Appendix D

California Air Resources Board

Greenhouse Gas Quantification Methodology for the Strategic Growth Council
Affordable Housing and Sustainable Communities Program

Fiscal Year 2014-15

January 20, 2015

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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[5]. 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.

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[5] http://www.capcoa.org/wp-content/uploads/2010/11/CAPCOA-Quantification-Report-9-14-Final.pdf

Table 1: Example Project Types and Quantification Method

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

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 <u>initial case</u> and a <u>project case</u>. 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[6] 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:

$$\frac{Metric\ tons\ (MT)\ of\ CO2\ over\ the\ project\ life}{GGRF\ Funds\ Requested\ (\$)}$$

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. Questions on this document should be forwarded to GGRFProgram@arb.ca.gov.

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[6] 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

The CalEEMod model, User's Guide, and other supporting documents can be downloaded, without charge, from www.caleemod.com.

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.

5. **ICP adjustment, if applicable**: This step applies only to ICP projects using CalEEMod <u>and</u> 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[7]

(Windspeed and Precipitation will "autofill")

Land Use Setting:	Select "Urban" unless project is in a defined "Rural" Census Tract
Operational Year:	<u>First run</u>, enter the first operational year of the project. <u>Second run</u>, add 30 years to the first operational year of the project. 30 years is the required project life for AHSC CalEEMod runs.
Select Utility Co.:	Select the utility company serving the proposed project.

(CO2, CH4, and N2O Intensity Factors will "autofill")

Pollutants:	Leave only the box for "Carbon Dioxide (CO2)" checked
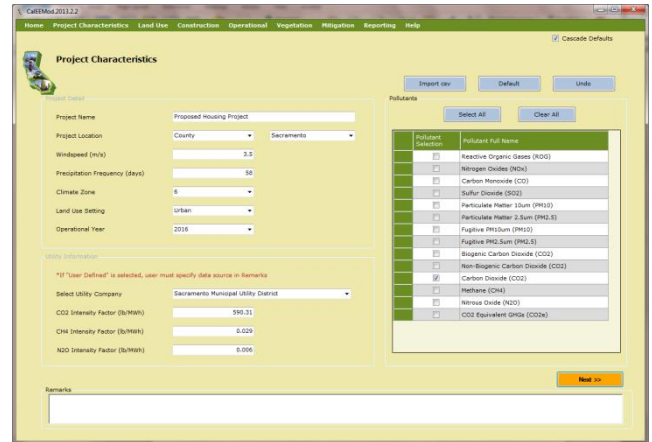
Land Use Screen

Cascade Defaults:	Leave this box checked
Land Use Type:	Select land use type
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:	*
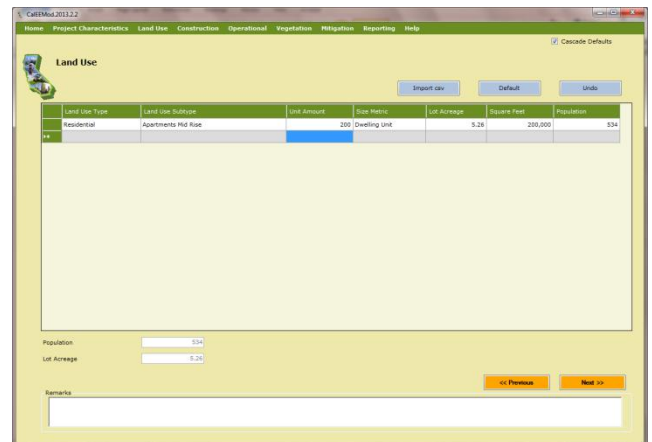
*Enter values if available in proposed project information. CalEEMod will use defaults if left blank.

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.

