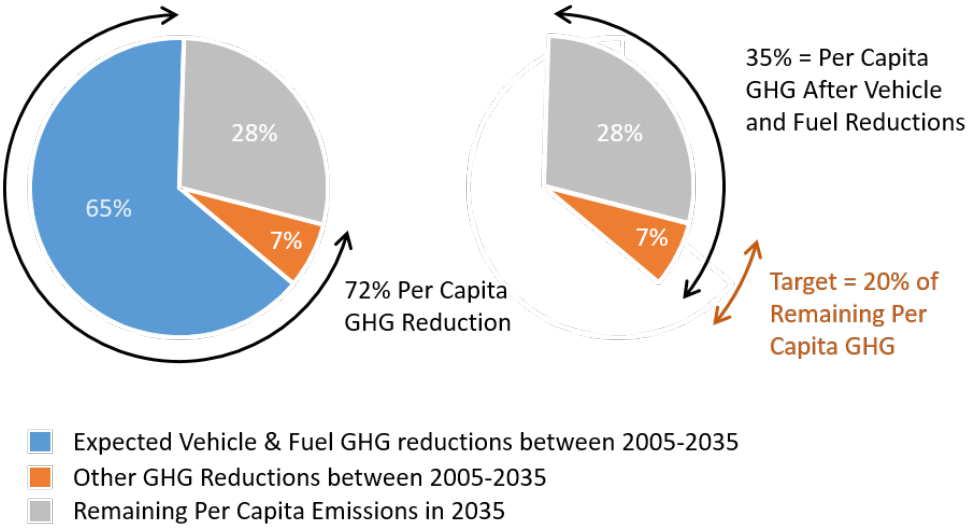
GHGs are molecules that absorb and emit infrared (heat) radiation. Because of this property, these molecules enable the earth's atmosphere to retain heat. While most GHGs are naturally occurring, man-made GHG emissions since the start of the industrial age have significantly increased atmospheric heat retention. There are a number of man-made GHGs that have different heat retention capabilities, but the most prevalent is carbon dioxide created by the combustion of fossil fuels.[4] Consequently, GHG emissions are measured in carbon dioxide equivalents (CO_2e); the amount of carbon dioxide that would produce the same warming effect. The quantity of man-made GHG emissions is typically represented in terms of the weight of CO_2e emitted. Total emissions are most often expressed in metric tons or in terms of metric tons per person. Emission rates are usually expressed in grams per mile of travel. For example, the Statewide Transportation Strategy (STS) for reducing GHG emissions estimated that the average emissions rate for light vehicles traveling in Oregon in 1990 was approximately 600 grams (about 1.3 pounds) of CO_2e per mile of travel. The total quantity of GHG light vehicle emissions in 1990 was estimated to be about 14 million metric tons (about 31 billion pounds).

2.1.1 Visual Explanation of Relationship between Emission Reduction Goals, Emission Rates, and Targets

Figure 1 illustrates how a hypothetical metropolitan area GHG reduction target is calculated from the per capita emissions reduction goal and the forecast for reduction in the light vehicle emissions rate. The circle represents total metropolitan area per capita emissions in 2005 while the grey slice shows per capita emissions in 2035 given the emissions reduction goal. Since the goal is to reduce per capita emissions by 72% from 2005 to 2035, the per capita emissions in 2035 would be 28% of the 2005 emissions. The blue slice indicates the reduction in per capita emissions due to the forecasted change in the light vehicle emissions rate. Since forecasted change in the emission rate would reduce per capita emissions by 65%, the emissions in 2035 would be 35% of the 2005 emissions if only the forecasted changes to light vehicles and the fuels they use occur. An additional 7 percentage point reduction is necessary to meet the 72% reduction goal (72% – 65%). That is 20% of the remaining emissions (7% ÷ 35%). This is the target; the percentage reduction in emissions beyond the reductions expected from changes in vehicles and fuels.

[4] Carbon dioxide accounts for about 85% of GHGs produced by Oregonians. http://www.keeporegoncool.org/content/goals-getting-there

Figure 1. Calculating Metropolitan Area Target from the Goal for Reducing 2005 Per Capita GHG Emissions and the Forecast for Emissions Reductions from Vehicle and Fuel Changes



2.1.2. Simple Introduction to Mathematics of Calculating Targets

The following simple equation relates the three quantities of emissions, vehicle emissions rate, and vehicle miles traveled (VMT).

Equation 1: Relationship between Per Capita Emissions, Vehicle Emissions Rate, and Per Capita VMT

$$EmissionsPersons = EmissionsMiles * MilesPersons$$

On the left side of the equation we have the average per capita emissions. On the right side of the equation we have the product of the average emissions produced per mile of vehicle travel, and the average miles of vehicle travel per person. [5]

This equation is the starting point for relating the metropolitan area targets to the goal for reducing emissions and to the forecasted improvements to vehicle technologies and fuels. The goal, forecasted improvements, and target are all expressed in terms of the change from the base year (i.e. 2005) values. In the hypothetical example above, the goal is to reduce per capita emissions by 72%, the forecast is that improvements to vehicles and the fuels they use will reduce emissions per mile of travel by 65%, and the target is for miles of vehicle travel per person to be reduced by 20%. You'll notice that expressed in this way, it is not so simple to relate these changes, however, if the changes are expressed in terms of the ratio of future year to base year values, there is a simple mathematical relationship. If you divide Equation 1 for the future year by the same equation for base year, you get the following equation that is also true.

[5] A conversion factor is also needed when emissions are measured in metric tons and vehicle emissions rates are measured in grams. One million grams equals one metric ton.

Equation 2: Relationship between the Goal for Reducing Per Capita Emissions, the Change in the Vehicle Emissions Rate, and the Change in VMT

Equation 2

$$Goal = Rate * Target$$

Where the *Goal* is the ratio of the future year to the base year per capita emissions, the *Rate* is the ratio of the future year to base year emissions per mile of vehicle travel, and the *Target* is the ratio of future year to base year vehicle miles traveled per capita. When the percentage reductions from the example above are converted into ratios, we see that this relationship holds true as follows:

Goal = GHG emissions per capita
Rate = GHG emissions per mile
Target = miles per capita

$$0.28 = 0.35 * 0.8$$

- A ratio of 0.28 of future to base year per capita emissions is equivalent to a 72% reduction.[6]
- A ratio of 0.35 of future to base year vehicle emissions per mile is equivalent to a 65% reduction.
- A ratio of 0.8 of future to base year vehicle miles traveled per capita is equivalent to a 20% reduction.

There are several reasons why it is important to understand this mathematical relationship. The first is to dispel incorrect interpretations of the combined effects of reductions. It is common for people to incorrectly add the percentages of reductions to calculate the total reduction. For example a person might incorrectly reason that if new vehicle technologies will reduce vehicle emission rates by 65% and various policies will reduce per capita vehicle miles traveled by 20%, total per capita GHG emissions will be reduced by 85%. This reasoning is wrong and it overestimates the total effect. The correct reduction, as shown by the equation and the graphic above is 72%. The second reason for understanding this mathematical relationship is to be able to understand and check the calculations that are presented later in this memo.

2.2. Summary of Calculation Methods

Several considerations entered into the calculation of the goals, emissions rates, and targets that are discussed below. These include the Statewide Transportation Strategy (STS) for reducing GHG emissions from the transportation sector, more recent county-level population forecasts, the approach to distinguishing targets by metropolitan area, and whether the Albany and Grants Pass metropolitan areas are included in the calculations.

