

Expanding Transit Signal Priority for the Regional Transit Fleet
TriMet/Metro Coalition
CPRG Implementation Proposal
Documentation of GHG Reduction Assumptions Technical Appendix

The following results were calculated for TriMet's Climate Pollution Reduction Grant Implementation Grant proposal technical appendix. The results in this Technical Analysis were calculated by Good Company, a division of Parametrix based in Eugene, OR. The company has provided climate resiliency and sustainability consulting services to TriMet during the years in which the agency has developed its Climate Action Plan, Fleet Transition Plan and Clean Corridors Plan. The lead analyst on this appendix was Claudia Denton, Climate Consultant for Good Company/Parametrix.

Methodology is primarily based on the approach used in the Preliminary Climate Action Plan prepared for Metro (Portland, OR) but the methodology is fine-tuned to TriMet's specific intentions and context. The methodology includes estimates for emissions reductions for both community emissions and TriMet emissions from fuel savings, which were ultimately added together for the total estimated reductions. Documentation is specific to TriMet.

1. Measure-Specific Documentation: GHG Reduction Estimate Method

The methodology utilized by Good Company is directly related to and in alignment with the regional Priority Climate Action Plan (PCAP) submitted by Metro Regional Government (Metro), one of two metropolitan Planning Organizations (MPOs) serving the Portland, OR, region. Good Company was under contract to develop the GHG emissions reduction calculations for Metro's PCAP. The methodology used in both the TriMet and the Metro PCAP analyses is the California Air Pollution Control Officers Association (CAPCOA) Handbook for Analyzing Greenhouse Gas Emission Reductions, Assessing Climate Vulnerabilities, and Advancing Health and Equity, with some modifications.

For Community Emissions

The methodology follows California Air Pollution Control Officers Association (CAPCOA) [Handbook for Analyzing Greenhouse Gas Emission Reductions, Assessing Climate Vulnerabilities, and Advancing Health and Equity](#): T-27. *Implement Transit-Supportive Roadway Treatments*, adjusting percent of routes for a more accurate "percent of transit vehicle revenue miles", applying reductions to community gasoline use in the Tri-County area serviced by TriMet.

CAPCOA states that "Transit-supportive treatments ... improve transit travel times and reliability. This results in a mode shift from single occupancy vehicles to transit, which reduces VMT and the associated GHG emissions." These assumptions also underlie the Metro PCAP and the region's Regional Transportation Plan.

For TriMet Emissions

There is one bus line already using NextGen TSP in TriMet's system, and there has been extensive analysis of the fuel savings resulting from improved transit travel speeds. In 2023, TriMet's existing TSP vendor, LYT, conducted an analysis for TriMet concluding that .047 gallons of diesel fuel per mile of travel were reduced where TSP was implemented. The number of TriMet revenue miles which would be impacted annually by adding TSP was multiplied by this factor to calculate gallons of fuel to be reduced. Lifecycle emissions were calculated for renewable diesel (R99), because TriMet's fixed route fleet operates using that fuel source and has a contract to continue using that lower carbon option. Though

TriMet has committed to transitioning its entire bus fleet to zero-emission by 2040, that will not occur as part of this specific greenhouse gas reduction strategy or funding application, so R99 is the assumed fuel type to estimate emissions reduction in the short and long term.

2. Models/Tools Used:

As discussed above, the methodology from the CAPCOA Handbook was used to calculate these numbers. The handbook is the basis for a calculator tool, [CalEEMod](#), that is widely used to quantify GHG and air pollutant emissions during environmental review of transportation and development projects in California. CalEEMod is designed to help users assess the cumulative impacts of multiple pollution reduction strategies easily and in an evidence-based manner, which means that it allows for limited customization of assumptions and default values. TriMet elected to use custom calculations based on the CAPCOA handbook rather than CalEEMod for the purposes of this application because this application is focused on a single emissions reduction strategy, and because this approach makes it easier for TriMet to apply detailed data about its fleet and project performance in the analysis and customize calculations while still following an evidence-based methodology.

