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A. Introduction

The California Air Resources Board (ARB) is responsible for providing the quantification methodology to estimate greenhouse gas (GHG) emission reductions from projects receiving monies from the Greenhouse Gas Reduction Fund (GGRF). For the Strategic Growth Council’s (SGC) Affordable Housing and Sustainable Communities Program (AHSC), ARB staff developed this GHG emission reduction quantification methodology to be used by grant applicants to estimate proposed project GHG emission reductions for Fiscal Year (FY) 2014-15 funds.

This methodology uses currently available tools to estimate the changes in vehicle miles traveled (VMT) and GHG emission reductions based on specific land use and transportation characteristics of the proposed project. These tools include specific components of the “California Emissions Estimator Model” (CalEEMod) and calculation methodologies based on 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” (CMAQ Methods).

Methodology Development

For the first year (FY 2014-15) of the AHSC Program, ARB and SGC staff followed a set of principles to guide the development of the quantification methodology.

These principles ensure that the methodology for AHSC projects would:
- Apply at the project-level.
- Align with the project types proposed for funding with the AHSC program.
- Provide uniform methods to be applied statewide, and be accessible by all applicants.
- Estimate GHG emission reductions from a discrete list of VMT reduction measures.
- Use existing and proven tools or methodologies where available.
- Reflect relationships between VMT and GHG reduction that are supported by empirical literature.

Both tools fit these objectives, and provide a uniform methodology to quantify VMT and GHG emission reductions from individual project proposals based on established modeling techniques.

Tools

Both CalEEMod and the CMAQ Methods are used statewide, publicly available, and are subject to regular updates to incorporate new information. The tools and documentation are free of charge and available to anyone with internet access. Both tools use on-road vehicle GHG emission factors from the ARB Mobile-Source Emission Factor model (EMFAC 2011), and provide an accurate method for quantifying air quality impacts from land use and transportation projects throughout California.

CalEEMod is a “state-of-the-practice” land use emissions calculator tool designed to quantify GHG emissions and criteria air pollutants associated with land use
development projects, including transit-oriented developments and mixed-used developments. It is used by municipal lead agencies to evaluate the GHG emissions and criteria air pollutants of land use development projects pursuant to California Environmental Quality Act (CEQA), National Environmental Protection Act (NEPA), and for compliance with local air quality rules and regulations. CalEEMod includes a suite of twenty-five VMT reduction measures. The emission reduction impacts of the measures were developed by and are detailed in a study titled “Quantifying Greenhouse Gas Mitigation Measures” (CAPCOA GHG Quantification Report) by the California Air Pollution Control Officers Association\(^1\). The CAPCOA GHG Quantification Report includes detailed fact sheets that describe the underlying research and the data used to develop the reduction impacts (also called effects or elasticities) and provide project level examples for each measure.

The CMAQ Methods were developed by ARB and the California Department of Transportation to evaluate the cost-effectiveness of certain types of transportation projects, including bicycle paths, vanpools, and new bus service, among others. They are used statewide by transportation agencies to evaluate criteria pollutant emission reductions from transportation projects competing for State motor vehicle fee and federal CMAQ funding.

**AHSC Project Types and Quantification Tools**

The AHSC Program will reduce GHG emissions through projects that implement land use, housing, and transportation strategies to support infill, compact, and affordable housing development. The AHSC Program identifies two project types: Transit Oriented Development (TOD) and Integrated Connectivity Projects (ICP). For GHG quantification purposes, the TOD projects and ICP projects that include affordable housing or housing related infrastructure will primarily use CalEEMod. The remaining ICP projects will use the methodologies from the CMAQ Methods. For this document, these are referred to as “Transit and Connectivity (TAC) Methods.”

Table 1 lists the most common project types SGC expects to receive in the AHSC Program, and identifies which quantification method would likely be used. For some projects, it may be appropriate to use both.

Table 1: Example Project Types and Quantification Method

<table>
<thead>
<tr>
<th>AHSC Project Type</th>
<th>CalEEMod</th>
<th>TAC Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transit-oriented development</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Mixed use development</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Transit and commute improvements (e.g., transit subsidy) associated with housing or other land use development</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Regional transit projects (e.g., new bus service, vanpools) not associated with housing or other land use development</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Bicycle paths or lanes</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Pedestrian facilities</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

These methods require land use characteristics and VMT reduction strategies from the proposed project, which should be readily available in the project application.

**GHG Emission Reductions**

This methodology estimates the GHG emission reductions of a proposed AHSC project that are based on the reduction in VMT due to specific project characteristics (e.g. density) and project measures (e.g. new bus service). Both CalEEMod and the TAC Methods combine project specific data with default data to establish an initial case and a project case. The difference between the initial case and project case is the quantified GHG emission reductions from the VMT reduction measures identified in the proposed project.

Applicants will estimate the total GHG emission\(^2\) reductions from the proposed project over the project life, as defined in the methodology.

For AHSC Program application scoring purposes, the applicant will report results as:

\[
\text{Metric tons (MT) of CO2 over the project life} \\
\text{GGRF Funds Requested (£)}
\]

The following sections describe the calculations needed to estimate the GHG emission reductions for proposed projects under the FY 2014-15 AHSC Program.

**Technical Assistance**

ARB staff will be available to provide technical assistance in using this quantification methodology for AHSC applications. ARB staff will also review the quantification portions of the project applications to ensure that the methods outlined in this document were properly applied to estimate the GHG emission reductions for the proposed project. For more information on ARB’s efforts to support implementation of GGRF investments, see: [www.arb.ca.gov/auctionproceeds](http://www.arb.ca.gov/auctionproceeds). Questions on this document should be forwarded to [GGRFProgram@arb.ca.gov](mailto:GGRFProgram@arb.ca.gov). For frequently asked questions concerning the quantification methodology, see [http://www.arb.ca.gov/cc/capandtrade/auctionproceeds/quantification.htm](http://www.arb.ca.gov/cc/capandtrade/auctionproceeds/quantification.htm)

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\(^2\) This methodology results in estimated CO2 reductions only. For the purposes of this quantification methodology and the AHSC application, the applicant will report CO2 reductions as GHG reductions.
B. Using CalEEMod


Please Note: This FY 2014-15 quantification methodology for the AHSC Program focuses on the suite of twenty-five VMT reduction measures and project characteristics that are included within CalEEMod. This methodology does not use the CalEEMod input or output screens for calculating construction, energy, and water-related emissions.