2.2.1. Statewide Transportation Strategy

The legislation that established the requirement that LCDC adopt target rules addressing all metropolitan areas also directed the Oregon Transportation Commission of adopt a statewide transportation strategy for reducing GHG emissions.[7]

[6] The formula to calculating the percentage reduction from the ratio is 100 * (1 – ratio).
[7] Chapter 85, Section 2, Oregon Laws 2010.

Development of the STS started prior to the development and adoption of the target rules but was not completed until 2013. Extensive scenario testing was carried out to test various ways for reducing transportation sector GHG emissions to reach a 75% reduction in total emissions by 2050. The completed strategy includes ambitious assumptions for land use planning, alternative modes, systems management, pricing, as well as improvements to vehicle and fuels technologies. This is the scenario that was incorporated into the final strategy. The STS will serve as the basis for calculations that follow. Assumed vehicle emissions reductions are compared with adopted policies to assure that they are reasonable assumptions.

Results of GreenSTEP model runs for the STS recommended scenario were the starting point of the analysis. Tabulations of outputs from the GreenSTEP model of estimated and projected population, daily vehicle miles traveled (DVMT) by light-duty vehicle, and light-duty vehicle CO_2e emissions were made by county and development type (i.e. metropolitan, town, rural). From the tabulations of light-duty vehicle travel, which represent the travel demand of households, the light-duty vehicle travel on metropolitan area roadways was calculated using the conversion factors used for the STS and the analysis done for the original target rules.[8] Factors were estimated for the Albany and Grants Pass metropolitan areas as described below. The conversion factors were also used to convert tabulations of light-duty vehicle CO_2e into tabulations of metropolitan area roadway emissions.

2.2.2. New County-Level Population Forecasts

The analyses that were done for the original target rules and for the STS assumed slightly higher population growth for the state than is now assumed in state forecasts.[9] The current state and metropolitan area population forecasts for 2050 are 5% and 4.5% lower respectively than the forecasts assumed during the development of the target rules and the STS. Since the GHG reduction goal is expressed as the reduction in per capita emissions given a 75% reduction in total emissions from 1990 by 2050, a lower population forecast means that the goal for reducing per capita emissions will be lower as well.

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[8] Light-duty vehicle travel includes travel by households by light-duty vehicles and travel by light-duty commercial service vehicles (e.g. delivery and service vehicles). The GreenSTEP model calculates household light duty vehicle travel and tabulates the travel where the household resides rather than where the household drives, which is not modeled. Commercial service vehicle travel is calculated as a function of household light-duty vehicle travel and is allocated to places in proportion to the allocation of the household light duty vehicle travel. Travel on roadways within a metropolitan area is calculated by factoring the light-duty vehicle travel attributed to the metropolitan area. This metropolitan area factor is estimated for the year 2005 by dividing an estimate of light-duty DVMT on metropolitan area roads by the GreenSTEP model estimate of light-duty DVMT attributable to the metropolitan area households and businesses using the calibrated model. Factors are individual to metropolitan areas. They are held constant for all years.

[9] The STS population forecast was based on two sources. The first was an interim county-level population forecast by age cohort prepared by the Oregon Office of Economic Analysis (OEA). That forecast was developed prior to the release of the 2010 Census population counts. The second was the population forecast for Clackamas, Multnomah, and Washington Counties prepared by Metro. Those forecasts only extended to 2040 so ODOT staff extrapolated the forecasts out to 2050. The current forecasts are from 3 sources. Metro staff provided forecasts out to 2050 for Clackamas, Multnomah, and Washington Counties. The forecasts for Benton, Clatsop, Columbia, Lincoln, Linn, Polk, Tillamook, and Yamhill Counties are from the OEA official forecasts from 2010 to 2050 published in 2013 (https://www.oregon.gov/das/OEA/Pages/forecastdemographic.aspx). The forecasts for all other counties are more recent forecasts prepared by the Portland State University Population Research Center (https://www.pdx.edu/prc/opfp).

The new county-level forecasts were allocated by development type (i.e. metropolitan, town, rural) by assuming that the proportional allocation by development type in each county would be unchanged. Light-duty vehicle DVMT and CO_2e forecasts corresponding to the lower population projection were calculated by scaling the STS forecasts using the ratio between the new population projection and the STS population projection. This was done by county and development type.

2.2.3. How Targets are Distinguished by Metropolitan Area

Three options were presented to the Rules Advisory Committee for how to specify metropolitan area targets. They were:

1. All metropolitan areas have the same targets.
2. There is one set of targets for the Portland metropolitan area and another set of targets for all other metropolitan areas.
3. Every metropolitan area has its own set of targets.

There was very little support for the third option which would require an extensive amount of time and money to provide a strong basis to make distinctions between the targets for the smaller metropolitan areas. The first two options had the most support, but there was no decision as to which should be used.

Since no decision was made whether the first or second option should be used, the analysis for this memo was done for both options. To do this, the tabulations of population, DVMT, and CO_2e by county and development type were summed for all metropolitan areas, for just the Portland metropolitan area, and for just the smaller metropolitan areas. This enabled the results of the two options to be compared.

2.2.4. Including Albany and Grants Pass

Since the target rules were adopted, the populations of the Albany and Grants Pass areas exceeded the threshold for the areas being classified as urbanized by the U.S. Census Bureau. Consequently the areas qualified for having designated metropolitan planning organizations to coordinate transportation planning and federal transportation funding.

Analyzing the option where Albany and Grants Pass are included in the target calculations requires splitting out the estimates of population, DVMT, and CO_2e from those areas from the estimates for other urban areas in Linn and Josephine counties respectively. Proportional splits were calculated using 2010 population estimates for incorporated cities within the counties.[10] The population proportions were used to split DVMT and CO_2e as well.

Analyzing this option also requires the estimation of metropolitan area factors to calculate roadway DVMT and CO_2e from household and commercial service vehicle DVMT and CO_2e. Given the paucity of information available to calculate these factors and limited time available to calculate them, factors were estimated from the estimated factors for other metropolitan areas. Since both Albany and Grants Pass are located on I-5 and the ratio of roadway DVMT to metropolitan household and commercial service DVMT is likely to be affected by I-5 traffic, the roadway factor for these metropolitan areas was

[10] The Albany metropolitan area proportion was calculated by dividing the sum of the Albany, Millersburg, and Tangent city population estimates by the sum of the population estimates for all incorporated cities in Linn County. The Grants Pass metropolitan area proportion was calculated by dividing the Grants Pass population estimate by the sum of the population estimates for all incorporated cities in Josephine County.

calculated as the average of the roadway factors calculated for the Salem-Keizer, Eugene-Springfield, Rogue Valley metropolitan areas.

The relative effects of including the Albany and Grants Pass metropolitan areas in the metropolitan area calculations are explored in the next section of this memo.

3. Comparison of STS-Based Calculations of 2035 Emission Goal and Target with Target Rules and Evaluation of the Effect of New Population Projections

The analysis of emissions goals and targets in this memo uses outputs from GreenSTEP model runs for the STS recommended scenario. In this section, the calculations of per capita emissions goals and targets for 2035 based on the STS are compared with the calculations carried out in 2011 for the target rules. This is done to determine whether improvements to the GreenSTEP model, changes to vehicle and fuels technology forecasts, or policy assumptions in the STS result in significantly different conclusions about what emissions reduction goals and travel targets should be.