In addition to the CAPCOA handbook, the following tools were used to aid in the analysis:

- [EPA GHG Equivalencies Calculator](#)
- [Oregon Clean Fuels Program](#)
- [Office of Energy Efficiency and Renewable Energy \(EERE\)](#)
- [TriMet Climate Action Plan](#)
- [California Air Resources Board](#)
- [EPA Motor Vehicles Emission Simulator \(MOVES\)](#)

3. Measure Implementation Assumptions:

The timeline for the implementation of these projects is explained in the workplan narrative. Based on the design and implementation timeline provided in the application, which is based on the project delivery and implementation timeline for similar projects that TriMet and Metro have delivered, the GHG emissions methodology assumes that the Next Generation TSP will be operational on 4 bus lines by September 2028 and that emissions reductions will begin immediately. These 4 routes were selected for analysis for this application because they best met the criteria outlined in page 2 of the workplan: where there is existing transit delay, high existing air pollution levels, where investments will benefit LIDAC communities, balance regional investments, complement other transportation investments and not conflict with future transit project investments.

This application assumes that the project will make improvements for the 8.13% of daily TriMet revenue miles which will be served specifically with these investments.

This funding request covers the labor and capital costs to make the TSP improvements but not the ongoing operations and maintenance of those signals to continue to support these signals through the

2050. Short term (through 2030) maintenance costs are included in the project budget as part of the licensing costs. Longer term operating and maintenance costs responsibilities will be worked out as part of partner agreements.

Research summarized in the CAPCOA handbook has shown that more people use transit when it connects them to destinations more quickly, and has quantified the elasticities relating speed and ridership. TriMet's Bus Delay tool builds on these assumptions by targeting where bus delay is most likely to depress ridership. Analysis conducted as part of the Division Transit Project and for the most recent Regional Transportation Plan showed that increase in transit speed produces an increase in ridership. The CAPCOA methodology assumes that a percentage of these new transit trips will replace car trips, and applies the average length of transit trips to estimate the total VMT reduction.

4. GHG Reduction Estimate Assumptions

This analysis' approach generally aligns with CAPCOA, but was slightly modified with additional input from TriMet regarding fuel savings from TSP treatments. *See GHGcalcs_TriMet for details.*

For Community Emissions

Emissions factors and notes:

- Gasoline: Carbon dioxide (8.78 kg CO₂/gallon) from [EPA Emissions Factors Hub](#). This was modified to E10 per Oregon fuel standards, which is 10% biogenic ethanol, resulting in an emissions factor of 7.90 kg CO₂/gallon of E10 gasoline.
- Methane (.015 grams/mile) and nitrous oxide (.004 grams/mile) emissions factors from MOVES3 Table 2, Model Year 2015 passenger car for the Tri-County Portland Metro area. Gasoline use was estimated by dividing community vehicle miles traveled by an assumed fuel economy of 23 miles per gallon, consistent with the values used in the air quality analysis for the 2023 [Metro Regional Transportation Plan update](#).
- Emissions of greenhouse gases other than CO₂ are converted into CO₂ equivalents using IPCC AR5 GWP values.
- The CAPCOA methodology estimates the percent reduction in total transportation GHG emissions in the community due to increasing transit speeds. Total transportation emissions are assumed to be equivalent to total emissions from gasoline in Multnomah, Washington, and Clackamas counties, which are the three counties that TriMet serves.

GHG Reduction Formula

$$A = -1 \times \frac{B \times C \times D \times E \times G}{F}$$

GHG Calculation Variables

ID	Variable	Value	Unit	Source
Output				
A	Percent reduction in GHG emissions from vehicle travel in plan/community	0–0.6	%	calculated
User Inputs				
B	Percent of plan/community transit routes that receive treatments	0–100	%	user input
Constants, Assumptions, and Available Defaults				
C	Percent change in transit travel time due to treatments	-10	%	TRB 2007
D	Elasticity of transit ridership with respect to transit travel time	-0.4	unitless	TRB 2007
E	Transit mode share in plan/community	Table T-3.1	%	FHWA 2017a
F	Vehicle mode share in plan/community	Table T-3.1	%	FHWA 2017a
G	Statewide mode shift factor	57.8	%	FHWA 2017b

- Output A: The resulting -0.0091% reduction was applied to gasoline emissions in the tri-County area (4,834,609 MT CO₂e) for a result of 439.8 MT CO₂e reduction (methane and nitrous oxide was calculated separately).
- Input B: 4,895 of TriMet's 60,227 daily revenue miles (8.13%) is planned to receive treatment.
- Input C: 10% reduction in transit travel times due to TSP treatments, based on CAPCOA methodology
- Input E and F: Required inputs include transit mode share and vehicle mode share, which were pulled from the [Metro Regional Transportation Plan](#) table 7.2.