AHSC Program applicants will follow these steps to estimate the GHG emission reductions for a proposed project using CalEEMod.

1. **Define the proposed project**: The applicant will use CalEEMod’s “Project Characteristics” and “Land Use” screens to define the proposed project setting and land use characteristics.

2. **Identify and enter VMT reduction measures**: The applicant will identify the VMT reduction measures associated with the proposed project, and enter the applicable values using CalEEMod’s “Mitigation-Traffic Mitigation-Land Use & Site Enhancement” and “Mitigation-Traffic Mitigation-Commute” screens.

3. **Generate a CalEEMod Report**: The applicant will use CalEEMod’s “Reporting” screen to generate an output file that will automatically calculate the initial case and project case GHG emissions.

   The applicant will complete Steps 1-3 two times. First, applicants will use the first operational year of the project (e.g., 2017). Second, applicants will add 30 years (e.g., 2047). All CalEEMod projects must use a 30 year project life to complete this methodology.

4. **Calculate additional benefits**: The applicant will calculate additional GHG benefits to correct for a known underestimation in CalEEMod of the GHG benefits for projects with densities over 7.6 dwelling units/acre, and for projects that are closer than 12 miles to a central business district or job center. Applicants will calculate additional GHG benefits for subsidized/discount transit passes for housing residents using the equations provided.

5. **ICP adjustment, if applicable**: This step applies only to ICP projects using CalEEMod and taking credit for increased transit accessibility (LUT-5).

6. **Calculate the GHG reductions over the project life**: The applicant will calculate the GHG reductions over the project life using results from Steps 1-5.
Step 1: Define the Proposed Project

Project Characteristics Screen

Cascade Defaults: Leave this box checked
Project Name: Enter project name
Project Location: Select the county
Climate Zone: Enter Climate Zone 3
(Windspeed and Precipitation will “autofill”)
Land Use Setting: Select “Urban” unless project is in a defined “Rural” Census Tract
Operational Year: First run, enter the first operational year of the project.
Second run, add 30 years to the first operational year of the project.
30 years is the required project life for AHSC CalEEMod runs. 4
Select Utility Co.: Select the utility company serving the proposed project. 5
(CO2, CH4, and N2O Intensity Factors will “autofill”)
Pollutants: Leave only the box for “Carbon Dioxide (CO2)” checked

Land Use Screen

Cascade Defaults: Leave this box checked
Land Use Type: Select land use type 6
Land Use Subtype: Select land use subtype (multiple rows may be used to characterize the proposed project)
Unit Amount: Enter number of units
Size Metric: Select the size metric
Lot Acreage: *
Square Feet: *
Population: *

*Enter values if available in proposed project information. CalEEMod will use defaults if left blank.

Navigation Note - After entering project information on the “Land Use Screen,” navigate to the “Mitigation” area of CalEEMod. The “Construction,” “Operational,” and “Vegetation” areas of CalEEMod should not be used for AHSC project quantification.

3 The climate zone for a project can be looked up using CalEEMod’s User’s Guide Appendix F - Climate Zones Zip Code/Cities Lookup, Climate Zone Zip Code/Cities Lookup or the Climate Zone Map. If your ZIP code has multiple climate zones, use the Climate Zone Map to approximate within which zone the project is located. These files are available at: http://www.aqmd.gov/caleemod/user%27s-guide.
4 If the project life extends past 2035, the applicant must use 2035 as a proxy for any final project year (YrF). 2035 is the latest available operational year in CalEEMod.
5 If the utility serving the project is not listed, the applicant can select the user defined option and supply the CO2, CH4 and N2O intensity factors. If intensity factors are not known, select the statewide average.
6 Definitions for all land use types and subtypes can be found in the CalEEMod User’s Guide, pages 16-21 at the following link: http://www.aqmd.gov/docs/default-source/caleemod/usersguide.pdf?sfvrsn=2.
**Step 2: Identify and Enter VMT Reduction Measures**

Applicants identify which of the following VMT reduction measures and project characteristics apply to the proposed AHSC project, and enter the applicable project data into the “Land Use & Site Enhancement” or “Commute” screens.

**Mitigation-Traffic, Land Use & Site Enhancement Screen**

**Project Setting:** Select the one that best characterizes the existing surrounding land use pattern. See Table 2 below.

**Select the VMT reduction measures:** included in the proposed project and enter the required project specific data as identified in Table 3 below. *Do not select LUT-1 or LUT-4; instead, see Step 4.*

### Table 2. Project Settings in the “Land Use & Site Enhancement” Screen

<table>
<thead>
<tr>
<th>CalEEMod Project Setting Types</th>
<th>Location Setting Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Density Suburban</td>
<td>An area characterized by dispersed, low-density, single-use, automobile dependent land use patterns, usually outside of the central city (a suburb).</td>
</tr>
<tr>
<td>Suburban Center</td>
<td>An area that serves the population of the suburb with office, retail, and housing which is denser than the surrounding suburb.</td>
</tr>
<tr>
<td>Urban</td>
<td>An area which is located within the central city with higher density of land uses than would be found in the suburbs. It may be characterized by multi-family housing and located near office and retail.</td>
</tr>
<tr>
<td>Urban Center</td>
<td>An area within or contiguous with the central city. Examples may include redevelopment areas, abandoned sites, or underutilized older buildings/sites.</td>
</tr>
</tbody>
</table>

**For “Rural” Projects:** CalEEMod does not include a rural project setting due to the limited empirical studies regarding the relationship between VMT and GHG emission reductions in rural areas. For proposed AHSC projects that are in census tracts designated as “Rural”, the “Low Density Suburban” land use setting can be used if the project meets the following requirements:

1. Project site is designated for development in an adopted general plan or zoning ordinance, or
2. Project site is within an existing urban services boundary or sphere of influence, and
3. Rural census track in which project site is located is adjacent to a census track with contiguous development on at least one side.

