Quantification Methodology

Strategic Growth Council
Affordable Housing and Sustainable Communities Program

California Climate Investments

February 25, 2021
Quantification Methodology for the SGC AHSC Program

Table of Contents

Section A. Introduction ................................................................................................... 1
  Methodology Development .......................................................................................... 2
  Tools........................................................................................................................... 4
  Updates....................................................................................................................... 4

Section B. Methods ......................................................................................................... 6
  Project Components ................................................................................................... 6
  General Approach ....................................................................................................... 7
  A. Affordable Housing Developments and Residential Transit Subsidies .................. 8
  B. Solar PV Electricity Generation ............................................................................. 17
  C. New Bicycle Facility or Walkway .......................................................................... 18
  D. New or Expanded Bike Share .............................................................................. 20
  E. New or Expanded Bus, Cable Car, Rail, Streetcar, Shuttle, Trolley Bus, or Van Service ................................................................................................................................................................................................. 22
  F. New or Expanded Ferry Service ........................................................................... 25
  G. Capital Improvements and Fare Reductions ........................................................ 27

Section C. References ................................................................................................... 28

Table 1. Project Components by Eligible Cost ............................................................... 6
Table 2. General Approach to Quantification by Project Component ........................... 7
Table 3. Minimum Net Density by Project Area Type .................................................. 11
Table 4. Maximum VMT Reductions by Project Area Type .......................................... 13
Table 5. Active Transportation Adjustment Factors ................................................... 18
Table 6. Key Destination Credits ................................................................................ 19
Table 7. Default Trip Lengths and Adjustment Factors by Mode .................................. 22
List of Acronyms and Abbreviations

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHSC</td>
<td>Affordable Housing and Sustainable Communities</td>
</tr>
<tr>
<td>Caltrans</td>
<td>California Department of Transportation</td>
</tr>
<tr>
<td>CARB</td>
<td>California Air Resources Board</td>
</tr>
<tr>
<td>CMAQ</td>
<td>Congestion Mitigation and Air Quality</td>
</tr>
<tr>
<td>Diesel PM$_{10}$</td>
<td>diesel particulate matter with a diameter less than 10 micrometers</td>
</tr>
<tr>
<td>DC</td>
<td>direct current</td>
</tr>
<tr>
<td>g</td>
<td>grams</td>
</tr>
<tr>
<td>gal</td>
<td>gallons</td>
</tr>
<tr>
<td>gCO$_2$e/MJ</td>
<td>grams of carbon dioxide equivalent per megajoule</td>
</tr>
<tr>
<td>GGRF</td>
<td>Greenhouse Gas Reduction Fund</td>
</tr>
<tr>
<td>GHG</td>
<td>greenhouse gas</td>
</tr>
<tr>
<td>ICP</td>
<td>Integrated Connectivity Project Area</td>
</tr>
<tr>
<td>kg</td>
<td>kilograms</td>
</tr>
<tr>
<td>kWh</td>
<td>kilowatt hours</td>
</tr>
<tr>
<td>lbs</td>
<td>pounds</td>
</tr>
<tr>
<td>MTCO$_2$e</td>
<td>metric tons of carbon dioxide equivalent</td>
</tr>
<tr>
<td>NO$_x$</td>
<td>nitrous oxide</td>
</tr>
<tr>
<td>PM$_{2.5}$</td>
<td>particulate matter with a diameter less than 2.5 micrometers</td>
</tr>
<tr>
<td>PV</td>
<td>photovoltaic</td>
</tr>
<tr>
<td>RIPA</td>
<td>Rural Innovation Project Area</td>
</tr>
<tr>
<td>ROG</td>
<td>reactive organic gas</td>
</tr>
<tr>
<td>scf</td>
<td>standard cubic feet</td>
</tr>
<tr>
<td>SGC</td>
<td>Strategic Growth Council</td>
</tr>
<tr>
<td>TOD</td>
<td>Transit Oriented Development Project Area</td>
</tr>
<tr>
<td>VMT</td>
<td>vehicle miles traveled</td>
</tr>
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</table>
Section A. Introduction

California Climate Investments is a statewide initiative that puts billions of Cap-and-Trade dollars to work facilitating GHG emission reductions; strengthening the economy; improving public health and the environment; and providing benefits to residents of disadvantaged communities, low-income communities, and low-income households, collectively referred to as “priority populations.” Where applicable and to the extent feasible, California Climate Investments must maximize economic, environmental, and public health co-benefits to the State.

CARB is responsible for providing guidance on estimating the GHG emission reductions and co-benefits from projects receiving monies from the GGRF. This guidance includes quantification methodologies, co-benefit assessment methodologies, and benefit calculator tools. CARB develops these methodologies and tools based on the project components eligible for funding by each administering agency, as reflected in the program expenditure records available at: www.arb.ca.gov/cci-expenditurerecords.

For the SGC AHSC Program, CARB developed this AHSC Quantification Methodology to provide guidance for estimating the GHG emission reductions and selected co-benefits of each proposed project type. This methodology uses calculations to estimate GHG emission reductions from avoided passenger VMT as a result of land use, housing, and transportation strategies to support infill, compact, and affordable housing development projects, in addition to GHG emission reductions from solar PV electricity generation.

The AHSC Benefits Calculator Tool automates methods described in this document, provides a link to a step-by-step user guide with a project example, and outlines documentation requirements. Applicants will estimate and SGC will report the total project GHG emission reductions and co-benefits estimated using the AHSC Benefits Calculator Tool, as well as the total project GHG emission reductions per dollar of GGRF funds requested. The AHSC Benefits Calculator Tool is available for download at: www.arb.ca.gov/cci-resources.

Using many of the same inputs required to estimate GHG emission reductions, the AHSC Benefits Calculator Tool estimates the following co-benefits and key variables from AHSC projects:

- Passenger VMT reductions (miles);
- Net density (dwelling units per acre);
- Renewable energy generation (kWh);
- Local and remote ROG emission reductions (lbs);
- Local and remote NOx emission reductions (lbs);
- Local and remote PM2.5 emission reductions (lbs);
- Local diesel PM10 emission reductions (lbs);
Quantification Methodology for the SGC AHSC Program

- Fossil fuel use reductions (gallons);
- Travel cost savings ($); and
- Energy and fuel cost savings ($).

Additional co-benefits for which CARB assessment methodologies were not incorporated into the Benefits Calculator Tool may also be applicable to the project. Applicants should consult the AHSC Guidelines\(^1\), solicitation materials, and agreements to ensure they meet AHSC requirements. All CARB co-benefit assessment methodologies are available at: [www.arb.ca.gov/cci-cobenefits](http://www.arb.ca.gov/cci-cobenefits).

