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TECHNICAL APPENDICES – VMT
FPC RESIDENTIAL

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APPENDIX A

CAPCOA VMT REDUCTION MEASURE EXCERPTS

T-1. Increase Residential Density

GHG Mitigation Potential

Up to 30.0% of GHG emissions from project VMT in the study area

Co-Benefits (icon key on pg. 34)

Climate Resilience

Increased density can put people closer to resources they may need to access during an extreme weather event. Increased density can also shorten commutes, decreasing the amount of time people are on the road and exposed to hazards such as extreme heat or flooding.

Health and Equity Considerations

Neighborhoods should include different types of housing to support a variety of household sizes, age ranges, and incomes.

Measure Description

This measure accounts for the VMT reduction achieved by a project that is designed with a higher density of dwelling units (du) compared to the average residential density in the U.S. Increased densities affect the distance people travel and provide greater options for the mode of travel they choose. Increasing residential density results in shorter and fewer trips by single-occupancy vehicles and thus a reduction in GHG emissions. This measure is best quantified when applied to larger developments and developments where the density is somewhat similar to the surrounding area due to the underlying research being founded in data from the neighborhood level.

Subsector

Land Use

Locational Context

Urban, suburban

Scale of Application

Project/Site

Implementation Requirements

This measure is most accurately quantified when applied to larger developments and/or developments where the density is somewhat similar to the surrounding neighborhood.

Cost Considerations

Depending on the location, increasing residential density may increase housing and development costs. However, the costs of providing public services, such as health care, education, policing, and transit, are generally lower in more dense areas where things are closer together. Infrastructure that provides drinking water and electricity also operates more efficiently when the service and transmission area is reduced. Local governments may provide approval streamlining benefits or financial incentives for infill and high-density residential projects.

Expanded Mitigation Options

When paired with Measure T-2, *Increase Job Density*, the cumulative densification from these measures can result in a highly walkable and bikeable area, yielding increased co-benefits in VMT reductions, improved public health, and social equity.

GHG Reduction Formula

$$A = \frac{B - C}{C} \times D$$

GHG Calculation Variables

ID	Variable	Value	Unit	Source
Output				
A	Percent reduction in GHG emissions from project VMT in study area	0–30.0	%	calculated
User Inputs				
B	Residential density of project development	[ ]	du/acre	user input
Constants, Assumptions, and Available Defaults				
C	Residential density of typical development	9.1	du/acre	Ewing et al. 2007
D	Elasticity of VMT with respect to residential density	-0.22	unitless	Stevens 2016

Further explanation of key variables:

- (C) – The residential density of typical development is based on the blended average density of residential development in the U.S. forecasted for 2025. This estimate includes apartments, condominiums, and townhouses, as well as detached single-family housing on both small and large lots. An acre in this context is defined as an acre of developed land, not including streets, school sites, parks, and other undevelopable land. If reductions are being calculated from a specific baseline derived from a travel demand forecasting model, the residential density of the relevant transportation analysis zone should be used instead of the value for a typical development.
- (D) – A meta-regression analysis of five studies that controlled for self-selection found that a 0.22 percent decrease in VMT occurs for every 1 percent increase in residential density (Stevens 2016).

GHG Calculation Caps or Maximums

Measure Maximum

(A_{max}) The percent reduction in GHG emissions (A) is capped at 30 percent. The purpose for the 30 percent cap is to limit the influence of any single built environmental factor (such as density). Projects that implement multiple land use strategies (e.g., density, design, diversity) will show more of a reduction than relying on improvements from a single built environment factor.

Subsector Maximum

($\sum A_{max_{T\text{-}1 \text{ through } T\text{-}4}} \leq 65\%$) This measure is in the Land Use subsector. This subcategory includes Measures T-1 through T-4. The VMT reduction from the combined implementation of all measures within this subsector is capped at 65 percent.

Example GHG Reduction Quantification

The user reduces VMT by increasing the residential density of the project study area. In this example, the project's residential density would be 15 du per acre (B), which would reduce GHG emissions from project VMT by 14.2 percent.

$$A = \frac{15 \frac{du}{ac} - 9.1 \frac{du}{ac}}{9.1 \frac{du}{ac}} \times -0.22 = -14.2\%$$

Quantified Co-Benefits

Improved Local Air Quality

The percent reduction in GHG emissions (A) would be the same as the percent reduction in NO_X, CO, NO_2, SO_2, and PM. Reductions in ROG emissions can be calculated by multiplying the percent reduction in GHG emissions (A) by an adjustment factor of 87 percent. See *Adjusting VMT Reductions to Emission Reductions* above for further discussion.

Energy and Fuel Savings

The percent reduction in vehicle fuel consumption would be the same as the percent reduction in GHG emissions (A).

VMT Reductions

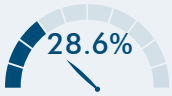
The percent reduction in VMT would be the same as the percent reduction in GHG emissions (A).

Sources

- Ewing, R., K. Bartholomew, S. Winkelman, J. Walters, and D. Chen. 2007. *Growing Cooler: The Evidence on Urban Development and Climate Change*. October. Available: https://www.nrdc.org/sites/default/files/cit_07092401a.pdf. Accessed: January 2021.
- Stevens, M. 2016. Does Compact Development Make People Drive Less? *Journal of the American Planning Association* 83:1(7–18), DOI: 10.1080/01944363.2016.1240044. November. Available: https://www.researchgate.net/publication/309890412_Does_Compact_Development_Make_People_Drive_Less. Accessed: January 2021.