The target rules calculations and the STS calculations were based on GreenSTEP model runs that used the same population projections, so the comparison of results is exclusive of the effects of changes to population forecasts. As explained in Section 2.2.2 above, current state and metropolitan area population forecasts are lower respectively than the forecasts assumed during the development of the target rules and the STS. Since the GHG reduction goal is expressed as the reduction in per capita emissions given statutory goals for reducing total emissions, a lower population forecast means that goal for reducing per capita emissions and corresponding target will be lower as well. The effects of population projections also depends on whether or not the Albany and Grants Pass metropolitan areas are included in the calculation of metropolitan area emissions. The effects of alternative population projections on per capita emission reduction goals and travel targets are shown at the end of this section.

Table 1 shows the calculation of the 2035 metropolitan area average per capita emissions, the goal for reducing per capita emissions, and the corresponding target for reducing VMT. These calculations are based on the STS model results for the population projections assumed for the STS and target rules. The calculation steps are as follows:

1. Calculate the metropolitan area proportions of total state roadway CO_2e 2020 and 2050 from STS model run outputs.
2. The goals for 2020 and 2050 total state roadway CO_2e are calculated by reducing 1990 estimated total state roadway CO_2e by 10% and 75% respectively to reflect statutory goals.
3. The metropolitan area roadway CO_2e for 2020 and 2050 are calculated by multiplying the state goals (step 2) by the metropolitan proportions (step 1).
4. Sum up the forecasted metropolitan area populations for 2020 and 2050.
5. The metropolitan area roadway CO_2e per capita for 2020 and 2050 are calculated by dividing the metropolitan area roadway CO_2e (step 3) by the projected metropolitan area population for 2020 and 2050.
6. The rate of decline (% per year) in metropolitan area CO_2e per capita from 2020 to 2050 is calculated from the metropolitan area roadway CO_2e per capita for 2020 and 2050 (step 4).

7. The rate of decline calculated in step 5 is used to calculate metropolitan area roadway CO_2e per capita by year in 2035 and annually for the years from 2040 to 2050.
8. The ratio of future metropolitan area roadway CO_2e per capita (step 6) to base year (i.e. 2005) metropolitan area roadway CO_2e per capita is calculated.
9. From 2005 and 2035 summations of CO_2e and DVMT, calculate the emissions rates (CO_2e per mile) and the ratio of future to base year emissions rates (see Section 4 below).
10. Calculate an overall average target by dividing the CO_2e per capita ratio by the emissions rate ratio.

Table 1: Calculations of Average Metropolitan CO_2e Per Capita Reduction Goal and Corresponding Target Using STS Population Forecast Assumption

Calculation Step	**1990**	**2005**	**2020**	**2035**	**2050**
1. Metropolitan roadway CO_2e proportions of total state roadway CO_2e			0.461		0.372
2. Goals for total state roadway CO_2e for 2020 and 2050 (metric tons per day)	43,584		39,226 (-10%)		10,896 (-75%)
3. Metropolitan area roadway CO_2e for 2020 and 2050 (metric tons per day)			18,089		4,052
4. Metropolitan area population			2,642,300		3,700,467
5. Metropolitan area roadway CO_2e per capita for 2005, 2020 and 2050 (metric tons per year)			2.5		0.4
6. Percentage rate of decline in metropolitan area roadway CO_2e between 2020 and 2050			5.9		
7. Metropolitan area 2035 CO_2e per capita (metric tons per year) and 2005 value for comparison		3.75		1.0	
8. Ratio of 2035 to 2005 metropolitan area roadway CO_2e and percentage reduction				0.27 73.3%	
9. Ratio of 2035 to 2005 vehicle emissions rates (see Section 4)				0.33	
10. Target ratio and percentage reduction				0.81 -19.5%	

The results of the calculations shown in Table 1 are close to the results calculated for the original target rules. The target rule calculations also established a 2035 goal for all metropolitan area roadway CO_2e per capita that was also about 1 metric ton per person per year. The percentage reduction in per capita emissions from the 2005 level was calculated to be 73.7% for the target rules. Furthermore, when an all metropolitan area target is calculated using the assumed change in the vehicle emissions rate (Section 4), the result is close to the average in the target rules (-19.5% vs. -19.7%). These findings are significant because they show that despite upgrades to the GreenSTEP model, revisions to the assumptions about base year and future year vehicle characteristics, and more research into potential state and local policies to reduce GHG emissions, there are very similar outcomes for metropolitan areas as a whole.

To determine the relative effects of the new population projections and inclusion of the Albany and Grants Pass metropolitan areas in the metropolitan area averages, the calculations outlined above were carried on the STS GreenSTEP model results that were factored to reflect the new projections. This was done with both including the Albany and Grants Pass metropolitan areas in the metropolitan area totals, and excluding those areas from the metropolitan area totals. Table 2 compares the 2035 CO_2e per capita, the percentage reduction in the goal (CO_2e per capita)m and the corresponding percentage reduction in the target (VMT per capita) for the original targets, the STS, and the current population projections with and without the inclusion of the Albany and Grants Pass metropolitan areas.

Table 2: Comparison of Average Metropolitan CO_2e Per Capita Reduction Goals and Corresponding Targets for Target Rules, STS, and New Population Projections

Percentage Change from 2005	Target Rules	STS	New Population Forecast	
			Albany and Grants Pass NOT Included	Albany and Grants Pass Included
Goal (MT CO_2e per capita)	1.00	1.00	1.04	1.06
Goal Percent Change	-73.7%	-73.3%	-72.2%	-71.8%
Target Percent Change	19.7%	-19.5%	-16.2%	-14.8%

It can be seen that the STS value for CO_2e per capita is identical (out to 2 decimal points) to the value calculated for the original target rules. Moreover the other values for the STS are very close to the target rules values. The new population projections increase the allowable emissions per capita by 4% to 6%. This corresponds to the difference in the population projections. The differences in the population projections translate into differences in the percentage change in the goal and the target. There is a greater difference in the target percentage change than the goal percentage change because of how the target is defined. This can be understood by reviewing Figure 1.

The bottom line is that the STS results for metropolitan areas as a whole are very close to the results calculated for the original targets. Updating the calculations to account for newer population projections increases the allowable per capita emissions in 2035 by 4% to 6%. This change in allowable per capita emissions results in a significant reduction in the target percentage change.

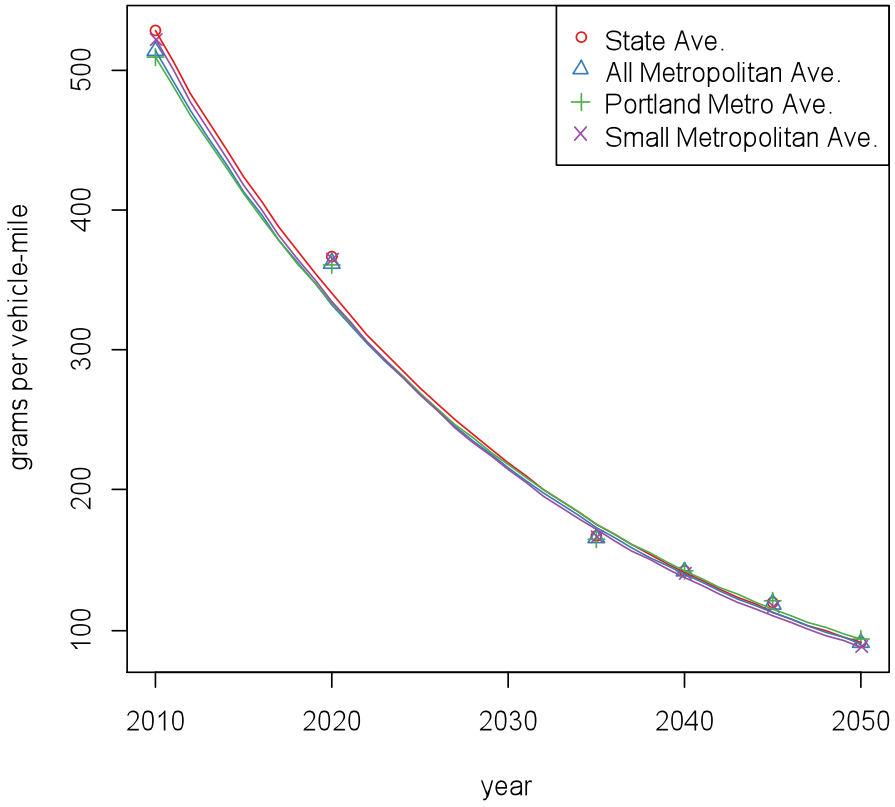
Section 5 of this memo examines several alternative methods for establishing future targets using these results. That analysis is based on the calculations which reflect the new population projections and the inclusion of the Albany and Grants Pass metropolitan areas in the metropolitan area calculations based on the recommendation of DLCD staff.