**Methodology Development**

CARB developed this Quantification Methodology consistent with the guiding principles of California Climate Investments, including ensuring transparency and accountability.\(^2\) CARB developed this AHSC Quantification Methodology to be used to estimate the outcomes of proposed projects, inform project selection, and track results of funded projects. The implementing principles ensure that the methodology would:

- Apply at the project level;
- Provide uniform methods to be applied statewide and be accessible by all applicants;
- Use existing and proven tools and methods, where available and appropriate;
- Use project-level data, where available and appropriate; and
- Result in GHG emission reduction estimates that are conservative and supported by empirical literature.

CARB assessed peer-reviewed literature and tools and consulted with experts, as needed, to determine methods appropriate for the AHSC project types. CARB also consulted with SGC to determine the project-level inputs available. The methods were developed to provide estimates that are as accurate as possible with data readily available at the project level.

CARB released the Draft AHSC Quantification Methodology and Draft AHSC Benefits Calculator Tool for public comment in September 2020. This Final AHSC Quantification Methodology and accompanying AHSC Benefits Calculator Tool have been updated to address public comments, where appropriate, and for consistency with updates to the AHSC Guidelines.

The “Methods to Find the Cost-effectiveness of Funding Air Quality Projects for Evaluating Motor Vehicle Registration Fee Projects and Congestion Mitigation and Air Quality Improvement Projects” were the basis for developing the GHG emission

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\(^1\) Strategic Growth Council. [sgc.ca.gov/programs/ahsc/resources/guidelines.html](http://sgc.ca.gov/programs/ahsc/resources/guidelines.html)

\(^2\) California Air Resources Board. [www.arb.ca.gov/cci-fundingguidelines](http://www.arb.ca.gov/cci-fundingguidelines)
reduction estimates for transit and connectivity project features. The CMAQ Methods are equations for evaluating the cost-effectiveness of certain types of transportation projects, such as bicycle paths, vanpools, and new bus services. CARB and the California Department of Transportation developed the CMAQ Methods, which are used statewide by transportation agencies to assess criteria and toxic pollutant emission reductions from transportation projects competing for State motor vehicle fee and federal CMAQ funding. All of the CMAQ Methods equations and assumptions needed for this quantification method are included in this document, and some assumptions have been modified as necessary. Therefore, the equations presented in this Quantification Methodology are referred to as Transit and Connectivity Methods. The CMAQ Methods Guide is available at: www.arb.ca.gov/planning/tsaq/eval/eval.htm.

To develop VMT reduction estimates for projects that include affordable housing developments, the AHSC Benefits Calculator Tool uses information from the California Statewide Travel Demand Model, metropolitan planning organizations, the Institute of Transportation Engineers Trip Generation Manual and Parking Generation Manual, and the California Air Pollution Control Officers Association “Quantifying Greenhouse Gas Mitigation Measures” report and California Emissions Estimator Model®. The AHSC Benefits Calculator Tool adapts a methodology from this model for ease of use and alignment with the specific requirements of the AHSC Program.

In addition, the University of California, Berkeley, in collaboration with CARB, developed assessment methodologies for a variety of co-benefits such as providing cost savings, lessening the impacts and effects of climate change, and strengthening community engagement. Co-benefit assessment methodologies are posted at: www.arb.ca.gov/cci-cobenefits.

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4 California Department of Transportation. California Statewide Travel Demand Model. 2016. dot.ca.gov/programs/transportation-planning/multi-modal-system-planning/statewide-modeling

5 The Association of Monterey Bay Area Governments, Butte County Association of Governments, Metropolitan Transportation Commission, Sacramento Area Council of Governments, San Luis Obispo Council of Governments, and Southern California Association of Governments provided trip length data for this AHSC Quantification Methodology.


The AHSC Quantification Methodology and AHSC Benefits Calculator Tool are applicable only to AHSC project types and should not be used to estimate GHG emission reductions or co-benefits for any projects which do not meet AHSC Program requirements.

**Tools**

The AHSC Benefits Calculator Tool relies on project-specific outputs from the National Renewable Energy Laboratory PVWatts® Calculator, a web-based tool that estimates the electricity production of grid-connected roof- or ground-mounted solar PV systems. PVWatts calculates estimated values for the proposed system’s monthly and annual electricity production. For projects that include solar PV systems, the AHSC Benefits Calculator Tool relies on estimates of solar PV electricity generation from PVWatts. PVWatts is publicly available to anyone with internet access, free of charge, and subject to regular updates to incorporate new information. The tool can be accessed at: [pvwatts.nrel.gov](http://pvwatts.nrel.gov).

In addition to PVWatts, the AHSC Benefits Calculator Tool relies on CARB-developed emission factors. CARB has established a single repository for emission factors used in CARB benefits calculator tools, referred to as the California Climate Investments Quantification Methodology Emission Factor Database, available at: [www.arb.ca.gov/cci-resources](http://www.arb.ca.gov/cci-resources). The Emission Factor Database Documentation explains how emission factors used in CARB benefits calculator tools are developed and updated.

Applicants must use the AHSC Benefits Calculator Tool to estimate the GHG emission reductions and co-benefits of the proposed project. The AHSC Benefits Calculator Tool and User Guide can be downloaded from: [www.arb.ca.gov/cci-resources](http://www.arb.ca.gov/cci-resources).

**Updates**

CARB staff periodically review each quantification methodology to evaluate its effectiveness and update methodologies to make them more robust, user-friendly, and appropriate to the projects being quantified. CARB updated the AHSC Quantification Methodology and AHSC Benefits Calculator Tool from the previous versions\(^\text{10}\) to enhance the analysis and provide additional clarity, including the following additions:

- Guidance to clarify frequently asked questions;
- Updated GHG emission factors and fuel economy values for passenger autos;
- Simplified inputs for residential parking;

\(^{10}\) California Air Resources Board. November 2019. [www.arb.ca.gov/cci-resources](http://www.arb.ca.gov/cci-resources)
• Equations to estimate GHG emission reductions and co-benefits from conversion of Class II bike lanes to Class IV separated bikeways and new bicycle boulevards;
• Project-specific useful life and trips inputs for bike share;
• Equations to estimate GHG emissions from bike share collection and distribution vehicles;
• Growth factor adjustments for bicycle infrastructure;
• Annual rather than daily ridership inputs for transit;
• Optional carbon intensity and fuel consumption inputs for transit vehicles;
• Revised guidance on transit vehicle useful life;
• Equations to estimate GHG emission reductions and co-benefits from transit fare reductions;
• Updated data on job center locations; and
  Separate summaries of GHG emission reductions from housing, active transportation, and solar PV components and transit components.
Section B. Methods

The following section provides details on the methods supporting emission reductions in the AHSC Benefits Calculator Tool.