For TriMet Emissions

Emissions factors and notes:

- All emissions factors are for lifecycle emissions. This is necessary to capture the full impact of this strategy since TriMet uses R99 diesel (99% renewable diesel) fuel. R99 produces similar tailpipe GHG emissions to conventional diesel, but significantly fewer upstream emissions due to the use of renewable fuel stocks.
- Lifecycle Carbon Intensity Scores are in grams of CO₂e per MJ, in alignment with the Oregon Clean Fuels Program. Greenhouse gases beyond tailpipe methane and nitrous oxide are unknown as CI scores are reported in CO₂e and not split by gas. All GHG emissions that were not known to be methane or nitrous oxide were categorized as carbon dioxide.
- R99 CI score (39g/MJ) is typical for TriMet purchases and is provided by the fuel vendor(s); TriMet has maximum CI score requirements written into the procurement contract(s).

- R99 fuel energy content of 129.7 MJ/gallon were used to calculate CO₂e emissions factor per gallon of fuel. GHG emissions were calculated using anticipated vehicle revenue mile reductions and a fuel reduction per mile, which was multiplied by the estimated emissions factor.
- Methane (.020 grams/mile) and nitrous oxide (.003 grams/mile) emissions factors from MOVES3 Table 12, Model Year 2015 diesel transit buses.
- Emissions of greenhouse gases other than CO₂ are converted into CO₂ equivalents using IPCC AR5 GWP values.

5. Co-pollutant Reduction Estimate Method:

Co-pollutant reductions are estimated from community VMT reduction. 440 MT CO₂ (from gasoline, excludes 2 MT CO₂e from methane and nitrous oxide for accuracy) equals 55,657 gallons of gasoline (assuming an emissions factor of 8.78 kg CO₂/gallon [EPA HUB] and an E10 factor of 7.90 kg CO₂/gallon. From there, an average fuel economy of 23 miles per gallon was assumed, resulting in an annual reduction of 1,280,102 vehicle miles traveled.

$$440 \text{ MT CO}_2 / .0079 \text{ MT CO}_2 \text{ per gallon} * 23 \text{ miles per gallon} = 1,280,102 \text{ miles}$$

Emissions factors and notes:

- NO_x, PM_{2.5}, PM₁₀, VOC, and CO emissions reductions are calculated based on factors from MOVES3 for passenger vehicles, using Metro-specific factors.
- Black carbon and organic carbon emissions reductions are calculated based on factors from MOVES3 Table 2 for passenger vehicles.

Co-pollutant reductions from community VMT are assumed to occur in the same areas as the transit improvements. 42% these reductions occur in LIDAC tracts. TriMet's transit vehicles will not have additional co-pollutant reductions since vehicle revenue miles are estimated to stay consistent with the reference case.

6. Reference Case Scenario (GHG Emissions or Activity Level)

For Community Emissions

The reference case scenario assumes that the current transportation gasoline emissions for the tri-county area (estimated for year 2022) remain unchanged at 4,834,609 MT CO₂e (part of PCAP analysis).

For TriMet Emissions

The reference case scenario assumes that the current transit vehicle revenue miles and use of R99 fuel remain unchanged at 1,786,841 vehicle revenue miles with a fuel economy of 4.78 miles per gallon (average for TriMet buses, not specific to these routes).

7. Measure-Specific Activity

The measures estimated for this application were based on:

- Fuel economy data, and therefore fuel use, along the selected routes.
- Community emissions data is not possible to be tracked by TriMet; however, implementation is estimated to reduce GHG emissions by 442 MT CO₂e. This is estimated to equal community VMT reduction by 1,280,102 miles per year through mode shift to transit.