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[7] The Climate Zone is identified by zip code in the lookup table found here:
http://www.aqmd.gov/docs/default-source/caleemod/caleemod-appendixf.pdf

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.*
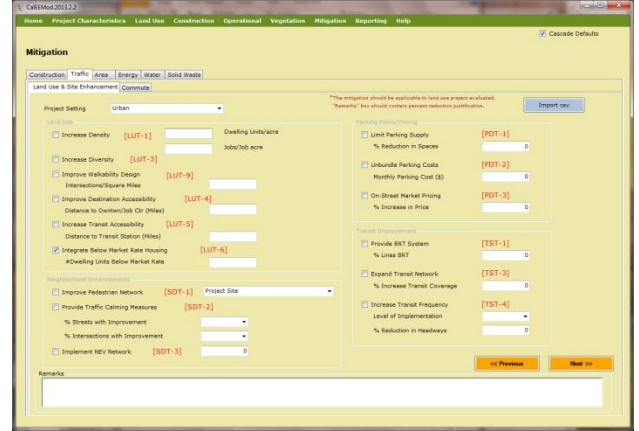
Table 2. Project Settings in the "Land Use & Site Enhancement" Screen

CalEEMod Project Setting Types[8]	Location Setting Description
Low Density Suburban	An area characterized by dispersed, low-density, single-use, automobile dependent land use patterns, usually outside of the central city (a suburb).
Suburban Center	An area that serves the population of the suburb with office, retail, and housing which is denser than the surrounding suburb.
Urban	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.
Urban Center	An area within or contiguous with the central city. Examples may include redevelopment areas, abandoned sites, or underutilized older buildings/sites.

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 tract in which project site is located is adjacent to a census track with contiguous development on at least one side.

Table 3. "Land Use & Site Enhancement" VMT Reduction Measures

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[8] 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.

ID[9]	VMT Reduction Measure	Description	Project Specific Data Inputs Required by CalEEMod
Land Use & Site Enhancement Measures			
LUT-1	Increase Density	Project more dense (housing or jobs) than typical developments	**Do not check LUT-1 box in CalEEMod, and See Step 4**
LUT-3	Increase Diversity	Different types of land uses are near each other	Project land use types
LUT-9	Improve Walkability Design	Walkable street network	Intersections per square mile
LUT-4	Improve Destination Accessibility	Project close to regional employment or destination center	**Do not check LUT-4 box in CalEEMod, and See Step 4**
LUT-5	Increase Transit Accessibility	Project near high-quality transit	Distance to transit station (miles). **If ICP, See Step 5**
LUT-6	Integrate Below Market Rate Housing	Incorporates affordable housing	**CalEEMod: enter Percentage of units (not # of Units)** that are affordable as defined by AHSC Guidelines.
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
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
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
TST-4	Increase Transit Frequency	Reduces headways of existing transit	Level of implementation % reduction in headway

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[9] 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.

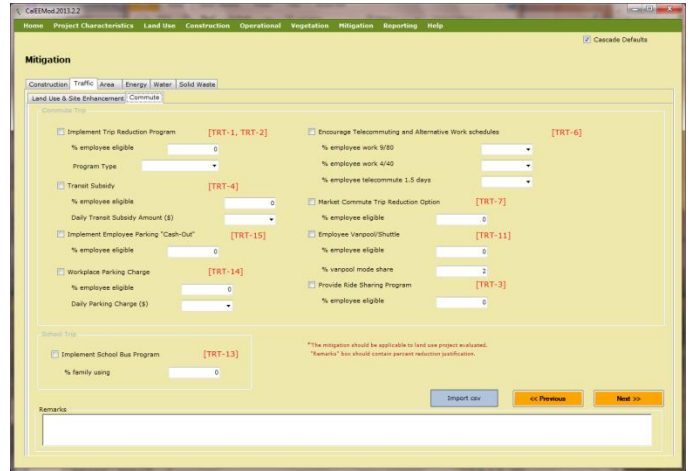*These VMT reduction measures only apply
to non-residential land use types.*

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Table 4. "Commute" VMT Reduction Measures

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

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[10] Measures listed in the order shown on the CalEEMod screens. IDs reference to the CAPCOA GHG Quantification Report.