Project Components

SGC developed five categories of eligible costs that meet the objectives of the AHSC Program.\(^{11}\) For quantification purposes, CARB defined project components within those eligible costs for which there are methods to quantify GHG emission reductions.

Other project features may be eligible for funding under the AHSC Program; however, each project requesting GGRF funding must include at least one of the project components listed in Table 1 below.

<table>
<thead>
<tr>
<th>Eligible Cost</th>
<th>Project Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Affordable Housing Development; Housing-related Infrastructure</td>
<td>Construction or substantial rehabilitation of affordable housing, including mixed-use development, and related infrastructure</td>
</tr>
<tr>
<td></td>
<td>Grid-connected solar PV system</td>
</tr>
<tr>
<td>Sustainable Transportation Infrastructure; Transportation-related Amenities</td>
<td>New bicycle facility (bicycle boulevard, Class I bike path, Class II bike lane, Class IV separated bikeway, or Class II to IV conversion)</td>
</tr>
<tr>
<td></td>
<td>New walkway</td>
</tr>
<tr>
<td></td>
<td>New bike share equipment(^{12})</td>
</tr>
<tr>
<td></td>
<td>New or expanded transit service (bus, cable car, ferry, heavy rail, light rail, microtransit shuttle or van, streetcar, trolley bus, or vanpool)</td>
</tr>
<tr>
<td></td>
<td>Capital improvement that encourages mode shift(^{13})</td>
</tr>
<tr>
<td>Program</td>
<td>Transit subsidies</td>
</tr>
<tr>
<td></td>
<td>New bike share operations(^{12})</td>
</tr>
</tbody>
</table>

\(^{11}\) Strategic Growth Council. sgc.ca.gov/programs/ahsc/resources/guidelines.html

\(^{12}\) Bike share infrastructure and fleets are eligible Sustainable Transportation Infrastructure costs according to the AHSC Guidelines, while bike share operations are eligible Active Transportation Program costs. Quantification of the benefits of new bike share infrastructure, fleets, or operations is equivalent regardless of the funding type requested.

\(^{13}\) Capital improvements are infrastructure or equipment improvements, other than vehicle purchases, that increase transit ridership without increasing transit vehicle emissions.
General Approach

This section describes the methods used in the AHSC Benefits Calculator Tool to estimate GHG emission reductions and air pollutant emission co-benefits by project component. These methods account for emission reductions from avoided passenger VMT and the generation of solar PV electricity.

In general, the GHG and air pollutant emission reductions are estimated in the AHSC Benefits Calculator Tool using the quantification approaches by project component outlined in Table 2 below.

<table>
<thead>
<tr>
<th>Project Component</th>
<th>Emission Reductions Estimated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Affordable housing development or residential transit subsidy</td>
<td>Emissions from avoided passenger VMT</td>
</tr>
<tr>
<td>Solar PV electricity generation</td>
<td>Emissions from avoided grid electricity production</td>
</tr>
<tr>
<td>New bicycle facility, walkway, or bike share</td>
<td>Emissions from displaced autos (less emissions from electric bikes and collection and distribution vehicles, if applicable)</td>
</tr>
<tr>
<td>New or expanded transit service</td>
<td>Emissions from displaced autos less emissions from new service vehicle</td>
</tr>
<tr>
<td>Capital improvements or transit fare reductions</td>
<td>Emissions from displaced autos</td>
</tr>
</tbody>
</table>
A. Affordable Housing Developments and Residential Transit Subsidies

The emission reductions from affordable housing developments and residential transit subsidies are calculated as the emission reductions from avoided passenger VMT compared to a baseline scenario lacking VMT reduction measures. Equations 1 through 4 are used to estimate unmitigated VMT for the baseline scenario.¹⁴

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¹⁴ Equations 1 through 4 use a methodology and trip type and link percentages described in Appendices A and D of the User’s Guide for CalEEMod Version 2016.3.2. www.aqmd.gov/caleemod/user’s-guide
Trip lengths not provided by metropolitan planning organizations are calculated for multi-county regions from the California Statewide Travel Demand Model. dot.ca.gov/programs/transportation-planning/multi-modal-system-planning/statewide-modeling
**Equation 2: Primary Trip Length**

\[
\text{Primary Trip Length} = (H-W \text{ Length} \times H-W \text{ Share}) + (H-S \text{ Length} \times H-S \text{ Share}) + (H-O \text{ Length} \times H-O \text{ Share})
\]

*Where,*

- **Primary Trip Length** = County-specific average length of urban or rural primary home-based trip
- **H-W Length** = County-specific average length of urban or rural trip between home and work
- **H-W Share** = Statewide default percentage of primary home-based trips which are between home and work (42.3%)
- **H-S Length** = County-specific average length of urban or rural trip between home and shopping
- **H-S Share** = Statewide default percentage of primary home-based trips which are between home and shopping (19.6%)
- **H-O Length** = County-specific average length of urban or rural trip between home and locations other than work or shopping
- **H-O Share** = Statewide default percentage of primary home-based trips which are between home and other locations (38.1%)

*Units: miles*

**Equation 3: Overall Trip Length**

\[
\text{Overall Trip Length} = (\text{Primary Trip Length} \times \text{Primary Share}) + (\text{Primary Trip Length} \times 25\% \times \text{Diverted Share}) + (0.1 \text{ miles} \times \text{Pass-by Share})
\]

*Where,*

- **Overall Trip Length** = County-specific average length of urban or rural overall home-based trip
- **Primary Trip Length** = County-specific average length of urban or rural primary home-based trip, from Equation 2
- **Primary Share** = Statewide average percentage of home-based trips which are primary (86%)
- **Diverted Share** = Statewide average percentage of home-based trips which are diverted (11%)
- **Pass-by Share** = Statewide average percentage of home-based trips which are pass-by (3%)

*Units: miles*
Equations 5 through 16 are used to calculate the expected percent reductions in passenger VMT resulting from the characteristics of the affordable housing development.\(^\text{15}\)

**Equation 4: Annual Unmitigated VMT**

\[
\text{Annual Unmitigated VMT} = \text{Average Daily Trips} \times \text{Overall Trip Length} \times \text{Total Units} \times 365 \text{ days}
\]

Where, 
- Annual Unmitigated VMT: Annual VMT by residents of housing development without VMT mitigation measures
- Average Daily Trips: Average daily trip rate per dwelling unit for applicable dwelling type, from Equation 1
- Overall Trip Length: County-specific average length of urban or rural overall home-based trip, from Equation 3
- Total Units: Number of dwelling units in affordable housing development

**Equation 5: VMT Reductions from Increased Density**

\[
\text{Density VMT Reductions} = \left( \frac{\text{Density} - \text{Required Density}}{\text{Required Density}} \right) \times 7\%
\]

Where, 
- Density VMT Reductions: VMT reductions associated with increased net density over required baseline, capped at 30%
- Density: Net density of affordable housing development
- Required Density: Required baseline net density per Project Area Type, defined by the AHSC Guidelines (see Table 3)

\(^{15}\) Equations 5 through 17 use methodologies and elasticities described in the Quantifying Greenhouse Gas Mitigation Measures report.  
Table 3. Minimum Net Density by Project Area Type

<table>
<thead>
<tr>
<th>Project Area Type</th>
<th>Minimum Net Density (dwelling units per acre)(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOD</td>
<td>30</td>
</tr>
<tr>
<td>ICP</td>
<td>20</td>
</tr>
<tr>
<td>RIPPA</td>
<td>15</td>
</tr>
</tbody>
</table>

Equations 6 and 7 are applicable to mixed-use developments only.