---

7 CalEEMod project setting labels differ slightly than those listed in the CAPCOA GHG Quantification Report (CAPCOA 2010). Applicants should apply the definitions provided in these instructions.
Table 3. “Land Use & Site Enhancement” VMT Reduction Measures

<table>
<thead>
<tr>
<th>ID</th>
<th>VMT Reduction Measure</th>
<th>Description</th>
<th>Project Specific Data Inputs Required by CalEEMod</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Land Use &amp; Site Enhancement Measures</td>
<td></td>
</tr>
<tr>
<td>LUT-1</td>
<td>Increase Density</td>
<td>Project more dense (housing or jobs) than typical developments</td>
<td>Do not check LUT-1 box in CalEEMod, and See Step 4</td>
</tr>
<tr>
<td>LUT-3</td>
<td>Increase Diversity</td>
<td>Different types of land uses are near each other</td>
<td>Project land use types</td>
</tr>
<tr>
<td>LUT-9</td>
<td>Improve Walkability Design</td>
<td>Walkable street network</td>
<td>Intersections per square mile&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>LUT-4</td>
<td>Improve Destination Accessibility</td>
<td>Project close to regional employment or destination center</td>
<td>Do not check LUT-4 box in CalEEMod, and See Step 4</td>
</tr>
<tr>
<td>LUT-5</td>
<td>Increase Transit Accessibility</td>
<td>Project near high-quality transit</td>
<td>Distance to transit station (miles). If ICP, See Step 5</td>
</tr>
<tr>
<td>LUT-6</td>
<td>Integrate Below Market Rate Housing</td>
<td>Incorporates affordable housing</td>
<td>CalEEMod: enter Percentage of units (not # of Units) that are affordable as defined by AHSC Guidelines.</td>
</tr>
</tbody>
</table>

|     |                                      | Neighborhood Enhancement Measures                                           |                                                  |
| SDT-1| Improve Pedestrian Network            | On-site pedestrian access network links project internally and externally   | Designate if improvements are “Project Site” only or “Project Site and Connecting Off-Site” |
| SDT-2| Provide Traffic Calming Measures      | Project’s streets and intersections feature traffic calming features         | % Streets with improvements and % intersections with improvements<sup>a</sup> |
| SDT-3| Implement NEV Network                | Project provides viable neighborhood electric vehicle (NEV) network         | Number of NEVs per household                    |

|     |                                      | Parking Policy/Pricing Measures                                             |                                                  |
| PDT-1| Limit Parking Supply                 | Parking supply below Institute of Traffic Engineer (ITE) rates              | % reduction in spaces                           |
| PDT-2| Unbundle Parking Costs               | Parking and property costs separate                                        | Monthly parking cost ($)                        |
| PDT-3| On-Street Market Pricing             | On-street parking utilizes market-rate pricing (such as meters)             | % increase in price<sup>a</sup>                 |

|     |                                      | Transit Improvement Measures                                               |                                                  |
| TST-1| Provide BRT System                   | Establish a Bus Rapid Transit line with operational funding stream         | % of lines serving project converting to BRT    |
| TST-3| Expand Transit Network                | Establishes or enhances bus line with operational funding stream           | % increase transit coverage<sup>a</sup>         |
| TST-4| Increase Transit Frequency            | Reduces headways of existing transit                                        | Level of implementation % reduction in headway  |

Note (a). These metrics should be evaluated for an area within the housing development and surrounding area which can extend a distance (d) from the housing development not to exceed one-half (½) mile.

<sup>8</sup> Measures listed in the order shown on the CalEEMod screens. IDs reference to the CAPCOA GHG Quantification Report.
Mitigation-Traffic, Commute Screen

Select the VMT reduction measures: included in the proposed project and enter the required project specific data as identified in Table 4 below.

These VMT reduction measures only apply to non-residential land use types.

### Table 4. “Commute” VMT Reduction Measures

<table>
<thead>
<tr>
<th>ID(^9)</th>
<th>VMT Reduction Measure</th>
<th>Description</th>
<th>Project Specific Data Inputs Required by CalEEMod</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRT-1&amp;2</td>
<td>Implement Trip Reduction Program</td>
<td>TMA membership or other comprehensive services</td>
<td>% employee eligible and program type</td>
</tr>
<tr>
<td>TRT-4</td>
<td>Transit Subsidy(^10)</td>
<td>Proponent subsidizes sustainable modes of transportation</td>
<td>% employee eligible and daily transit subsidy amount ($)</td>
</tr>
<tr>
<td>TRT-15</td>
<td>Implement Employee Parking “Cash-Out”</td>
<td>Employer provides cash-value of a parking space to employees who do not use one</td>
<td>% employee eligible</td>
</tr>
<tr>
<td>TRT-14</td>
<td>Workplace Parking Charge</td>
<td>Charge employees for their parking</td>
<td>% employee eligible and daily parking charge ($)</td>
</tr>
<tr>
<td>TRT-6</td>
<td>Encourage Telecommuting and Alternative Work Schedules</td>
<td>Allow/require 9/80s, 4/10, and telecommuting</td>
<td>% employee work 9/80, % employee work 4/40, and % employee telecommute 1.5 days</td>
</tr>
<tr>
<td>TRT-7</td>
<td>Market Commute Trip Reduction Option</td>
<td>Market sustainable travel options</td>
<td>% employee eligible</td>
</tr>
<tr>
<td>TRT-11</td>
<td>Employee Vanpool/Shuttle</td>
<td>Provide employer-sponsored vanpool or shuttle program</td>
<td>% employee eligible and % vanpool mode share</td>
</tr>
<tr>
<td>TRT-3</td>
<td>Provide Ride Sharing Program</td>
<td>Establish a carpooling program with associated infrastructure</td>
<td>% employee eligible</td>
</tr>
<tr>
<td>TRT-13</td>
<td>School Bus Program</td>
<td>Restore or expand school bus service</td>
<td>% families using</td>
</tr>
</tbody>
</table>

\(^9\) Measures listed in the order shown on the CalEEMod screens. IDs reference to the CAPCOA GHG Quantification Report.