4. Vehicle Emission Rates

During the process of developing the STS, ODOT and its technical and policy committees concluded that ambitious improvements to vehicle fuels and technology along with local transportation and land use actions and other state policies would be necessary to meet the goal of reducing GHG emissions from

light-duty vehicles by 2050. The recommended scenario assumed that by 2050 over half of the light-duty vehicle fleet would be composed of either electric vehicles or plug-in hybrid electric vehicles. The improvements envisioned by the recommended STS scenario as well as further clean fuels improvements would drastically reduce vehicle emissions rates. Figure 2 shows the modeled fleet average emissions rates (grams of CO_2e per vehicle mile) given the recommended scenario assumptions about deployment of future vehicle technology and clean fuels. The points show the values at key benchmark years for the different levels of metropolitan aggregation. Trend lines are overlaid on the graph.[11] Average vehicle emissions rates would need to decline by a little over 4% per year from the 2010 estimated average in order to achieve the recommended level in 2050. It can be seen that the modeled values vary very little by aggregation level. It can also be seen that the trend lines approximate the modeled values reasonably well.

Figure 2: Fleet-wide Average Light-duty Vehicle Emissions Rates Modeled for the STS Recommended Scenario and Future Trend Lines

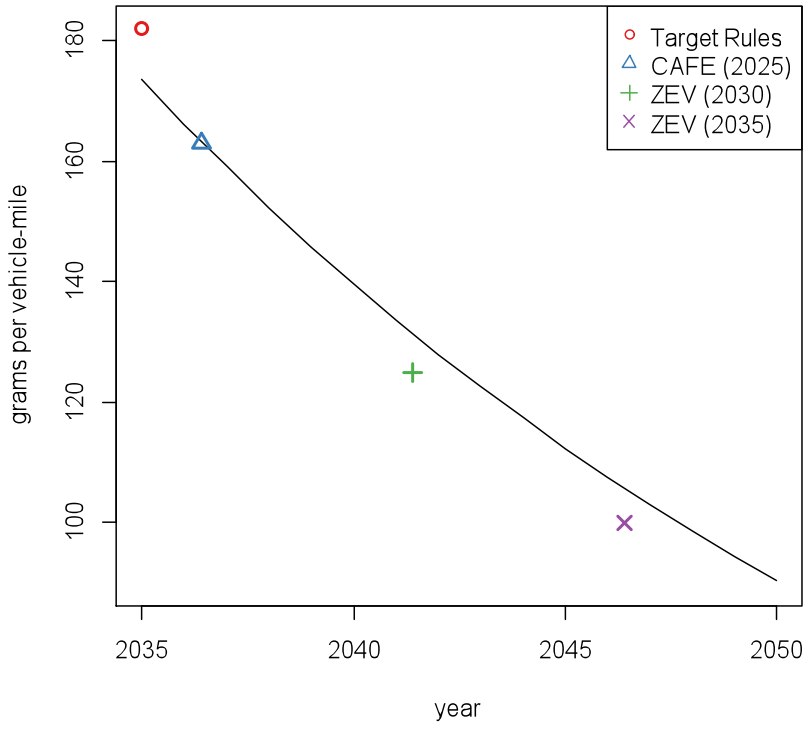


Although the technology assumptions in the STS are ambitious, they are not out of line with other state and federal policies that have been developed since the adoption of the target rules, including the US CAFE standards and California Rule/multi-state Zero Emission Vehicle (ZEV) standards. The CAFE standards equate to an average emissions rate for new vehicles of 163 grams per mile in 2025. The ZEV

[11] It is important to note that these 'trend lines' represent the trend in the model results given the vehicle assumptions in the STS recommended scenario. They do not represent an extrapolation of past trends. In other words, they represent the trend that needs to occur, not the trend that has occurred.

standards equate to average emissions rates for new vehicles of 125 and 100 grams per mile in 2030 and 2035 respectively.[12] Figure 3 compares the STS emission rate "trend line" for all metropolitan areas with the assumed value for the target rules, and with CAFE and ZEV emissions rates. To make the CAFE and ZEV standards, which are new car standards, comparable with the STS values, which are average fleet values, it is assumed that the new car standards will reflect average fleet values when the vehicles sold in those years reach the average vehicle age. The Bureau of Transportation Statistics reports that the national average vehicle age in 2014 (the latest year reported) was 11.4 years.[13] Thus the US CAFE standard for 2025 would reasonably represent the average fleet value in 2036 and the California Rule standards for 2030 and 2035 would represent average fleet values in 2041 and 2046. It can be seen that the STS emissions rate trend line values are close to the target rule, CAFE, and ZEV rule values. Table 3 shows the average projected rates for all years from 2040 to 2050 based on the all metropolitan area future trend line. The members on the Core Tech Team from the Departments of Environmental Quality and Energy agreed that the STS "trend line" is a reasonable reflection of goals that California, Oregon, and other states participating in the multi-state ZEV standards wish to achieve. They caution, however, that this planning trend does not reflect recent trends in vehicle fuel economy. Substantial efforts on the part of states and the federal government will be necessary to make this planning trend a reality.

Figure 3: Comparison of STS Metropolitan Trend Line Vehicle Emissions Rates and Target Rule, CAFE, and ZEV Standard Rates: 2035 to 2050



[12] Email communication from Dave Nordberg, Oregon DEQ, dated September 22, 2016.

[13] http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_01_26.html_mfd

Table 3: Projected Metropolitan Area Vehicle Emissions Rates (CO_2e per vehicle-mile)

Year	Emission Rates (grams / mile)	Ratio With 2005 Value	Percentage Change from 2005 Value
2040	140	0.267	-73%
2041	134	0.255	-74%
2042	128	0.244	-76%
2043	123	0.234	-77%
2044	117	0.224	-78%
2045	112	0.215	-79%
2046	108	0.205	-79%
2047	103	0.197	-80%
2048	99	0.188	-81%
2049	94	0.180	-82%
2050	90	0.173	-83%

5. Target Calculations for the Years 2040 to 2050

This section presents several alternative ways of calculating targets for the years 2040 to 2050 starting with information from the STS. This is done for two of the options previously discussed by the Rules Advisory Committee for allocating emissions reductions between the metropolitan areas:

1. Single statewide target
2. One target for the Portland region and another single target for all other metro areas

5.1. Option 1: Common Targets for All Metropolitan Areas

Table 4 shows the "all metropolitan area" values calculated from STS model results and adjusted to reflect the current county-level population projection and inclusion of the Albany and Grants Pass metropolitan areas in the metropolitan area numbers.