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.
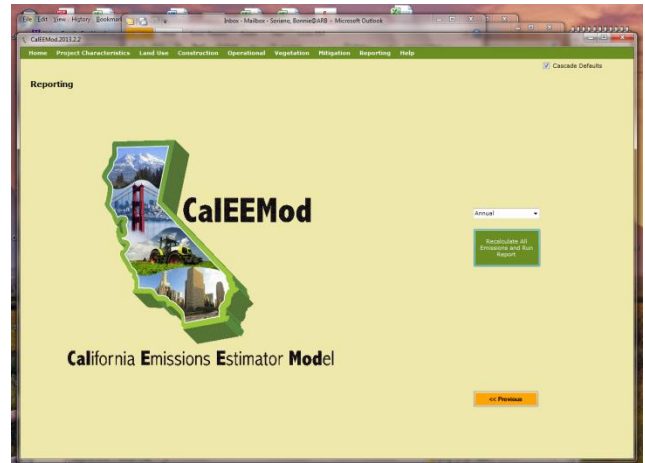

Figure 1. CalEEMod Report Section 2.2 Listing Overall Operational Mobile Unmitigated (i.e., Initial Case) GHG Emissions in MT/yr.

	ROG	NOx	CO	SO2	Fugitive PM10	Exhaust PM10	PM10 Total	Fugitive PM2.5	Exhaust PM2.5	PM2.5 Total	Bio- CO2	NBio- CO2	Total CO2	CH4	N2O	CO2e
Category							tons/yr							MT/yr		
Area													24.6121			
Energy													682.8471			
Mobile													3,104.5474			
Waste													41.8324			
Water													73.9439			
Total													3,927.7828			

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).

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**)

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

Increase Density (LUT-1)[11]

$$\% \, Density \, Increase = 100 * \frac{\boldsymbol{Project \, DU/acre} - 7.6}{7.6}$$

$$\% \, VMT \, Reduction = 0.07 * \% \, Density \, Increase$$

$$\% \, GHG \, Reduction = \% \, VMT \, Reduction$$

Increase Destination Accessibility (LUT-4)[12]

$$\% \, Distance \, Decrease = 100 * \frac{\boldsymbol{Project \, Distance} - 12}{12}$$

$$\% \, VMT \, Reduction = 0.20 * \% \, Distance \, Decrease$$

$$\% \, GHG \, Reduction = \% \, VMT \, Reduction$$

LUT-1 & LUT-4

$$Yr1 \, GHG \, Reduction = \% \, GHG \, Reduction * Yr1 \, Initial \, Case \, GHG \, Emissions$$
$$YrF \, GHG \, Reduction = \% \, GHG \, Reduction * YrF \, Initial \, Case \, GHG \, Emissions$$

Use the following GHG reduction results from LUT-1 and LUT-4 in Step 6 below:
- Yr1 LUT1 GHG Reduction
- YrF LUT1 GHG Reduction
- Yr1 LUT4 GHG Reduction
- YrF LUT4 GHG Reduction

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[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.

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 filled in.

Calculate the ICP GHG Adjustment[13] as follows:

$$Yr1\ ICP\ GHG\ Adjustment = 0.025 * Yr1\ Initial\ Case\ GHG\ Emissions$$

$$YrF\ ICP\ GHG\ Adjustment = 0.025 * YrF\ Initial\ Case\ GHG\ Emissions$$

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. <u>Use the first two equations two times. First for Yr1, then for YrF.</u>

$$\begin{aligned}
\textbf{\textit{Adj Project Case GHG Emissions}} \\
= Project\ Case\ GHG\ Emissions\ (Step\ 3) \\
- LUT1\ GHG\ Reductions\ (Step\ 4) \\
- LUT4\ GHG\ Reductions\ (Step\ 4) \quad\quad + ICP\ GHG\ Adustment\ (Step\ 5)
\end{aligned}$$

$$\textbf{\textit{Total GHG Reductions}} = Initial\ Case\ GHG\ Emissions - \textbf{\textit{Adj Project Case GHG Emissions}}$$

$$\begin{aligned}
Project\ Life\ GHG\ Reductions \\
= \left(\frac{\textbf{\textit{Yr1 Total GHG Reductions}} + \textbf{\textit{YrF Total GHG Reductions}}}{2}\right) * 30
\end{aligned}$$