**Equation 6: Land Use Index**

\[
\text{Land Use Index} = \left\lfloor \frac{4 \times (0.01 \times \ln 0.01) + \left( \frac{RS}{RS + MS} \times \ln \left( \frac{RS}{RS + MS} \right) + \left( \frac{MS}{RS + MS} \times \ln \left( \frac{MS}{RS + MS} \right) \right) }{\ln 6} \right\rfloor
\]

Where,

- \(\text{Land Use Index}\) = Measure of diversity of land use in mixed-use development
- \(RS\) = Space for residential uses in mixed-use development
- \(MS\) = Publicly accessible space for commercial or social services uses in mixed-use development

Units: unitless

**Equation 7: VMT Reductions from Increased Land Use Diversity**

\[
\text{Diversity VMT Reductions} = \left( \frac{\text{Land Use Index} - 0.15}{0.15} \right) \times 9\%
\]

Where,

- \(\text{Diversity VMT Reductions}\) = VMT reductions associated with increased land use diversity over baseline, capped at 30%, with increase in land use diversity capped at 500%
- \(\text{Land Use Index}\) = Measure of diversity of land use in mixed-use development, from Equation 6

Units: \%

\(^1\) Strategic Growth Council. [sgc.ca.gov/programs/ahsc/resources/guidelines.html](sgc.ca.gov/programs/ahsc/resources/guidelines.html)
The distance to the nearest central business district is identified using US Census data\textsuperscript{17} and the CARB mapping tool available at: www.arb.ca.gov/cc/capandtrade/auctionproceeds/kml/jobcentermap.htm.

\begin{equation}
\text{Equation 8: VMT Reductions from Increased Destination Accessibility}
\end{equation}

\[ \text{Accessibility VMT Reductions} = \left( \frac{12 \text{ miles} - \text{Distance}}{12 \text{ miles}} \right) \times 20\% \]

\begin{tabular}{ll}
\text{Where,} & \text{Units} \\
\text{Accessibility} & \text{VMT reductions associated with increased destination accessibility, capped at 20\%} \\
\text{VMT Reductions} & \% \\
\text{Distance} & \text{Distance from affordable housing development to nearest central business district} \\
& \text{miles} \\
\end{tabular}

\begin{equation}
\text{Equation 9: VMT Reductions from Integration of Affordable Housing}
\end{equation}

\[ \text{Affordability VMT Reductions} = \left( \frac{\text{Affordable Units}}{\text{Total Units}} \right) \times 4\% \]

\begin{tabular}{ll}
\text{Where,} & \text{Units} \\
\text{Affordability} & \text{VMT reductions associated with integration of affordable dwelling units into housing development, capped at 4\%} \\
\text{VMT Reductions} & \% \\
\text{Affordable Units} & \text{Number of affordable dwelling units in affordable housing development} \\
& \text{dwelling units} \\
\text{Total Units} & \text{Number of dwelling units in affordable housing development} \\
& \text{dwelling units} \\
\end{tabular}

\textsuperscript{17} United States Census Bureau. 2018. \textit{Longitudinal Employer-Household Dynamics Origin-Destination Employment Statistics – California Workplace Area Characteristics}. lehd.ces.census.gov/data/
**Quantification Methodology for the SGC AHSC Program**

Table 4. Maximum VMT Reductions by Project Area Type

<table>
<thead>
<tr>
<th>Project Area Type</th>
<th>Land Use Measures</th>
<th>Land Use, Parking, and Traffic Calming Measures</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOD</td>
<td>65%</td>
<td>70%</td>
<td>75%</td>
</tr>
<tr>
<td>ICP</td>
<td>30%</td>
<td>35%</td>
<td>40%</td>
</tr>
<tr>
<td>RIPA</td>
<td>5%</td>
<td>10%</td>
<td>15%</td>
</tr>
</tbody>
</table>

---

**Equation 10: Total VMT Reductions from Land Use Measures**

\[
\text{Land Use VMT Reductions} = 1 - (1 - \text{Density VMT Reductions}) \times (1 - \text{Diversity VMT Reductions}) \times (1 - \text{Accessibility VMT Reductions})
\]

Where,

- **Land Use VMT Reductions** = VMT reductions associated with all land use measures, capped according to Project Area Type (see Table 4)
- **Density VMT Reductions** = VMT reductions associated with increased density over required baseline, capped at 35%, from Equation 5
- **Diversity VMT Reductions** = VMT reductions associated with increased land use diversity over baseline, capped at 30%, from Equation 7
- **Accessibility VMT Reductions** = VMT reductions associated with increased destination accessibility, capped at 20%, from Equation 8
- **Affordability VMT Reductions** = VMT reductions associated with integration of affordable dwelling units into housing development, capped at 4%, from Equation 9

---

### Equation 11: VMT Reductions from Limited Parking Supply

\[
\text{Parking Supply VMT Reductions} = \left( \frac{\text{Total Units} \times \text{Parking Rate} - \text{Parking Spaces}}{\text{Total Units} \times \text{Parking Rate}} \right) \times 50\%
\]

<table>
<thead>
<tr>
<th>Terms</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parking Supply VMT Reductions</td>
<td>VMT reductions associated with limited residential parking supply, capped at 12.5%</td>
</tr>
<tr>
<td>Total Units</td>
<td>Number of dwelling units in affordable housing development</td>
</tr>
<tr>
<td>Parking Rate</td>
<td>Average peak parking demand per dwelling unit for applicable dwelling type</td>
</tr>
<tr>
<td>Parking Spaces</td>
<td>Number of residential parking spaces in affordable housing development</td>
</tr>
</tbody>
</table>

### Equation 12: VMT Reductions from Unbundled Parking Cost

\[
\text{Unbundled Parking VMT Reductions} = \text{Unbundled Cost} \times \left( \frac{12 \text{ months}}{4,000} \right) \times 0.4 \times 85\%
\]