Table 4: Calculation of Uniform Targets for All Metropolitan Areas

Year	Per Capita Emissions		Emissions Rate Change Ratio	Target	
	MT CO2e	Change Ratio		Change Ratio	Percentage Decrease
2040	0.783	0.209	0.267	0.785	-21.5
2041	0.738	0.197	0.255	0.772	-22.8
2042	0.695	0.186	0.244	0.760	-24.0
2043	0.655	0.175	0.234	0.747	-25.3
2044	0.617	0.165	0.224	0.735	-26.5
2045	0.581	0.155	0.215	0.723	-27.7
2046	0.547	0.146	0.205	0.711	-28.9
2047	0.515	0.138	0.197	0.700	-30.0
2048	0.485	0.130	0.188	0.689	-31.1
2049	0.457	0.122	0.180	0.677	-32.3
2050	0.431	0.115	0.173	0.666	-33.4

The per capita emissions are calculated at the same annual rate of decline as shown in line 6 of Table 1. The change ratio for per capita emissions is calculated by dividing the per capita emissions by the average per capita emissions in 2005 (Table 1, line 7). The emissions rate change ratio is from the third column of Table 3. The target change ratio is calculated by dividing the per capita emissions change ratio by the emissions rate change ratio. Finally, the target percentage decrease is calculated from the target change ratio.[14]

5.2 Option 2: Separate Targets for the Portland Metropolitan Area and Other Metropolitan Areas

In this section, several alternative scenarios are presented for targets that are different for the Portland metropolitan area and smaller metropolitan areas. All achieve the same overall emissions in 2050 as Option 1. The scenarios are:

- Assume STS values;
- Assume STS 2035 starting values and equal rates of per capita emissions decline for all metropolitan areas after 2035;
- Assume the Portland metropolitan area achieves a -29% target in 2035 based on the Climate Smart Strategy, the small metropolitan areas make up the difference in emissions in 2035, and after 2035 the rate of decline in per capita emissions is the same for all metropolitan areas;
- Assume the Portland metropolitan area achieves a -20% target in 2035 based on the existing target, the small metropolitan areas make up the difference in emissions in 2035, and after 2035 the rate of decline in per capita emissions is the same for all metropolitan areas;
- Assume the Portland metropolitan area achieves a -20% target in 2035, smaller metropolitan areas achieve a -20% target in 2040, and the rate of decline in per capita emissions is the same for all metropolitan areas.

The results for each alternative are presented without showing all of the intermediate calculations shown in Table 4. Each table shows the target percentage reductions for the Portland metropolitan area and small metropolitan areas, the average per capita emissions for all metropolitan areas, and the average per capita emissions from Table 4 for comparison.

5.2.1 Calculations from the STS

Table 5 shows the results of calculating targets from the population-adjusted model results for the STS. It is important to note that the STS was developed for the purpose of exploring what actions need to occur in order for the transportation sector to achieve the statutory goals for reducing GHG emissions. STS was not developed to determine what the policies of individual metropolitan areas should be to achieve emissions reductions. That is the purpose of metropolitan area scenario planning.

As can be seen, almost all of the burden for reducing CO_2e, beyond reductions due to forecasted improvements to vehicle technology and fuels, falls on the Portland metropolitan area. These results suggest that the STS assumptions may have been too ambitious for the Portland metropolitan area and not ambitious enough for the smaller metropolitan areas. By 2050 per capita VMT in the Portland metropolitan area would be almost cut in half from what it was in 2005. Smaller metropolitan area VMT would only be reduced by 5%. The large difference in targets is due to two things:

[14] 100 * (ChangeRatio – 1)

1. The reductions in the Portland metropolitan area by 2035 are much greater (-26% vs. +4%); and,
2. Per capita emissions decline at a much faster rate in the Portland metropolitan area (-6.6% per year vs. -4.8% per year).

Table 5: Target Reductions Calculated from Populated-Adjusted STS Model Run Outputs

Year	Target % Reductions		Average Per Capita Emissions	
	Portland Met.	Small Met	Alternative	Average from Table 4
2040	-34.8	1.2	0.783	0.783
2041	-36.4	0.6	0.738	0.738
2042	-37.9	0.0	0.695	0.695
2043	-39.4	-0.6	0.655	0.655
2044	-40.8	-1.2	0.617	0.617
2045	-42.3	-1.7	0.581	0.581
2046	-43.7	-2.3	0.547	0.547
2047	-45.0	-2.9	0.515	0.515
2048	-46.3	-3.5	0.485	0.485
2049	-47.6	-4.0	0.457	0.457
2050	-48.9	-4.6	0.431	0.431

The burden on the Portland metropolitan area would decrease significantly and the burden on the smaller metropolitan areas would increase significantly if it is assumed that per capita emissions decline at the same rate for all metropolitan areas after 2035. Table 6 shows the results.

Table 6: Assume STS 2035 Starting Values and Equal Rates of Decline

Year	Target % Reductions		Average Per Capita Emissions	
	Portland Met.	Small Met	Alternative	Average from Table 4
2040	-32.1	-2.0	0.783	0.783
2041	-33.2	-3.6	0.738	0.738
2042	-34.3	-5.2	0.695	0.695
2043	-35.4	-6.7	0.655	0.655
2044	-36.4	-8.2	0.617	0.617
2045	-37.4	-9.7	0.581	0.581
2046	-38.4	-11.2	0.547	0.547
2047	-39.4	-12.6	0.515	0.515
2048	-40.4	-14.0	0.485	0.485
2049	-41.4	-15.4	0.457	0.457
2050	-42.3	-16.8	0.431	0.431

The all metropolitan area average per capita emissions for these alternatives match the averages from Option 1.

5.2.2 Assume Portland Metropolitan Area Achieves a 29% Reduction Target in 2035

In this alternative it is assumed that the Portland metropolitan area achieves a 29% reduction target in 2035 as a result of implementing the Climate Smart Strategy (CSC). The small metropolitan areas are

assumed to make up the difference between the Portland metropolitan area emissions in 2035 and the emissions calculated for all metropolitan areas in 2035. After 2035, it is assumed that per capita emissions for all metropolitan areas will decline at the same annual rate and that the emissions in 2050 will be the same as in Option 1. The results for this alternative are shown in Table 7.

This alternative scenario would have a lower burden on the Portland metropolitan area than the STS alternative (Table 5) even though the assumed reduction for the Portland metropolitan area in 2035 is greater than the STS value (-29% vs. -26%). The smaller reductions for this scenario relative to the STS are due to the assumption that per capita emissions decline at an equal rate in all metropolitan areas. The burden on the Portland metropolitan area is greater with this scenario than with the modified STS alternative shown in Table 6 because of the higher starting reduction in 2035.

Table 7: Assume Portland Metropolitan Area Achieves 29% Reduction Target in 2035

Year	Target % Reductions		Average Per Capita Emissions	
	Portland Met.	Small Met	Alternative	Average from Table 4
2040	-34.5	2.4	0.783	0.783
2041	-35.6	0.8	0.738	0.738
2042	-36.6	-0.9	0.695	0.695
2043	-37.7	-2.5	0.655	0.655
2044	-38.7	-4.0	0.617	0.617
2045	-39.7	-5.6	0.581	0.581
2046	-40.6	-7.1	0.547	0.547
2047	-41.6	-8.6	0.515	0.515
2048	-42.5	-10.1	0.485	0.485
2049	-43.5	-11.5	0.457	0.457
2050	-44.4	-13.0	0.431	0.431

The all metropolitan area average per capita emissions for this alternative match the averages from Option 1.