\(^10\) TRT-4 is used for subsidized transit passes for employees. For subsidized transit passes for residents, see Step 4.
Step 3: Generate a CalEEMod Report

Reporting Screen

Select “Annual” emissions

Click “Recalculate Emissions and Run Report”

CalEEMod will generate a report that includes both the initial case, which is identified as “unmitigated” in the CalEEMod report, and the project case, identified as “mitigated”.

The GHG emissions value for AHSC projects are found in the Total CO2 column in the “Mobile” Category of the “Overall Operational” results table. Figure 1 below provides an example of an unmitigated, initial case results table.

Figure 1. CalEEMod Report Section 2.2 Listing Overall Operational Mobile Unmitigated (i.e., Initial Case) GHG Emissions in MT/yr.

Complete Steps 1-3 two times. First, use the first operational year of the project (YR1). Second, add 30 years (Yr1 + 30) for the final project year used for quantification purposes (YrF).

Use the following Total CO2 emissions results in Steps 4-6 below:

- Yr1 Initial Case GHG Emissions
- Yr1 Project Case GHG Emissions
- YrF Initial Case GHG Emissions
- YrF Project Case GHG Emissions
Step 4: Calculate Additional Benefits

CalEEMod underestimates the GHG benefits for projects with densities over 7.6 dwelling units/acre (LUT-1: Increase Density), and for projects that are closer than 12 miles to a central business district or job center (LUT-4: Increase Destination Accessibility). In addition, the CalEEmod Transit Subsidy (TRT-4) only applies to employees. An adjustment has been provided to apply transit subsidies to residents.

Applicants can use the following equations to estimate reductions for these three measures.

To complete this step, identify the following project specific data:

- LUT-1: Project Dwelling Units per acre (Project DU/acre)
- LUT-4: Distance in miles to a central business district or job center (Project Distance)
- TRT-4: Annual transit subsidy/discount for housing residents (Transit Subsidy, Percent Residents Eligible)

Calculate the additional GHG reductions for each measure using the formulas below:

**Increase Density (LUT-1)**

\[
\text{% Density Increase} = 100 \times \frac{\text{Project DU/acre} - 7.6}{7.6}
\]

\[
\text{% VMT Reduction} = 0.07 \times \text{% Density Increase}
\]

Eq. 1

**Increase Destination Accessibility (LUT-4)**

\[
\text{% Distance Decrease} = 100 \times \frac{\text{Project Distance} - 12}{12}
\]

\[
\text{% VMT Reduction} = -0.20 \times \text{% Distance Decrease}
\]

\[
\text{% GHG Reduction} = \text{% VMT Reduction}
\]

Eq. 3

Eq. 4

Eq. 5

Eq. 6

---

11 The maximum % GHG Reduction an applicant can take credit for with this measure is 30%.
12 The elasticity factor is the same for the distance to a job center or a central business district.
Transit Subsidy for Residents (TRT-4)

\[
GHG \text{ Reduction } Yr1 = A \times B \times \text{Initial Case GHG Emissions } Yr1 \times \left( \frac{C}{30} \right)
\]  
Eq. 7

\[
GHG \text{ Reduction } YrF = A \times B \times \text{Initial Case GHG Emissions } YrF \times \left( \frac{C}{30} \right)
\]  
Eq. 8

Where A is the percent VMT reduction per eligible resident shown in the following table:

<table>
<thead>
<tr>
<th>Transit Subsidy or Discount per Year per Eligible Resident</th>
<th>A=Percent Reduction in Commute VMT per Eligible Resident</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low Density Suburban</td>
</tr>
<tr>
<td>From $273.75 to $543.84</td>
<td>1.5</td>
</tr>
<tr>
<td>$543.85 to $1087.69</td>
<td>3.3</td>
</tr>
<tr>
<td>$1,087.70 to $2175.39</td>
<td>7.9</td>
</tr>
<tr>
<td>$2,175.40 or greater</td>
<td>20.0</td>
</tr>
</tbody>
</table>

B is the percent of residents eligible for the subsidized or discounted transit program.

C is the number of years that the subsidy/discount is funded or guaranteed under the proposed project or transit agency program.

Calculate the additional benefits for LUT-1, LUT-4 and TRT-4 as follows:

\[
Yr1 \text{ GHG Reduction} = \% \text{ GHG Reduction} \times \text{Yr1 Initial Case GHG Emissions}
\]  
Eq. 9

\[
YrF \text{ GHG Reduction} = \% \text{ GHG Reduction} \times \text{YrF Initial Case GHG Emissions}
\]  
Eq. 10

Use the following GHG reduction results from LUT-1, LUT-4 and TRT-4 in Step 6 below:

- Yr1 LUT1 GHG Reduction
- YrF LUT1 GHG Reduction
- Yr1 LUT4 GHG Reduction
- YrF LUT4 GHG Reduction
- Yr1 TRT4 GHG Reduction
- YrF TRT4 GHG Reduction
Step 5: ICP Adjustment, If Applicable

The data supporting transit accessibility (LUT-5) in CalEEMod are based on high-quality transit service. Since ICP projects do not qualify for high-quality transit, an adjustment is needed for these projects. As such, this step only applies to ICP projects that are taking credit for LUT-5 in CalEEMod and have transit peak headways with frequencies less than 75 minutes.