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

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[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 5. TAC Methods - For AHSC Projects

TAC Methods	Description	Project Life
Operation of New Bus Service	Extended and increased frequency routes with cleaner vehicles, new hours of service, and serve additional riders.	Number of years the new bus service is funded under the proposed project.
Vanpools and Shuttles	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.	Number of years the vanpool or shuttle service is funded under the proposed project.
Bicycle Paths or Lanes	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.	Class 1 bicycle paths-20 yrs Class 2 bicycle lanes-15 yrs
Pedestrian Facilities	Pedestrian facilities reduce VMT by providing pedestrian access and replacing auto trips with walking trips.	Pedestrian Facilities-20 yrs

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 20.

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

$$Annual\ Auto\ Trips\ Reduced\ in\ trips\ per\ year\ =\ [(D) * (R) * (A)] * [1 - (AA)]$$

$$Annual\ Auto\ VMT\ Reduced\ in\ miles\ per\ year\ =\ [(D) * (R) * (A)] * [(L) - (AA) * (LL)]$$

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

Step 2: Calculate GHG emission reductions

$$GHG\ Reductions\ in\ MTCO2\ per\ year$$
$$= \frac{[(AutoTrips) * (ATSEF) + (AutoVMT) * (AREF) - (BusVMT) * (BREF)]}{1,000,000}$$

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 from EMFAC2011. Instructions for obtaining the ATSEF, AREF, and BREF values from EMFAC2011 are included on page 20.

Step 3: Calculate the GHG Reductions Over the Project Life

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

$$Project\ Life\ GHG\ Reductions = \left(\frac{Yr1\ GHG\ Reductions + YrF\ GHG\ Reductions}{2}\right) * Project\ Life$$

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

$Annual\ Auto\ Trips\ Reduced\ in\ trips\ per\ year\ =\ [(D)*(R)*(A)]*[1-(AA)]$

$Annual\ Auto\ VMT\ Reduced\ in\ miles\ per\ year\ =\ [(D)*(R)*(A)]*[(L)-(AA)*(LL)]$

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

$GHG\ Reductions\ in\ MTCO2\ per\ year$
$$=\frac{[(AutoTrips)*(ATSEF)+(AutoVMT)*(AREF)-(VanVMT)*(VREF)]}{1,000,000}$$

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 20.

Step 3: Calculate the GHG Reductions Over the Project Life

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

$$Project\ Life\ GHG\ Reductions = \left(\frac{Yr1\ GHG\ Reductions + YrF\ GHG\ Reductions}{2}\right) * Project\ Life$$

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

$$Annual\ Auto\ Trips\ Reduced\ in\ trips\ per\ year\ =\ (D) * (ADT) * (A + C)$$

$$Annual\ Auto\ VMT\ Reduced\ in\ miles\ per\ year\ =\ (Annual\ Auto\ Trips\ Reduced) * (L)$$