5.2.3 Assume that the Portland Metropolitan Area Achieves the 20% Target in 2035

The target rules establish a target of a 20% reduction for the Portland metropolitan area in 2035. The small metropolitan area reduction in 2035 is calculated in the same way as in the previous alternative. After 2035, it is assumed that per capita emissions for all metropolitan areas will decline at the same annual rate and that the emissions in 2050 will be the same as in Option 1. Changing the 2035 target assumption for the Portland metropolitan area from -29% to -20% substantially reduces the burden on the Portland metropolitan area and increases it for the smaller metropolitan areas. The results are shown in Table 8.

Table 8: Assume Portland Metropolitan Area Achieves 20% Reduction Target in 2035

Year	Target % Reductions		Average Per Capita Emissions	
	Portland Met.	Small Met.	Alternative	Average from Table 4
2040	-26.3	-12.8	0.783	0.783
2041	-27.5	-14.2	0.738	0.738
2042	-28.6	-15.6	0.695	0.695
2043	-29.8	-16.9	0.655	0.655
2044	-30.9	-18.3	0.617	0.617
2045	-32.1	-19.6	0.581	0.581
2046	-33.2	-20.9	0.547	0.547
2047	-34.2	-22.2	0.515	0.515
2048	-35.3	-23.5	0.485	0.485
2049	-36.4	-24.7	0.457	0.457
2050	-37.4	-25.9	0.431	0.431

The all metropolitan area average per capita emissions for this alternative match the averages from Option 1.

5.2.4 Assume Portland Metropolitan Area Achieves a 20% Target in 2035 and Small Metropolitan Areas Achieve a 20% Target in 2040

As with the previous alternative, this one assumes that the Portland metropolitan area achieves a 20% reduction target in 2035, but rather than assume that the small metropolitan areas make up the difference in emissions, this alternative assumes that the smaller metropolitan areas achieve a 20% reduction target in 2040. As with the other alternatives, it is assumed that the rate of reduction in per capita emissions is the same for all areas and that the emissions in 2050 will be the same as in Option 1. Table 9 shows the results.

Table 9: Assume Portland Metropolitan Area Achieves 20% Reduction Target in 2035 and Smaller Metropolitan Areas Achieve a 20% Reduction Target in 2040.

Year	Target % Reductions		Average Per Capita Emissions	
	Portland Met.	Small Met.	Alternative	Average from Table 4
2040	-25.3	-20.0	0.764	0.783
2041	-26.4	-21.1	0.721	0.738
2042	-27.4	-22.2	0.681	0.695
2043	-28.4	-23.3	0.643	0.655
2044	-29.4	-24.3	0.607	0.617
2045	-30.3	-25.3	0.574	0.581
2046	-31.3	-26.4	0.542	0.547
2047	-32.2	-27.4	0.511	0.515
2048	-33.2	-28.4	0.483	0.485
2049	-34.1	-29.4	0.456	0.457
2050	-35.0	-30.3	0.431	0.431

Unlike the previous alternatives, this alternative does not match the average per capita emissions for Option 1 except for the year 2050. Assuming the smaller metropolitan areas will achieve a 20% reduction by 2040 results in lower per capita emissions. The difference in the per capita emissions decreases as the year 2050 is approached.

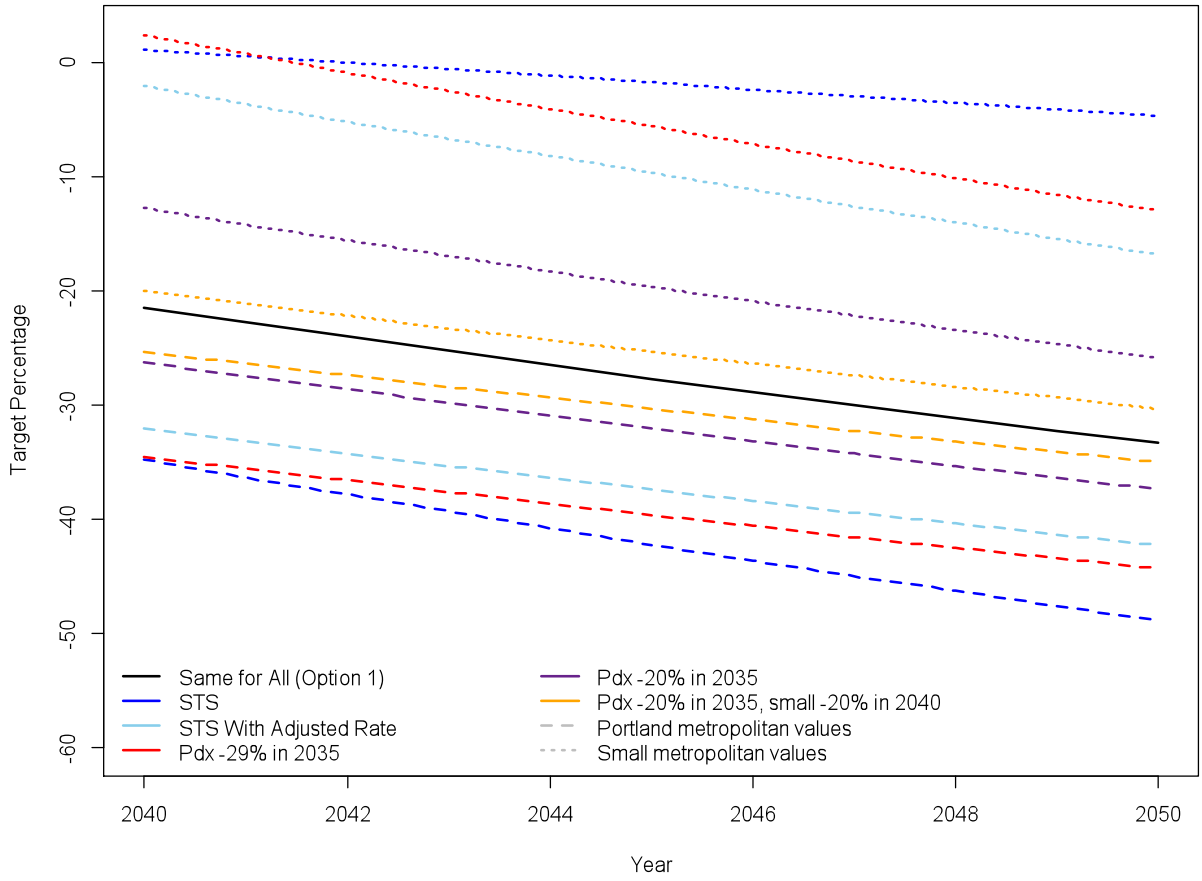
5.3 Summary Comparison

Figure 4 compares the target alternatives presented in Sections 5.1 and 5.2. The solid black line in the middle of the graph shows the alternative where all the metropolitan area targets are the same (Option 1). The dashed lines show the alternatives where the Portland metropolitan area targets and the small metropolitan area targets differ. The wide dashed lines below the solid black line are the Portland metropolitan area targets. The narrow dashed lines above the solid black line are the small metropolitan area targets. The lines are color-coded to identify the values for each alternative as follows:

- Dark Blue: Assuming STS values
- Light Blue: Assuming STS 2035 starting values and equal rates of decline after 2035
- Red: Assuming Portland metropolitan area achieves a -29% target in 2035
- Violet: Assuming Portland metropolitan area achieves a -20% target in 2035
- Yellow: Assuming Portland metropolitan area achieves a -20% target in 2035 and smaller metropolitan areas achieve a -20% target in 2040.