For applicable ICP projects:

Complete Step 2 (run CalEEMod) with the transit accessibility (LUT-5) option checked.

Calculate the ICP GHG Adjustment\(^{13}\) as follows:

\[
Yr1 \text{ ICP GHG Adjustment} = 0.025 \times Yr1 \text{ Initial Case GHG Emissions} \quad \text{Eq. 11}
\]

\[
YrF \text{ ICP GHG Adjustment} = 0.025 \times YrF \text{ Initial Case GHG Emissions} \quad \text{Eq. 12}
\]

Use the following ICP GHG adjustments in Step 6 below:
- Yr1 ICP GHG Adjustment
- YrF ICP GHG Adjustment

Step 6: Calculate the GHG Reductions Over the Project Life

Calculate the “Project Life GHG Reductions” using the results from Steps 1-5 and the following equations. Use the first two equations two times. First for Yr1, then for YrF.

\[
\text{Adj Project Case GHG Emissions} = \frac{\text{Project Case GHG Emissions (Step 3)}}{\text{LUT1 GHG Reductions (Step 4)}} - \frac{\text{LUT4 GHG Reductions (Step 4)}}{\text{TRT4 GHG Reductions(Step 4)}} + \text{ICP GHG Adjustment (Step 5)} \quad \text{Eq. 13}
\]

\[
\text{Total GHG Reductions} = \text{Initial Case GHG Emissions} - \text{Adj Project Case GHG Emissions} \quad \text{Eq. 14}
\]

\[
\text{Project Life GHG Reductions} = \left( \frac{\text{Yr1 Total GHG Reductions} + \text{YrF Total GHG Reductions}}{2} \right) \times 30 \quad \text{Eq. 15}
\]

The Project Life GHG Reductions will be used in Section D. Reporting.

\(^{13}\) Based on documentation in the CAPCOA GHG Quantification Report for TST-4: Increase Transit Frequency/Speed
C. Transit and Connectivity Methods

AHSC Integrated Connectivity Project applicants will identify the applicable Transit and Connectivity (TAC) method based on the proposed project. These methods apply only to ICP projects that do not include mixed-used development, affordable housing, or housing-related infrastructure.

In consultation with SGC, quantification methods are provided for four project types not covered in CalEEMod. Table 5 describes these project types and defines the project life that will be used for quantification purposes.

<table>
<thead>
<tr>
<th>TAC Methods</th>
<th>Description</th>
<th>Project Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation of New Bus Service</td>
<td>Extended and increased frequency routes with cleaner vehicles, new hours of service, and serve additional riders.</td>
<td>Number of years the new bus service is funded under the proposed project.</td>
</tr>
<tr>
<td>Vanpools and Shuttles</td>
<td>Commuter vanpools, shuttles, or rail feeder shuttles to work sites, homes, or schools. Emissions are reduced by replacing auto trips with higher occupancy vanpools or shuttles.</td>
<td>Number of years the vanpool or shuttle service is funded under the proposed project.</td>
</tr>
<tr>
<td>Bicycle Paths or Lanes</td>
<td>Bicycle paths (Class 1) or bicycle lanes (Class 2) that are targeted to reduce commute and other non-recreational auto travel. Emissions are reduced by replacing auto trips with bicycle trips.</td>
<td>Class 1 bicycle paths-20 yrs Class 2 bicycle lanes-15 yrs</td>
</tr>
<tr>
<td>Pedestrian Facilities</td>
<td>Pedestrian facilities reduce VMT by providing pedestrian access and replacing auto trips with walking trips.</td>
<td>Pedestrian Facilities-20 yrs</td>
</tr>
</tbody>
</table>

The following is a summary of the three steps AHSC Program applicants will follow to estimate the GHG emission reductions for a proposed project using the TAC methods; detailed instructions for each method are provided in the individual project instructions.

1. **Calculate VMT and trip reductions**: The applicant will calculate the VMT and trip reductions based on project specific data and calculation defaults.

2. **Calculate annual GHG emission reductions**: The applicant will use the VMT and trip data determined in Step 1, in conjunction with CO2 emission factors from EMFAC 2011, to calculate the initial year and final year GHG emission reductions. Detailed instructions for obtaining the EMFAC 2011 emission factors needed to estimate the GHG emissions are included on page 21.

3. **Calculate the GHG reductions over the project life**: The applicant will calculate the GHG reductions over the project life using results from Steps 1 and 2, and the project life definitions in Table 5.
Operation of New Bus Service

**Project Description:** New, extended, and increased-frequency routes with cleaner vehicles provide new hours of bus service per year and serve additional people. These are fixed-route services implemented by transit agencies or school districts. Cleaner buses could be used in bus service expansions in order to achieve additional emission reductions from the project.

**Step 1: Calculate VMT and trip reductions**

\[
\text{Annual Auto Trips Reduced in trips per year} = \left( D \times (R) \times (A) \times \left[ 1 - (AA) \right] \right) \times (L) \times (LL)
\]

**Where:**
- \( D \) = Days of operation per year
  - Use: 260 days for weekday service
  - 365 days for daily service
  - 180 to 200 days for school bus services
- \( R \) = Ridership in total bus trips per day
  - Use: expected ridership based on project data
- \( A \) = Adjustment factor to account for transit dependency
  - Use: 0.5 for local bus service; 0.83 for long distance commuter service
- \( L \) = Length of average auto trip reduced
  - Use: 10.8 miles
- \( AA \) = Adjustment factor to account for auto trips used to access transit service
  - Use: 0.1 for local bus service; 0.8 for long distance commuter service
- \( LL \) = Length of average trip for auto access to transit
  - Use: 2 miles for local bus service; 5 miles for long distance commuter service

\[
\text{Annual Auto VMT Reduced in miles per year} = \left( D \times (R) \times (A) \times \left[ 1 - (AA) \times (LL) \right] \right) \times (L) \times (LL)
\]