<table>
<thead>
<tr>
<th>Terms</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unbundled Parking VMT Reductions</td>
<td>VMT reductions associated with unbundled residential parking cost, capped at 20%</td>
</tr>
<tr>
<td>Unbundled Cost</td>
<td>Monthly unbundled cost for on-site residential parking</td>
</tr>
</tbody>
</table>

### Equation 13: Total VMT Reductions from Parking Measures

\[
\text{Parking VMT Reductions} = 1 - (1 - \text{Parking Supply VMT Reductions}) \times (1 - \text{Unbundled Parking VMT Reductions})
\]

<table>
<thead>
<tr>
<th>Terms</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parking VMT Reductions</td>
<td>VMT reductions associated with all parking measures, capped at 20%</td>
</tr>
<tr>
<td>Parking Supply VMT Reductions</td>
<td>VMT reductions associated with limited residential parking supply, capped at 12.5%, from Equation 11</td>
</tr>
<tr>
<td>Unbundled Parking VMT Reductions</td>
<td>VMT reductions associated with unbundled residential parking cost, capped at 20%, from Equation 12</td>
</tr>
</tbody>
</table>
Equation 14: VMT Reductions from Traffic Calming Measures

\[ \text{Traffic Calming VMT Reductions} = 1\% \]

\[ \text{Where,} \]
\[ \text{Traffic Calming VMT Reductions} = \text{VMT reductions associated with traffic calming measures within ½ mile of affordable housing development} \]

Equations 17 and 18 are used to apply the expected percent reductions in VMT to estimate avoided VMT from the affordable housing development.

---

Equation 15: VMT Reductions from Residential Transit Subsidy

\[ \text{Subsidy VMT Reductions} = \text{Elasticity} \times \frac{\text{Recipients}}{\text{Total Units}} \times \frac{\text{Duration}}{30 \text{ years}} \]

\[ \text{Where,} \]
\[ \text{Subsidy VMT Reductions} = \text{VMT reductions associated with transit passes for residents, capped at 20\%} \]
\[ \text{Elasticity} = \text{Elasticity of VMT specific to annual value of transit passes to residents and urban or rural project setting} \]
\[ \text{Recipients} = \text{Number of dwelling units receiving transit passes in affordable housing development} \]
\[ \text{Total Units} = \text{Number of dwelling units in affordable housing development} \]
\[ \text{Duration} = \text{Number of years for which transit passes are funded} \]

---

Equation 16: Total VMT Reductions

\[ \text{Total VMT Reductions} = \text{Land Use VMT Reductions} + \text{Parking VMT Reductions} + \text{Traffic Calming VMT Reductions} + \text{Subsidy VMT Reductions} \]

\[ \text{Where,} \]
\[ \text{Total VMT Reductions} = \text{VMT reductions associated with all mitigation measures, capped according to Project Area Type (see Table 3)} \]
\[ \text{Land Use VMT Reductions} = \text{VMT reductions associated with all land use measures, capped according to Project Area Type, from Equation 10} \]
\[ \text{Parking VMT Reductions} = \text{VMT reductions associated with all parking measures, capped at 20\%, from Equation 13} \]
\[ \text{Traffic Calming VMT Reductions} = \text{VMT reductions associated with traffic calming measures within ½ mile of affordable housing development, from Equation 14} \]
\[ \text{Subsidy VMT Reductions} = \text{VMT reductions associated with transit passes for residents, capped at 20\%, from Equation 15} \]
Equation 17: Annual Avoided VMT

\[
\text{Annual Avoided VMT} = \text{Annual Unmitigated VMT} \times \text{Total VMT Reductions}
\]

Where,
- Annual Avoided VMT = Annual reductions in baseline residential VMT, miles/year
- Annual Unmitigated VMT = Annual VMT by residents of housing development without VMT mitigation measures, from Equation 4, miles/year
- Total VMT Reductions = VMT reductions associated with all mitigation measures, from Equation 16, %

Equation 18: Total Avoided VMT

\[
\text{Total Avoided VMT} = \text{Annual Avoided VMT} \times 30 \text{ years}
\]

Where,
- Total Avoided VMT = Reductions in baseline residential VMT for quantification period of affordable housing development (30 years), miles
- Annual Avoided VMT = Annual reductions in baseline residential VMT, miles/year

Equation 19: Auto Emission Reductions from Affordable Housing Development and Residential Transit Subsidies

\[
\text{Emission Reductions} = \left( \frac{\text{Annual Avoided VMT} \times EF_{y1} + \text{Annual Avoided VMT} \times EF_{y2}}{2} \right) \times 30 \text{ years} \times U^{-1}
\]

Where,
- Auto Emission Reductions = Auto GHG or criteria and toxic air pollutant emission reductions for quantification period of affordable housing development (30 years), MTCO₂e or lbs
- Annual Avoided VMT = Annual reductions in baseline residential VMT, from Equation 17, miles/year
- EF₁ = County-specific auto vehicle emission factor for first year of project life, g/mile
- EF₂ = County-specific auto vehicle emission factor for final year of project life, g/mile
- U = Unit conversion factor (1,000,000 for grams to metric tons; 453.59 for grams to pounds), g/MT or g/lb
B. Solar PV Electricity Generation

The emission reductions from grid-connected solar PV projects are calculated as the emission reductions from avoided fossil-fuel-based electricity generation.\textsuperscript{19}

\begin{equation}
\text{Emission Reductions} = \sum_{n=1}^{30} (1 - \text{Degradation})^{n-1} \times \text{Production} \times \text{EF}
\end{equation}

\textbf{Where,}
\begin{align*}
\text{Emission Reductions} &= \text{GHG or criteria and toxic air pollutant emission reductions for useful life of solar PV system (30 years)}^{19} \\
\text{Degradation} &= \text{Annual rate of system degradation (0.5\%)}^{19} \\
\text{Production} &= \text{Annual electricity generation estimated using PVWatts Calculator} \\
\text{EF} &= \text{Emission factor for California grid electricity}
\end{align*}

\textbf{Units}
\begin{align*}
\text{Emission Reductions} &= \text{MTCO}_2\text{e or lbs} \\
\text{Degradation} &= \%\text{/year} \\
\text{Production} &= \text{kWh/year} \\
\text{EF} &= \text{MTCO}_2\text{e/kWh or lbs/kWh}
\end{align*}

\textsuperscript{19} The 30-year useful life was obtained from the National Renewable Energy Laboratory “Life Cycle Greenhouse Gas Emissions from Solar Photovoltaics” fact sheet. \url{www.nrel.gov/docs/fy13osti/56487.pdf}

The estimated rate of system degradation was obtained from the National Renewable Energy Laboratory Technical Report “Photovoltaic Degradation Rates – An Analytical Review.” 2012. \url{www.nrel.gov/docs/fy12osti/51664.pdf}
C. New Bicycle Facility or Walkway

The emission reductions from new bicycle facilities or walkways are calculated as the emission reductions from displaced autos.