In all but the first alternative in this list, it is assumed that the rates of decline in per capita emissions is the same for all metropolitan areas after 2035. In all but the last alternative in the list, the total metropolitan area emissions every year are the same as the metropolitan area emissions for Option 1. For the last alternative in the list, the total metropolitan area emissions are lower than Option 1 except for the last year (2050).

Figure 4: Comparison of Alternative Targets



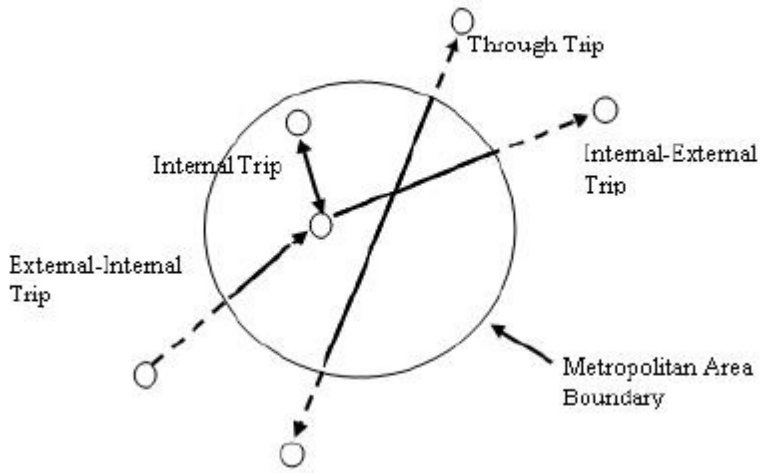
6. Target Specification Issues

This section addresses two issues that have arisen regarding how the targets are specified and how they can be practically applied.

6.1 Application of the Targets to Metropolitan Area Roadway Emissions Rather than to Metropolitan Area Household Emissions

The first of these issues regards the application of the targets to changes in light-duty vehicle travel on metropolitan area roadways rather than by metropolitan area households. Applying the targets to metropolitan area roadway travel necessitates consideration of travel passing through the metropolitan area and travel by persons who live outside the metropolitan area, as well as travel by persons who live within the metropolitan area. Figure 5 illustrates the different categories of travel occurring within a metropolitan area and the portions of that travel which the target rules define the targets as applying to. The small circles in the figure represent different types of origins and destinations of light vehicle trips. The solid lines indicate the portions of the trips that the targets apply to.

Figure 5: Light Vehicle Travel within a Metropolitan Area[15]



As a practical matter, modeling future trends of traffic and GHG emissions from external trip sources and the potential effects of metropolitan area policies on those trends is very difficult, expensive, and time consuming as doing so requires:

- Projecting the populations of all urban and rural areas that would produce travel either destined for the metropolitan area or traveling through the metropolitan area;
- Forecasting how the travel interactions between all the different urban and rural areas would change as their respective populations change;[16]
- Forecasting how different metropolitan area policies in combination with the policies of other metropolitan areas would affect travel interactions and the amount of travel on metropolitan area roadways.

There are models that attempt to do this, but those models cost a lot to develop, require a lot of staff time to run, take a long time to run, and address a limited number of factors that affect GHG emissions.

The GreenSTEP model and Regional Strategic Planning Model (RSPM) that have been used to date for strategic assessments in CAMPO and RVMPO and scenario planning in Metro and CLMPO, model metropolitan area household-related travel emissions, not roadway emissions. This is a more practical, less expensive, and more reliable approach. In addition, it has a stronger relationship to the effects of GHG emissions which, unlike criteria air pollutants, have effects that are minimally related to where they occur. Scenario planning to date, using these models, have translated metropolitan area household

[15] OAR 660-044-0005(10)

[16] For example, as the population of Woodburn grows along with the populations of the Portland and Salem metropolitan areas, will the travel of Woodburn residents grow in equal measure to the two metropolitan areas or will it grow more rapidly to one than the other?

travel and emissions to metropolitan area roadway travel and emissions by applying a factor that is calculated as the ratio of metropolitan roadway VMT to metropolitan household VMT in 2005. This factor is held constant for future forecasts because there is no practical way to forecast how it will change. Since the roadway factor is held constant and since the targets are expressed as the ratio of future year to base year (2005) roadway travel, the roadway travel considerations are superfluous. What is calculated is the ratio of metropolitan area household travel.

Although the targets are practically applied by modeling how metropolitan area household travel would be affected by policies and other changes, the rule reference to metropolitan area roadway travel causes confusion and concerns. Confusion is caused by the questions of how the travel from external sources is to be accounted for. Concern is caused by perceptions that local governments in metropolitan areas have limited abilities to affect travel from external sources. These would be resolved if the targets rules were restated to apply to changes in metropolitan area household-related travel rather than to metropolitan area roadway travel.

There are two types of household-related light vehicle travel that are modeled by the GreenSTEP and RSPM models:

- Travel by household members in light vehicles;
- Commercial vehicle travel using light-duty vehicles that is a function of household labor and/or demand (e.g. delivery and service vehicle travel, travel to business meetings/jobsites, but not commuting to work)

Travel by household members is about 90% of the household-related light vehicle travel. These two categories of travel separately because commercial vehicle fleets have somewhat different characteristics and potentials for reducing GHG emissions. In practice, the amount of household-related commercial vehicle travel has been modeled by assuming it is a fixed proportion of travel in household vehicles.

6.2 How to Express and Calculate the Target

The target rules define the GHG reduction targets as follows:

> *Greenhouse gas emissions reduction target" or "target" means the percent reduction in greenhouse gas emissions from light vehicle travel within a metropolitan area from 2005 emissions levels that is to be met by the year 2035 through scenario planning. Greenhouse gas emissions reduction targets are expressed as a percentage reduction in emissions per capita, i.e., total emissions divided by the population of the metropolitan area.* ***Targets represent additional reductions from 2005 emissions levels beyond reductions in vehicle emissions that are likely to result by 2035 from the use of improved vehicle technologies and fuels and changes to the vehicle fleet.*** *…*[17]

The rules define future vehicle technologies and fuels by specifying a number of detailed characteristics such as average fuel economy, the proportion of electric vehicles, the average vehicle age, changes in the carbon content of fuels, etc. Although the requirement seems simple enough, it has been challenging to implement for a couple of reasons. First, it is not possible to separate the effects of some policies on vehicle travel and on average vehicle emissions. Second, the meaning of the target is not

[17] OAR 660-044-0005(6)

readily understandable and is difficult to communicate. This poses a problem for how to compute whether a plan would achieve the target. These challenges are discussed below.

Equation 2, which translates the target definition into a mathematical relationship, makes the process of determining whether a plan does or does not meet the target seem simple. It has not been so simple in practice because policies that affect vehicle emissions rates also affect vehicle travel and vice versa. For example:

- If fuel economy is increased, the cost of travel (per mile) is reduced. This in turn results in some increase in the miles traveled (i.e. the rebound effect).
- If urban area densities increase, vehicle miles traveled decrease. This would also affect that amount of future travel powered by electricity when plug-in hybrid electric vehicles and battery electric vehicles become more common.

The way in which future vehicle technology and fuel assumptions are specified in the rules add to the problem. Table 10, excerpted from the target rules, shows the baseline assumptions.