T-4. Integrate Affordable and Below Market Rate Housing

GHG Mitigation Potential



Up to 28.6% of GHG emissions from project/site multifamily residential VMT

Co-Benefits (icon key on pg. 34)

Climate Resilience

Increasing affordable housing creates the opportunity for a greater diversity of people to be closer to their desired destinations and the resources they may need to access during an extreme weather event. Close proximity to destinations allows for more opportunities to use active transportation and transit and to be less reliant on private vehicles. Alleviating the housing-cost burden also enables more people to remain housed, and increases people's capacity to respond to disruptions, including climate impacts.

Health and Equity Considerations

Neighborhoods should include different types of housing to support a variety of household sizes, age ranges, abilities, and incomes.

Measure Description

This measure requires below market rate (BMR) housing. BMR housing provides greater opportunity for lower income families to live closer to job centers and achieve a jobs/housing match near transit. It is also an important strategy to address the limited availability of affordable housing that might force residents to live far away from jobs or school, requiring longer commutes. The quantification method for this measure accounts for VMT reductions achieved for multifamily residential projects that are deed restricted or otherwise permanently dedicated as affordable housing.

Subsector

Land Use

Locational Context

Urban, suburban

Scale of Application

Project/Site

Implementation Requirements

Multifamily residential units must be permanently dedicated as affordable for lower income families. The California Department of Housing and Community Development (2021) defines lower-income as 80 percent of area median income or below, and affordable housing as costing 30 percent of gross household income or less.

Cost Considerations

Depending on the source of the affordable subsidy, BMR housing may have implications for development costs but would also have the benefit of reducing costs for public services, similar to Measure T-1, *Increase Residential Density*.

Expanded Mitigation Options

Pair with Measure T-1, *Increase Residential Density*, and Measure T-2, *Increase Job Density*, to achieve greater population and employment diversity.

GHG Reduction Formula

$A = B \times C$

GHG Calculation Variables

ID	Variable	Value	Unit	Source
Output				
A	Percent reduction in GHG emissions from Project/Site VMT for multifamily residential developments	0–28.6	%	calculated
User Inputs				
B	Percent of multifamily units permanently dedicated as affordable	0–100	%	user input
Constants, Assumptions, and Available Defaults				
C	Percent reduction in VMT for qualified units compared to market rate units	-28.6	%	ITE 2021

Further explanation of key variables:

- (B) – This refers to percent of multifamily units in the project that are deed restricted or otherwise permanently dedicated as affordable.
- (C) – The 11th Edition of the *ITE Trip Generation Manual* (ITE 2021) contains daily vehicle trip rates for market rate multifamily housing that is low-rise and not close to transit (ITE code 221) as well as affordable multifamily housing (ITE code 223). While these rates do not account for trip length, they serve as a proxy for the expected difference in vehicle trip generation and VMT generation presuming similar trip lengths for both types of land use. If the user has information about trip length differences between market rate and affordable housing, then adjusting the percent reduction accordingly is recommended.

  Users should note that the ITE trip rate estimates are based on a small sample of studies for the affordable housing rate and that no stratification of affordable housing by number of stories was available. This is an important distinction since the multifamily low-rise vehicle trip rate applies to four or fewer stories. Therefore, this measure may not apply to affordable housing projects with more than four stories.

GHG Calculation Caps or Maximums

Measure Maximum

(A_{max}) The maximum GHG reduction from this measure is 28.6 percent. This maximum scenario is presented in the below example quantification.

Subsector Maximum

($\sum A_{max_{T\text{-}1 \text{ through } T\text{-}4}} \leq 65\%$) This measure is in the Land Use subsector. This subsector includes Measures T-1 through T-4. The VMT reduction from the combined implementation of all measures within this subsector is capped at 65 percent.

Example GHG Reduction Quantification

The user reduces project VMT by requiring a portion of the multifamily residential units to be permanently dedicated as affordable. In this example, the percent of units (B) is 100 percent, which would reduce GHG emissions from VMT by 28.6 percent.

$$A = 100\% \times -28.6\% = -28.6\%$$

Quantified Co-Benefits

Improved Local Air Quality

The percent reduction in GHG emissions (A) would be the same as the percent reduction in NO_X, CO, NO_2, SO_2, and PM. Reductions in ROG emissions can be calculated by multiplying the percent reduction in GHG emissions (A) by an adjustment factor of 87 percent. See *Adjusting VMT Reductions to Emission Reductions* above for further discussion.

Energy and Fuel Savings

The percent reduction in vehicle fuel consumption would be the same as the percent reduction in GHG emissions (A).

VMT Reductions

The percent reduction in VMT would be the same as the percent reduction in GHG emissions (A).

Sources

- California Department of Housing and Community Development. 2021. *Income Limits*. Available: https://www.hcd.ca.gov/grants-funding/income-limits/index.shtml#:~:text=%E2%80%9CAffordable%20housing%20cost%E2%80%9D%20for%20lower,of%20gross%20income%2C%20with%20variations. Accessed; November 2021.
- Institute of Transportation Engineers (ITE). 2021. *Trip Generation Manual*. 11th Edition. Available: https://www.ite.org/technical-resources/topics/trip-and-parking-generation/. Accessed; November 2021.