**Step 2: Calculate GHG emission reductions**

\[
\text{GHG Reductions in MTC02 per year} = \left[ \frac{(Auto Trips) \times (ATSEF) + (AutoVMT) \times (AREF) - (BusVMT) \times (BREF)}{1,000,000} \right]
\]

**Where:**
- AutoTrips = Annual Auto Trips Reduced value from Step 1
- AutoVMT = Annual Auto VMT Reduced value from Step 1
- BusVMT = Annual Bus VMT based on project data
- ATSEF = Auto Trip Start Emission Factor in grams/trip from EMFAC2011
- AREF = Auto Running Emission Factor in grams/mile from EMFAC2011
- BREF = Bus Running Emission Factor in grams/mile from EMFAC2011

**Reminder:** this formula must be used two times to calculate both Yr1 and YrF. The only difference between the two calculations will be the calendar year emission factor values.
Step 3: Calculate the GHG Reductions Over the Project Life

Calculate the "Project Life GHG Reductions" using the following equation.

\[
\text{Project Life GHG Reductions} = \left( \frac{Yr1 \, \text{GHG Reductions} + YrF \, \text{GHG Reductions}}{2} \right) \times \text{Project Life} \quad \text{Eq. 19}
\]

Where:
Project life = Number of years the new bus service is funded under the proposed project.

The Project Life GHG Reductions will be used in Section D. Reporting.
Vanpools and Shuttles

**Project Description:** Projects are commuter vanpools; tourist or shopping shuttles; or rail feeders to work sites, homes, or schools. Services are operated by transit agencies, local governments, transportation management associations (TMAs), private businesses, etc.

**Step 1: Calculate VMT and trip reductions**

\[
\text{Annual Auto Trips Reduced in trips per year} = [(D) \times (R) \times (A)] \times [1 - (AA)] \quad \text{Eq. 20}
\]

\[
\text{Annual Auto VMT Reduced in miles per year} = [(D) \times (R) \times (A)] \times [(L) - (AA) \times (LL)] \quad \text{Eq. 21}
\]

*Where:*

- **D** = Days of operation per year  
  Use:  
  - 250 days for weekday vanpools  
  - 260 days for weekday shuttles  
  - 365 days for daily service  
  - 180 to 200 days for school services  

- **R** = Ridership in total trips (one-way trips by riders or number of boardings) per day  
  Use: expected ridership based on project data  

- **A** = Adjustment factor to account for transit dependency  
  Use: 0.83 for long distance commuter service  

- **L** = Length of average auto trip reduced  
  Use: 35 miles for vanpools; 16 miles for shuttles; or documented value based on project data  

- **AA** = Adjustment factor to account for auto trips used to access vanpool/shuttle  
  Use: 0.75  

- **LL** = Length of average trip for auto access to vanpool/shuttle  
  Use: 5 miles

**Step 2: Calculate GHG emission reductions**

\[
\text{GHG Reductions in Mt CO2 per year} = \frac{[(\text{AutoTrips}) \times (ATSEF) + (\text{AutoVMT}) \times (AREF) - (\text{VanVMT}) \times (VREF)]}{1,000,000} \quad \text{Eq. 22}
\]

*Where:*

- **AutoTrips** = Annual Auto Trips Reduced value from Step 1  
- **AutoVMT** = Annual Auto VMT Reduced value from Step 1  
- **VanVMT** = Annual Van VMT based on project data  
- **ATSEF** = Auto Trip Start Emission Factor in grams/trip from EMFAC2011  
- **AREF** = Auto Running Emission Factor in grams/mile from EMFAC2011  
- **VREF** = Van Running Emission Factor in grams/mile from EMFAC2011

*Reminder:* this formula must be used two times to calculate both Yr1 and YrF. The only difference between the two calculations will be the calendar year emission factor values.
from EMFAC2011. Instructions for obtaining the ATSEF, AREF, and VREF values from EMFAC2011 are included on page 21.

**Step 3: Calculate the GHG Reductions Over the Project Life**

**Calculate** the “Project Life GHG Reductions” using the following equation.

\[
Project \ Life \ GHG \ Reductions = \left( \frac{Yr1 \ GHG \ Reductions + YrF \ GHG \ Reductions}{2} \right) \times Project \ Life
\]

*Eq. 23*

Where:
- **Project life** = Number of years the vanpool or shuttle service is funded under the proposed project.

The Project Life GHG Reductions will be used in Section D. Reporting.
Bicycle Paths or Lanes

**Project Description:** Bicycle paths (Class 1) or bicycle lanes (Class 2) that are targeted to reduce commute and other non-recreational auto travel. Class 1 facilities are paths that are physically separated from motor vehicle traffic. Class 2 facilities are striped bicycle lanes giving preferential or exclusive use to bicycles. Bike lanes should meet Caltrans' full-width standard depending on street facility type.

**Step 1: Calculate VMT and trip reductions**

\[
\text{Annual Auto Trips Reduced in trips per year} = (D) \times (ADT) \times (A + C) \quad \text{Eq. 24}
\]

\[
\text{Annual Auto VMT Reduced in miles per year} = (\text{Annual Auto Trips Reduced}) \times (L) \quad \text{Eq. 25}
\]

*Where:*

- \(D\) = Days of use per year  
  Use: 200

- \(ADT\) = Annual Average Daily Traffic (two-way traffic volume in trips/day on parallel road)  
  Use applicable value from project data (MAXIMUM = 30,000)

- \(A\) = Adjustment factor to account for bike use  
  Use applicable value from Table 6

- \(C\) = Activity Center Credit near project  
  Use applicable value from Table 7