Table 10: Table of Baseline Vehicle Technology and Fuel Assumptions in Target Rules[18]

Vehicle Technologies			
Characteristic	**1990 Model Year**	**2005 Model Year**	**2035 Model Year**
Auto fuel economy—internal combustion engine	28 mpg	28 mpg	68 mpg
Light truck fuel economy—internal combustion engine	20 mpg	20 mpg	48 mpg
Auto fuel economy—plug-in hybrids in charge sustaining mode	—	—	81 mpg
Light truck fuel economy—plug-in hybrids in charge sustaining mode	—	—	56 mpg
% of autos that are plug-in hybrids or electric vehicles	—	—	8%
% of light trucks that are plug-in hybrids or electric vehicles	—	—	2%
Plug-in hybrids battery range	—	—	35 miles
Electric vehicles battery range	—	—	175 miles
Vehicle Fuels			
Characteristic	**1990**	**2005**	**2035**
% reduction in fuel carbon intensity from current levels	—	—	20%
Electric power sources compared to current Renewable Portfolio Standard	—	—	Meet
Vehicle Fleet			
Characteristic	**1990**	**2005**	**2035**
Average vehicle replacement rate	10 years	10 years	8 years

The origin of this table was the GreenSTEP model inputs for one of 12 vehicle and fuels scenarios that was considered by the target rules advisory committee at the time the rules were being developed. The committee recommended that this scenario be used in calculating the targets. The data in the table was summarized from the more detailed vehicle and fuel inputs to the GreenSTEP model. Although the table provides a convenient summary of the model inputs, it can't be used directly in the GreenSTEP or RSPM

[18] OAR 660-044-0010(2)

models. Instead the input files that this summary was based on have been used in metropolitan area scenario planning and strategic assessments.[19]

This approach to specifying the future inputs makes it fairly simple to use a model to calculate the emissions for a future scenario and, by also modeling the base year (2005) conditions, calculate the change in CO_2e emissions from base year to the future year. But since the results used in the calculation include the effects of forecasted changes to vehicle and fuel technology, they do not correspond to what the rule is asking for. In order to calculate what the rule is asking for, a third scenario is needed which allows one to remove the technological effects but keep all the other non-technological effects. So, for example, what has been done for all of the scenario planning and strategic assessment work is to create a "2005 hybrid" scenario that has all the 2005 characteristics except for the vehicle and fuel technology characteristics which are the future year characteristics instead. Then by calculating the change between the "2005 hybrid" scenario and the future year scenario we would (ideally) be calculating the change that is due to everything but changes in the emissions rate.

However, the real world and how it is modeled is not the ideal for calculating rule compliance. The problem is that vehicle technology doesn't just affect the emissions rate (grams CO_2e per mile), it also affects the amount of vehicle travel (miles per capita). For example, if fuel economy increases, the emissions rate goes down but the miles driven goes up because the cost to drive goes down as well.[20] This is called the rebound effect and is important to account for in emissions models, which the GreenSTEP and RSPM models do. This means that by using the "2005 hybrid" to calculate the change, we are altering the calculation of the change in the vehicle travel in the process of attempting to remove the effect of the change in the emissions rate due to technology. Calculating the change by using a "future hybrid" which substitutes 2005 technology for the future technology would be not better because it would eliminate any consideration of the effect that future technology will have on the amount of vehicle travel; which could be significant, especially if future fuel costs are high. The issue will become more problematic as the planning horizon extends farther into the future because difference with 2005 technology will become greater and greater.

Two approaches for addressing this problem are described. Both would simplify the rules. In short they are:

1. Establish goals (i.e. change in per capita emissions) rather than targets as they are now defined.
2. Establish targets, but change how they are defined.

Both approaches would replace the table of baseline assumptions in the rule (e.g. Table 10) with a schedule of the average vehicle emissions rate change ratio and/or percentage decrease in the vehicle emissions rate (e.g. Table 3). This would simplify the rules and the procedures for calculating whether the specifications are met.

[19] Changes were made to the input files to support upgrades to the GreenSTEP and RSPM models. The changes were done in a way to maintain consistency with the target rules assumptions.

[20] Fortunately the proportional increase in miles driven is substantially less than the proportional decrease in emissions so the net effect of improving fuel economy is to reduce total emissions.

Approach #1

In the first approach, the rules would specify the goals for reducing per capita emissions by year. This could be done by specifying the ratio of future year per capita emissions to base year (2005) per capita emissions or by specifying a percentage reduction. Row 8 of Table 1 shows an example of both specifications. In addition, the rules would specify the default assumptions for the change in the average vehicle emissions rate (e.g. Table 3). The steps for determining whether a scenario meets the goal would be:

1. Model the base year and the future scenario. The technology and fuels input files would be the ones used to model the STS recommended scenario.
2. Calculate the change in per capita emissions (i.e. change ratio or percentage change) from the model results.
3. Compare the calculated change in per capita emissions to the rule specifications. If the rule specifies a change ratio, the calculated change ratio should be equal to or less than the change ratio specified in the rule. If the rule specifies a percentage reduction, then the calculated reduction should be greater than or equal to the specified reduction.
4. Calculate the change in the average emissions rate from the model results.
5. Compare the calculated change in the average emissions rate with the change ratio specified in the rule. The calculated emissions rate change ratio should be equal to or greater than the change ratio specified in the rule.

Approach #2

In the second approach, the rules would specify targets similar to what is now in the rules. As with the first approach, the rules would also specify the default assumptions for the change in the average vehicle emissions rate (e.g. Table 3). The steps for determining whether a scenario meets the target would be:

1. Model the base year and the future scenario. The technology and fuels input files would be the ones used to model the STS recommended scenario.
2. Calculate the change in per capita emissions (i.e. change ratio) from the model results.
3. Calculate the change in the average emissions rate (i.e. change ratio) from the model results.
4. Calculate the equivalent target change ratio by dividing the change in per capita emissions change by the change in the emissions rate. According to Equation 2:

   *Goal = Rate * Target* therefore:

   Target = Goal / Rate

5. Compare the equivalent target change to the rule specifications. If the rule specifies a change ratio, the calculated change ratio should be equal to or less than the change ratio specified in the rule. If the rule specifies a percentage reduction, then the calculated reduction should be greater than or equal to the specified reduction.
6. Compare the calculated change in the average emissions rate with the change ratio specified in the rule. The calculated emissions rate change ratio should be equal to or greater than the change ratio specified in the rule.

The 2nd approach has one more step than the 1st approach. All that that step does is place the value that is to be compared on a different scale. Rather than comparing the change in per capita emissions, that change is divided by the change in the emissions rate to produce a target.

The last step in each approach is necessary in order to determine that the goal (Approach #1) or target (Approach #2) are not being met just because more ambitious assumptions are being made about improvements to vehicle and fuels technologies. However, having a greater reduction in the vehicle emissions rate than the rule default should not necessarily disqualify a scenario because it may be caused by synergistic interactions between policies.

In addition to being simpler, the first approach would be easier to describe in the rules and explain to planners, the public, and decision makers. Communicating what the existing targets mean and how they relate to other expressed goals (e.g. reduce emissions by 75%) has been very challenging. The targets are not a percent of total emission reductions or a percentage point portion of the overall reduction. Understanding how the targets are calculated requires one to work through an example such as that shown in Figure 1 or to understand algebraic relationships that not a lot of people are familiar with. It would be easier to define and explain a goal for reducing per capita emissions and to explain how that goal relates to the statutory goal for reducing GHG emissions.