**Equation 21: VMT Reducions from Bicycle Facility or Walkway**

\[ VMT\ Displaced = D \times ADT \times (A + C) \times GFA \times L \]

**Table 5. Active Transportation Adjustment Factors**

<table>
<thead>
<tr>
<th>Average Daily Traffic (vehicle trips per day)</th>
<th>One-way Facility Length(^{20}) (miles)</th>
<th>Adjustment Factor for Population &gt; 250,000 or Non-university Town with Population &lt; 250,000</th>
<th>Adjustment Factor University Town with Population &lt; 250,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 12,000</td>
<td>( \leq 1 )</td>
<td>0.0019</td>
<td>0.0104</td>
</tr>
<tr>
<td></td>
<td>1.01 to 2</td>
<td>0.0029</td>
<td>0.0155</td>
</tr>
<tr>
<td></td>
<td>&gt; 2</td>
<td>0.0038</td>
<td>0.0207</td>
</tr>
<tr>
<td>12,001 to 24,000</td>
<td>( \leq 1 )</td>
<td>0.0014</td>
<td>0.0073</td>
</tr>
<tr>
<td></td>
<td>1.01 to 2</td>
<td>0.0020</td>
<td>0.0109</td>
</tr>
<tr>
<td></td>
<td>&gt; 2</td>
<td>0.0027</td>
<td>0.0145</td>
</tr>
<tr>
<td>24,001 to 30,000</td>
<td>( \leq 1 )</td>
<td>0.0010</td>
<td>0.0052</td>
</tr>
<tr>
<td></td>
<td>1.01 to 2</td>
<td>0.0014</td>
<td>0.0078</td>
</tr>
<tr>
<td></td>
<td>&gt; 2</td>
<td>0.0019</td>
<td>0.0104</td>
</tr>
</tbody>
</table>

\(^{20}\) The length of bicycle facilities and walkways should be measured in one direction because the adjustment factor, based on length and two-way average daily traffic, accounts for trips in both directions. Crosswalks should not be included in the length of sidewalks since they are accounted for as traffic calming measures.
Table 6. Key Destination Credits

<table>
<thead>
<tr>
<th>Number of Key Destinations</th>
<th>Credit Within ½ Mile of Facility</th>
<th>Credit Within ¼ Mile of Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0.0005</td>
<td>0.001</td>
</tr>
<tr>
<td>4 to 6</td>
<td>0.0010</td>
<td>0.002</td>
</tr>
<tr>
<td>≥ 7</td>
<td>0.0015</td>
<td>0.003</td>
</tr>
</tbody>
</table>

Equation 22: Auto Emission Reductions from Bicycle Facility or Walkway

\[
\text{Auto Emission Reductions} = \left( \frac{VMT \text{ Displaced} \cdot EF_{Y1} + VMT \text{ Displaced} \cdot EF_{YF}}{2} \right) \cdot UL \cdot U^{-1}
\]

Where,

- **Auto Emission Reductions** = Auto GHG or criteria and toxic air pollutant emission reductions for useful life of bicycle facility or walkway
- **Units** = MTCO₂e or lbs
- **VMT Displaced** = Annual passenger VMT replaced by cycling or walking trips, from Equation 21
- **Units** = miles/year
- **EF_{Y1}** = County-specific auto vehicle emission factor for first year of useful life
- **Units** = g/mile
- **EF_{YF}** = County-specific auto vehicle emission factor for final year of useful life
- **Units** = g/mile
- **UL** = Useful life of bicycle facility or walkway (20 years for Class I bike path or walkway; 15 years for Class II bike lane, Class IV separated bikeway, or bicycle boulevard)
- **Units** = years
- **U** = Unit conversion factor (1,000,000 for grams to metric tons; 453.59 for grams to pounds)
D. New or Expanded Bike Share

The emission reductions from bike share components that result in an increase in bike trips are calculated as the emission reductions from displaced autos less the emissions from electric bicycles, if applicable.

\[ VMT \text{ Displaced} = \frac{(\text{Trips}_{\text{yr}1} + \text{Trips}_{\text{yrF}})}{2} \times A \times L \]

*Where,*

- **VMT Displaced** = Annual passenger VMT replaced by bike share trips
- **Trips}_{\text{yr}1** = Total number of trips using bike share expected in first year
- **Trips}_{\text{yrF**} = Total number of trips using bike share expected in final year
- **A** = Adjustment factor to account for induced demand and recreational bike share use (0.5)
- **L** = Average length of auto trip replaced (1.5 miles)

\[ \text{Auto Emission Reductions} = \left( \frac{VMT \text{ Displaced} \times EF_{\text{yr}1} + VMT \text{ Displaced} \times EF_{\text{yrF}}}{2} \right) \times UL \times U^{-1} - \left( \frac{\text{Trips}_{\text{yr}1} + \text{Trips}_{\text{yrF}}}{2} \right) \times L \times EF_{V} \times UL \times U^{-1} \]

*Where,*

- **Auto Emission Reductions** = Auto GHG or criteria and toxic air pollutant emission reductions for useful life of bike share
- **VMT Displaced** = Annual passenger VMT replaced by bike share trips, from Equation 23
- **EF}_{\text{yr}1** = County-specific auto vehicle emission factor for first year of service
- **EF}_{\text{yrF**} = County-specific auto vehicle emission factor for final year of service
- **EF}_{V** = Emission factor for bike share collection and distribution vehicle
- **Trips}_{\text{yr}1** = Total number of trips using bike share expected in first year
- **Trips}_{\text{yrF**} = Total number of trips using bike share expected in final year
- **L** = Average length of auto trip replaced (1.5 miles)
- **UL** = Quantification period for new bike share
- **U** = Unit conversion factor (1,000,000 for grams to metric tons; 453.59 for grams to pounds)
Equations 25 and 26 apply to electric bike share only.