- \(L\) = Length of bicycle trip  
  Use: 1.8 miles per trip in one direction

**Table 6. Adjustment Factor Lookup Table**

<table>
<thead>
<tr>
<th>BIKE FACILITY CLASS</th>
<th>AVERAGE DAILY TRAFFIC (ADT)</th>
<th>LENGTH OF BIKE PROJECT (one direction)</th>
<th>ADJUSTMENT FACTORS FOR CITIES WITH POP. ≥ 250,000 and non-university towns &lt; 250,000</th>
<th>ADJUSTMENT FACTORS FOR UNIVERSITY TOWNS WITH POP. &lt; 250,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1 (bike path) &amp; Class 2 (bike lane)</td>
<td>ADT ≤ 12,000 vehicles per day</td>
<td>≤ 1 mile</td>
<td>.0019</td>
<td>.0104</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;1 &amp; ≤ 2 miles</td>
<td>.0029</td>
<td>.0155</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; 2 miles</td>
<td>.0038</td>
<td>.0207</td>
</tr>
<tr>
<td>Class 1 (bike path) &amp; Class 2 (bike lane)</td>
<td>12,000&lt; ADT ≤24,000 vehicles per day</td>
<td>≤ 1 mile</td>
<td>.0014</td>
<td>.0073</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;1 &amp; ≤ 2 miles</td>
<td>.0020</td>
<td>.0109</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; 2 miles</td>
<td>.0027</td>
<td>.0145</td>
</tr>
<tr>
<td>Class 2 bike lane</td>
<td>24,000&lt; ADT ≤30,000 vehicles per day</td>
<td>≤ 1 mile</td>
<td>.0010</td>
<td>.0052</td>
</tr>
<tr>
<td></td>
<td>Maximum is 30,000</td>
<td>&gt;1 &amp; ≤ 2 miles</td>
<td>.0014</td>
<td>.0078</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; 2 miles</td>
<td>.0019</td>
<td>.0104</td>
</tr>
</tbody>
</table>
Table 7. Activity Center Credit Lookup Table

<table>
<thead>
<tr>
<th>Count your activity centers. If there are…</th>
<th>Credit (C)</th>
<th>Credit (C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Within 1/2 mile</td>
<td>Within 1/4 mile</td>
</tr>
<tr>
<td>3</td>
<td>.0005</td>
<td>.001</td>
</tr>
<tr>
<td>More than 3 but less than 7</td>
<td>.001</td>
<td>.002</td>
</tr>
<tr>
<td>7 or more</td>
<td>.0015</td>
<td>.003</td>
</tr>
</tbody>
</table>

Step 2: Calculate GHG emission reductions

\[
GHG \text{ Reducions in } MT\text{CO}_2 \text{ per year} = \frac{[(\text{AutoTrips}) \times (\text{ATSEF}) + (\text{AutoVMT}) \times (\text{AREF})]}{1,000,000}
\]

Where:
- AutoTrips = Annual Auto Trips Reduced value from Step 1
- AutoVMT = Annual Auto VMT Reduced value from Step 1
- ATSEF = Auto Trip Start Emission Factor in grams/trip from EMFAC2011
- AREF = Auto Running Emission Factor in grams/mile from EMFAC2011

Reminder: this formula must be used two times to calculate both Yr1 and YrF. The only difference between the two calculations will be the calendar year emission factor values from EMFAC2011. Instructions for obtaining the ATSEF and AREF values from EMFAC2011 are included on page 21.

Step 3: Calculate the GHG Reducions Over the Project Life

Calculate the “Project Life GHG Reductions” using the following equation.

\[
\text{Project Life GHG Reducions} = \left( \frac{Yr1 \text{ GHG Reducions} + YrF \text{ GHG Reducions}}{2} \right) \times \text{Project Life}
\]

Where:
- Project life = Class 1 bicycle paths = 20 yrs
  - Class 2 bicycle lanes = 15 yrs

The Project Life GHG Reductions will be used in Section D. Reporting.
Pedestrian Facilities

**Project Description:** Pedestrian facilities replace auto trips by providing or improving pedestrian access. An example is a pedestrian passageway over several lanes of heavy traffic providing safe walking access to adjacent activity centers.

**Step 1: Calculate VMT and trip reductions**

*Annual Auto Trips Reduced in trips per year*  
\[ (W) \times (T) \quad \text{Eq. 28} \]

*Annual Auto VMT Reduced in miles per year*  
\[ (W) \times (T) \times (L) \quad \text{Eq. 29} \]

Where:
- **W** = Weeks of operation per year  
  Use: 52
- **T** = Auto trips eliminated  
  Use: Total one-way trips per week based on project data
- **L** = Length of auto trip eliminated  
  Use: Average distance to adjacent activity center (Default: 1.0)

**Step 2: Calculate GHG emission reductions**

\[
\text{GHG Reductions in MTC02 per year} = \frac{[(\text{AutoTrips}) \times (\text{ATSEF}) + (\text{AutoVMT}) \times (\text{AREF})]}{1,000,000}
\]  
*Eq. 30*

Where:
- **AutoTrips** = Annual Auto Trips Reduced value from Step 1
- **AutoVMT** = Annual Auto VMT Reduced value from Step 1
- **ATSEF** = Auto Trip Start Emission Factor in grams/trip from EMFAC2011
- **AREF** = Auto Running Emission Factor in grams/mile from EMFAC2011

*Reminder:* This formula must be used two times to calculate both Yr1 and YrF. The only difference between the two calculations will be the calendar year emission factor values from EMFAC2011. Instructions for obtaining the ATSEF and AREF values from EMFAC2011 are included on page 21.