To calculate activity data, we used a similar approach to the evaluation of TriMet’s existing TSP system to evaluate GHG emissions, cost-effectiveness, as well as operational cost-savings. Fuel usage along with vehicle miles traveled were measured on FX2 buses during the TSP On/Off study conducted in May 2023. We use these measurements to derive an approximate fuel savings factor of .047 gallons per mile traveled when TSP is enabled. This fuel savings factor was applied to the total vehicle miles traveled on applicable TriNet routes based on the weekday revenue miles to determine the “Estimated Fuel Savings (gal)” values. To calculate “Estimated Emissions Reductions (Metric Tons),” we multiply the estimated fuel savings gallons by the EPA’s conversion factor of 0.01018 metric tons CO₂/gallon of diesel. For the cost savings calculation, we assume an average cost of \$5/gal of diesel fuel.

Should additional investments be made in other frequency improvements, transit priority or access to transit improvements on these roadways, transitioning some buses to battery electric or other improvements to improve ridership the greenhouse gas reductions and cost savings will improve.

See *GHGcalcs_TriMet* for calculations.

8. GHG Emissions Reduced

Combined Emissions Potential

Emissions Reduction Potential								
Annual		Implementation date	Number of years in implementation - 2030	2025-2030		Number of years in implementation - 2050	2025-2050	
(868)	MT CO ₂ e	Sept. 2028	2.33	(2,024)	MT CO ₂ e	22.33	(19,375)	MT CO ₂ e

Greenhouse Gas <i>in MT CO₂e</i>	Current Emissions from community gasoline (tri-County) and avoidable emissions from buses	2030 Emissions Reductions from four bus lines with TSP	2050 Emissions Reductions from four bus lines with TSP
Carbon dioxide equivalent (CO ₂ e)	4,835,035	(2,024)	(19,375)
Carbon dioxide (CO ₂)	4,814,297	(2,017)	(19,309)
Methane (CH ₄)	5,886	(4)	(34)
Nitrous oxide (N ₂ O)	14,852	(3)	(32)
Other high-GWP gases	N/E	N/E	N/E

Cost Efficiency

Cost Efficiency		
Total cost	Per ton through 2030	Per ton through 2050
\$ 8,690,881	\$4,293 / MT CO ₂ e	\$449 / MT CO ₂ e

Co-pollutant Emissions Reduced

Co-pollutant	2020 grams per mile	2030 grams per mile	2045 grams per mile
NO _x	0.421938579	0.039157018	0.007384454
PM _{2.5}	0.005486729	0.001555221	0.000630074
PM ₁₀	0.006132566	0.001746546	0.000710629
VOC	0.166844402	0.034458958	0.025512737
CO	3.463451853	1.314081447	0.965093155
Source: Metro specific factors based on MOVES3			
Co-pollutant	Grams per mile		
Black carbon	.002		
Organic carbon	.001		
Source: MOVES3, Table 2 for passenger vehicles model year 2015			

Co-pollutant	Annual reductions 2020 (kg)	Annual reductions 2030 (kg)	Annual reductions 2045 (kg)
NO _x	(540)	(50)	(9)
PM _{2.5}	(7)	(2)	(1)
PM ₁₀	(8)	(2)	(1)
VOCs	(214)	(44)	(33)
CO	(4,434)	(1,682)	(1,235)
Annual (kg)			
Black carbon	(3)		
Organic carbon	(1)		
LIDAC results (42%) Co-pollutant	Annual emissions 2020 (kg)	Annual emissions 2030 (kg)	Annual emissions 2045 (kg)
NO _x	(229)	(21)	(4)
PM _{2.5}	(3)	(1)	(0)
PM ₁₀	(3)	(1)	(0)
VOCs	(91)	(19)	(14)
CO	(1,881)	(714)	(524)

	Annual (kg)
Black carbon	(1)
Organic carbon	(1)

For TriMet Emissions

No co-pollutant reductions from TriMet's transit vehicles are estimated for this project since vehicle revenue miles are estimated to stay consistent with the reference case.

9. **GHG Emission Reduction Calculations** are attached as *GHGcalcs_TriMet-Coalition.xlsx*.