**Equation 25: Emissions from Electric Bike Share**

\[
\text{Electric Bicycle Emissions} = \left( \frac{\text{Trips}_{Yr1} + \text{Trips}_{YrF}}{2} \right) \times L \times EF_B \times UL \times U^{-1}
\]

Where,  
- **Electric Bicycle Emissions** = Electric bicycle GHG or criteria and toxic air pollutant emissions for useful life of bike share  
- **Trips**\(_{Yr1}\) = Total number of trips using bike share expected in first year  
- **Trips**\(_{YrF}\) = Total number of trips using bike share expected in final year  
- **L** = Average length of auto trip replaced (1.5 miles)  
- **EF\(_B\)** = Emission factor for electric bicycles  
- **UL** = Quantification period for bike share  
- **U** = Unit conversion factor (1,000,000 for grams to metric tons; 453.59 for grams to pounds)

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTCO(_2)e</td>
</tr>
<tr>
<td>or lbs</td>
</tr>
</tbody>
</table>

**Equation 26: Net Emission Reductions from Electric Bike Share**

\[
\text{Net Emission Reductions} = \text{Auto Emission Reductions} - \text{Electric Bicycle Emissions}
\]

Where,  
- **Net Emission Reductions** = GHG or criteria and toxic air pollutant emission reductions for useful life of electric bike share  
- **Auto Emission Reductions** = Auto GHG or criteria and toxic air pollutant emission reductions for useful life of bike share, from Equation 24  
- **Electric Bicycle Emissions** = Electric bicycle GHG or criteria and toxic air pollutant emissions for useful life of bike share, from Equation 25

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTCO(_2)e</td>
</tr>
<tr>
<td>or lbs</td>
</tr>
</tbody>
</table>
E. New or Expanded Bus, Cable Car, Rail, Streetcar, Shuttle, Trolley Bus, or Van Service

The emission reductions from new or expanded transit service are calculated as the emission reductions from displaced autos less the new emissions from transit vehicles.

**Equation 27: VMT Reductions from New or Expanded Transit Service**

\[ VMT_{\text{Displaced}} = R \times A \times L \]

Where,
- \( VMT_{\text{Displaced}} \) = Annual passenger VMT replaced by transit trips
- \( R \) = Increase in annual transit ridership in first or last year of service
- \( A \) = Adjustment factor for transit dependency (default or user-defined; see Table 7)
- \( L \) = Length of average auto trip replaced (default or user-defined; see Table 7)

**Units**
- miles/year
- trips/year
- unitless
- miles

**Table 7. Default Trip Lengths and Adjustment Factors by Mode**

<table>
<thead>
<tr>
<th>Mode</th>
<th>Statewide Average Trip Length (miles)(^{21})</th>
<th>Default Adjustment Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus rapid transit</td>
<td>6.56</td>
<td>0.542</td>
</tr>
<tr>
<td>Cable car</td>
<td>1.26</td>
<td>0.479</td>
</tr>
<tr>
<td>Commuter rail</td>
<td>25.69</td>
<td>0.867</td>
</tr>
<tr>
<td>Ferry</td>
<td>10.85</td>
<td>1.000</td>
</tr>
<tr>
<td>Heavy rail</td>
<td>11.48</td>
<td>0.794</td>
</tr>
<tr>
<td>Light rail</td>
<td>5.44</td>
<td>0.685</td>
</tr>
<tr>
<td>Local bus</td>
<td>3.77</td>
<td>0.561</td>
</tr>
<tr>
<td>Long-distance commuter bus</td>
<td>17.57</td>
<td>0.705</td>
</tr>
<tr>
<td>Microtransit shuttle or van</td>
<td>9.08</td>
<td>0.585</td>
</tr>
<tr>
<td>Streetcar</td>
<td>1.43</td>
<td>0.479</td>
</tr>
<tr>
<td>Trolley bus</td>
<td>1.48</td>
<td>0.479</td>
</tr>
<tr>
<td>Vanpool</td>
<td>42.28</td>
<td>0.879</td>
</tr>
</tbody>
</table>

The quantification period for a transit component is the number of years for which there are enforceable committed funds to operate the transit service using the AHSC-funded vehicle(s), capital improvement(s), operations, and/or fare reduction, not to exceed 50 years. For transit operations or fare reductions without vehicle purchases or capital improvements, the quantification period is the number of years that the new or expanded transit service or fare reduction will be provided with AHSC Round 6 funding, up to five years.

### Equation 28: Auto Emission Reductions from New or Expanded Transit Service

\[
Auto\ Emission\ Reductions = \frac{(VMT\ Displaced_{yr1} \times EF_{yr1}) + (VMT\ Displaced_{yrF} \times EF_{yrF})}{2} \times UL \times U^{-1}
\]

**Where,**

- **Auto Emission Reductions** = Auto GHG or criteria and toxic air pollutant emission reductions for quantification period of new or expanded service (Units: MTCO₂e or lbs)
- **VMT Displaced_{yr1}** = Annual passenger VMT replaced by transit trips in first year of service, from Equation 27 (Units: miles/year)
- **VMT Displaced_{yrF}** = Annual passenger VMT replaced by transit trips in final year of service, from Equation 27 (Units: miles/year)
- **EF_{yr1}** = County-specific auto vehicle emission factor for first year of service (Units: g/mile)
- **EF_{yrF}** = County-specific auto vehicle emission factor for final year of service (Units: g/mile)
- **UL** = Quantification period for transit service (Units: years)
- **U** = Unit conversion factor (1,000,000 for grams to metric tons; 453.59 for grams to pounds) (Units: g/MT or g/lb)
Equation 29 is applicable only to rail vehicles, when information on the additional fuel consumed rather than the VMT to operate new or expanded service is available.

<table>
<thead>
<tr>
<th>Equation 29: Rail Vehicle VMT from Fuel Consumption</th>
</tr>
</thead>
</table>
| \[
\text{Rail Vehicle VMT} = \text{Fuel Consumed} \times \text{Consumption Rate}^{-1} \times U^{-1}
\]
| Where, |
| Railroad Vehicle VMT = Annual VMT of rail vehicles to operate new or expanded service |
| Fuel Consumed = Annual fuel consumed by rail vehicles to operate new or expanded service |
| Consumption Rate = Statewide average fuel consumption rate for locomotives |
| U = Unit conversion factor for diesel gallon equivalent |
| Units |
| miles/year |
| units of fuel/year |
| gallons of diesel/mile |
| units of fuel/diesel gallon equivalent |

<table>
<thead>
<tr>
<th>Equation 30: Transit Vehicle Emissions</th>
</tr>
</thead>
</table>
| \[
\text{Transit Vehicle Emissions} = \text{Transit VMT} \times EF_{YrM} \times UL \times U^{-1}
\]
| Where, |
| Transit Vehicle Emissions = Transit vehicle GHG or criteria and toxic air pollutant emissions for quantification period of new or expanded service |
| Transit VMT = Annual VMT of transit vehicles to operate new or expanded service |
| EF_{YrM} = Transit vehicle emission factor for middle year of service |
| UL = Quantification period for transit service |
| U = Unit conversion factor (1,000,000 for grams to metric tons; 453.59 for grams to pounds) |
| Units |
| MTCO\text{\tiny{2}}e or lbs |
| miles/year |
| g/mile |
| years |
| g/MT or g/lb |