**Step 3: Calculate the GHG Reductions Over the Project Life**

Calculate the “Project Life GHG Reductions” using the following equation.

\[
\text{Project Life GHG Reductions} = \left( \frac{Yr1 \text{ GHG Reductions} + YrF \text{ GHG Reductions}}{2} \right) \times \text{Project Life}
\]  
*Eq. 31*

Where:
- **Project life** = 20 years for pedestrian facilities

The Project Life GHG Reductions will be used in Section D. Reporting.
EMFAC2011 Emission Factors

CO2 emission factors must be obtained from EMFAC2011. ARB provides a web-based EMFAC2011 tool (available at http://www.arb.ca.gov/emfac/) to determine vehicle emission factors based on region, calendar year, season, vehicle category, model year, speed, and fuel. The tool provides specified emission factor data in a comma separated values (CSV) output file that can be opened in most spreadsheet software.

Complete the following steps for both calendar years: Yr1 and YrF.

Step 1. Generate the Output File

Figure 2. EMFAC Emissions Database

On the EMFAC Emissions Database screen, select the following parameters:

Data Type: Emission Rates
Region: County
Calendar year: Obtain output files for both Yr1 and YrF
Season: Annual Average
Vehicle category: EMFAC2011 Categories
  Autos: LDA, LDT1, LDT2, and MDV
  Van: LHD1 or project specific vehicle category
  Bus: UBUS or project specific vehicle category
Model year: Aggregated for autos, buses or vans
  Model year specific for new gas or diesel bus or van projects
Speed: Aggregated
Fuel: Gas for autos; Gas or Diesel for vans; Diesel for buses

For the remaining steps, you will only need the following columns from the output file:

- VMT
- CO2_RUNEX (Pavley I+LCFS)
- CO2_STREX (Pavley I+LCFS)
Step 2. Calculate VMT-weighted Auto Running and Trip Start Emission Factors

AREF: Auto fleet average Running Factor in grams/vehicle/day

\[
\text{AREF} = \frac{(VMT \times \text{CO2\_RUNEX(Pavley I + LCFS)})_{LDA} + (VMT \times \text{CO2\_RUNEX(Pavley I + LCFS)})_{LDT1} + (VMT \times \text{CO2\_RUNEX(Pavley I + LCFS)})_{LDT2} + (VMT \times \text{CO2\_RUNEX(Pavley I + LCFS)})_{MDV}}{\text{Sum (VMT)}}
\]

ATSEF: Auto fleet average Start Factor in grams/vehicle/day divided by trips per vehicle per day.

\[
\text{ATSEF} = \frac{(VMT \times \text{CO2\_STREX(Pavley I + LCFS)})_{LDA} + (VMT \times \text{CO2\_STREX(Pavley I + LCFS)})_{LDT1} + (VMT \times \text{CO2\_STREX(Pavley I + LCFS)})_{LDT2} + (VMT \times \text{CO2\_STREX(Pavley I + LCFS)})_{MDV}}{\text{Sum (VMT)}}
\]

The Auto Trip Start Factor in grams/trip is calculated by dividing the Auto Start Factor by 6 trips/vehicle/day\(^{14}\) as follows:

\[
\text{Auto Trip Start Factor (ATSEF)} = \left(\frac{\text{Auto Start Factor}}{6}\right)
\]

Step 3. Identify the Van or Bus Emission Factors

VREF or BREF: For each calendar year, the van or Running Factor can be taken directly from the CSV file:

\[
\text{Running Factor} = \text{CO2\_RUNEX(Pavley I + LCFS)}
\]

Step 4. Obtain Emission Factors for both Yr1 and YrF

Don’t forget to get the emission factors for both the initial year and final year of the project!\(^{15}\)

---

\(^{14}\) The number of trips per vehicle per day was estimated by dividing the average number of trips per day by the number of vehicles for each vehicle category (LDA, LDT1, LDT2, and MDV) from the EMFAC web-based tool.

\(^{15}\) EMAC2011 emission factors are only available through 2035. Use 2035 as a proxy for any final year beyond 2035. This is consistent with CalEEMod.
D. Reporting and Documentation

The final step to complete this quantification methodology is to report the Total Project GHG Emission Reductions and provide documentation of the calculations.

The Total Project GHG Emission Reductions is equal to the sum total of each of the Project Life GHG Reductions calculated in Sections B and C, as follows:

\[
\text{Total Project GHG Emission Reductions in MTCO2} \quad \text{Eq. 36}
\]

\[
= \text{Project Life GHG Reductions (from CalEEMod, Section B)} \\
+ \text{Project Life GHG Reductions (from Bus, Section C)} \\
+ \text{Project Life GHG Reductions (from Vanpools, Section C)} \\
+ \text{Project Life GHG Reductions (from Bicycle, Section C)} \\
+ \text{Project Life GHG Reductions (from Pedestrian, Section C)}
\]

For AHSC Program application scoring purposes, the applicant must report results as:

\[
\text{Total Project GHG Emission Reductions in Metric tons (MT) of CO2 over the project life of GGRF Funds Requested (\$)} \quad \text{Eq. 37}
\]

Documentation

Applicants are required to provide electronic documentation that is complete, and sufficient enough to allow the quantification calculations to be reviewed and replicated. Paper copies of any materials must be available upon request by SGC or ARB staff.

Documentation will include such things as:

- Contact information for the person who can answer project specific questions from staff reviewers on the quantification calculations
- Project description, including excerpts or specific references to the location in the main AHSC application of the project information necessary to complete the applicable portions of the quantification methodology
- If applicable, electronic copies of the CalEEMod input and output files
  - A list of the VMT reduction measures used in the proposed project with clearly identified project specific input data used in Section B
  - Electronic documentation of calculations (spreadsheets, etc.) for all additional calculations
- If applicable, electronic copies of the TAC Methods used
  - Documentation of the project specific data used in Section C
  - Documentation of calculations (spreadsheets, EMFAC2011 reports, etc.)
  - Documentation for increased ridership estimates
- Summary page with, at minimum, the following information
  - GHG emissions estimates for Yr1 and YrF
  - GHG emission reductions for Yr1, YrF, and Total over the project life
  - GGRF funds requested for the project
  - Total Project GHG emission reductions per GGRF funds requested