<table>
<thead>
<tr>
<th>Equation 31: Net Emission Reductions from New or Expanded Transit Service</th>
</tr>
</thead>
</table>
| \[
\text{Net Emission Reductions} = \text{Auto Emission Reductions} - \text{Transit Vehicle Emissions}
\]
| Where, |
| Net Emission Reductions = GHG or criteria and toxic air pollutant emission reductions for quantification period of new or expanded transit service |
| Auto Emission Reductions = Auto GHG or criteria and toxic air pollutant emission reductions for quantification period of new or expanded service, from Equation 28 |
| Transit Vehicle Emissions = Transit vehicle GHG or criteria and toxic air pollutant emissions for quantification period of new or expanded service, from Equation 30 |
| Units |
| MTCO\text{\tiny{2}}e or lbs |
| MTCO\text{\tiny{2}}e or lbs |
| MTCO\text{\tiny{2}}e or lbs |
F. New or Expanded Ferry Service

The emission reductions from new or expanded ferry service are calculated as the emission reductions from displaced autos less the new emissions from the ferry.

Equation 32: VMT Reductions from New or Expanded Ferry Service

\[ VMT\ Displaced = D \times R \times A \times L \]

Where,
- \( VMT\ Displaced \) = Annual passenger VMT replaced by ferry trips
- \( D \) = Annual days of operation of ferry service
- \( R \) = Increase in daily ferry ridership in first or last year of service
- \( A \) = Adjustment factor for transit dependency (default or user-defined; see Table 7)
- \( L \) = Length of average auto trip replaced (default or user-defined; see Table 7)

Units:
- \( D \): days/year
- \( R \): trips/day
- \( A \): unitless
- \( L \): miles

Equation 33: Auto Emission Reductions from New or Expanded Ferry Service

\[
\text{Auto Emission Reductions} = \frac{(VMT\ Displaced_{Yr1} \times EF_{Yr1}) + (VMT\ Displaced_{YrF} \times EF_{YrF})}{2} \times UL \times U^{-1}
\]

Where,
- \( VMT\ Displaced_{Yr1} \) = Annual passenger VMT replaced by ferry trips in first year of service, from Equation 32
- \( VMT\ Displaced_{YrF} \) = Annual passenger VMT replaced by ferry trips in final year of service, from Equation 32
- \( EF_{Yr1} \) = County-specific auto vehicle emission factor for first year of service
- \( EF_{YrF} \) = County-specific auto vehicle emission factor for final year of service
- \( UL \) = Quantification period for ferry service
- \( U \) = Unit conversion factor (1,000,000 for grams to metric tons; 453.59 for grams to pounds)

Units:
- \( VMT\ Displaced_{Yr1} \): miles/year
- \( VMT\ Displaced_{YrF} \): miles/year
- \( EF_{Yr1} \): g/mile
- \( EF_{YrF} \): g/mile
- \( UL \): years
- \( U \): g/MT or g/lb
### Equation 34: Ferry Emissions

Ferry Emissions = Fuel Consumption * EF * UL * U⁻¹

<table>
<thead>
<tr>
<th>Where,</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferry Emissions = Ferry GHG or criteria and toxic air pollutant emissions for quantification period of new or expanded service</td>
<td>MTCO₂e or lbs</td>
</tr>
<tr>
<td>Fuel Consumption = Annual quantity of fuel consumed by ferry to operate new or expanded service</td>
<td>gal, scf, kWh, or kg</td>
</tr>
<tr>
<td>EF = Fuel-specific carbon intensity emission factor for ferry</td>
<td>g/unit of fuel</td>
</tr>
<tr>
<td>UL = Quantification period for ferry service</td>
<td>years</td>
</tr>
<tr>
<td>U = Unit conversion factor (1,000,000 for grams to metric tons; 453.59 for grams to pounds)</td>
<td>g/MT or g/lb</td>
</tr>
</tbody>
</table>

### Equation 35: Net Emission Reductions from New or Expanded Ferry Service

Net Emission Reductions = Auto Emission Reductions – Ferry Emissions

<table>
<thead>
<tr>
<th>Where,</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Emission Reductions = GHG or criteria and toxic air pollutant emission reductions for quantification period of new or expanded ferry service</td>
<td>MTCO₂e or lbs</td>
</tr>
<tr>
<td>Auto Emission Reductions = Auto GHG or criteria and toxic air pollutant emission reductions for quantification period of new or expanded service, from Equation 33</td>
<td>MTCO₂e or lbs</td>
</tr>
<tr>
<td>Ferry Emissions = Ferry GHG or criteria and toxic air pollutant emissions for quantification period of new or expanded service, from Equation 34</td>
<td>MTCO₂e or lbs</td>
</tr>
</tbody>
</table>
G. Capital Improvements and Fare Reductions

The emission reductions from capital improvements and fare reductions that result in mode shift to transit are calculated as the emission reductions from displaced autos.

\[
VMT\ Displaced = D \times R \times A \times L
\]

**Where,**

- **VMT Displaced** = Annual passenger VMT replaced by transit trips
- **D** = Annual days of operation of transit service utilizing capital improvement or when fare reduction is provided
- **R** = Increase in daily transit ridership in first or last year of service
- **A** = Adjustment factor for transit dependency (default or user-defined; see Table 7)
- **L** = Length of average auto trip reduced (default or user-defined; see Table 7)

**Units**

- miles/year
- days/year
- trips/day
- unitless
- miles

\[
Auto\ Emission\ Reductions = \left( \frac{VMT\ Displaced_{Yr1} \times EF_{Yr1} + VMT\ Displaced_{YrF} \times EF_{YrF}}{2} \right) \times UL \times U^{-1}
\]

**Where,**

- **Auto Emission Reductions** = Auto GHG or criteria and toxic air pollutant emission reductions for quantification period of capital improvement or fare reduction
- **VMT Displaced** = Annual passenger VMT replaced by transit trips, from Equation 36
- **EF_{Yr1}** = County-specific auto vehicle emission factor for first year of service
- **EF_{YrF}** = County-specific auto vehicle emission factor for final year of service
- **UL** = Quantification period for transit utilizing capital improvement or fare reduction
- **U** = Unit conversion factor (1,000,000 for grams to metric tons; 453.59 for grams to pounds)

**Units**

- MTCO₂e
- lbs
- miles/year
- g/mile
- g/mile
- years
- g/MT or g/lb
Section C. References

The following references were used in the development of this Quantification Methodology and the AHSC Benefits Calculator Tool.


California Air Resources Board (2020). *California Climate Investments Quantification Methodology Emission Factor Database*. [www.arb.ca.gov/cci-resources](www.arb.ca.gov/cci-resources)


Quantification Methodology for the SGC AHSC Program

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