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

BIKE FACILITY CLASS	AVERAGE DAILY TRAFFIC (ADT)	LENGTH OF BIKE PROJECT (one direction)	ADJUSTMENT FACTORS FOR CITIES WITH POP. $\geq$ 250,000 and non-university towns < 250,000	ADJUSTMENT FACTORS FOR UNIVERSITY TOWNS WITH POP. < 250,000
Class 1 (bike path) & Class 2 (bike lane)	ADT $\leq$ 12,000 vehicles per day	$\leq$ 1 mile	.0019	.0104
		>1 & $\leq$ 2 miles	.0029	.0155
		> 2 miles	.0038	.0207
Class 1 (bike path) & Class 2 (bike lane)	12,000< ADT $\leq$24,000 vehicles per day	$\leq$ 1 mile	.0014	.0073
		>1 & $\leq$ 2 miles	.0020	.0109
		> 2 miles	.0027	.0145
Class 2 bike lane	24,000< ADT $\leq$30,000 vehicles per day Maximum is 30,000	$\leq$ 1 mile	.0010	.0052
		>1 & $\leq$ 2 miles	.0014	.0078
		> 2 miles	.0019	.0104

Table 7. Activity Center Credit Lookup Table

Types of Activity Centers: Bank, church, hospital or HMO, light rail station (park & ride), office park, post office, public library, shopping area or grocery store, university or junior college.		
Count your activity centers. If there are…	**Credit (C) Within 1/2 mile**	**Credit (C) Within 1/4 mile**
3	.0005	.001
More than 3 but less than 7	.001	.002
7 or more	.0015	.003

Step 2: Calculate GHG emission reductions

$$GHG\ Reductions\ in\ MTCO2\ per\ year\ =\ \frac{[(\textbf{AutoTrips}) * (\textbf{ATSEF}) + (\textbf{AutoVMT}) * (\textbf{AREF})]}{1,000,000}$$

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 20.

Step 3: Calculate the GHG Reductions Over the Project Life

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

$$Project\ Life\ GHG\ Reductions = \left(\frac{\textbf{Yr1 GHG Reductions} + \ \textbf{YrF GHG Reductions}}{2}\right) * \textbf{Project Life}$$

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

$Annual\ Auto\ Trips\ Reduced\ in\ trips\ per\ year\ =\ (\boldsymbol{W}) * (\boldsymbol{T})$

$Annual\ Auto\ VMT\ Reduced\ in\ miles\ per\ year\ =\ (\boldsymbol{W}) * (\boldsymbol{T}) * (\boldsymbol{L})$

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

$$GHG\ Reductions\ in\ MTCO2\ per\ year\ =\ \frac{[(AutoTrips) * (ATSEF) + (AutoVMT) * (AREF)]}{1,000,000}$$

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 Reductions Over the Project Life

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

$$Project\ Life\ GHG\ Reductions = \left(\frac{Yr1\ GHG\ Reductions + YrF\ GHG\ Reductions}{2}\right) * Project\ Life$$

Where:
Project life = 20 years for pedestrian facilities

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

EMFAC2011 Emission Factors

CO_2 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
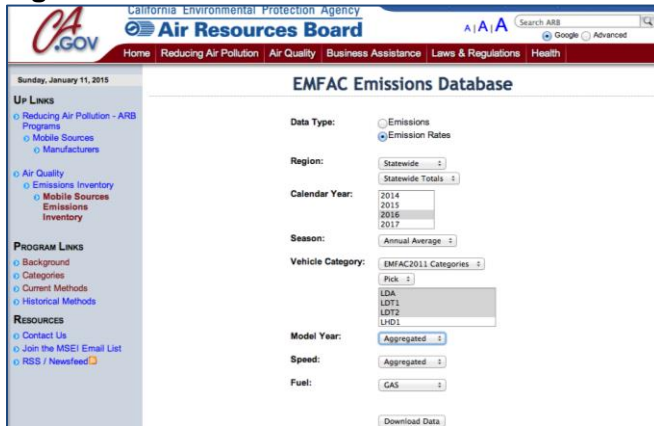
On the EMFAC Emissions Database screen, select the following parameters:

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

$$= \frac{\begin{array}{l}(VMT * CO2\_RUNEX(Pavley\ I + LCFS))_{LDA} + (VMT * CO2\_RUNEX(Pavley\ I + LCFS))_{LDT1} \\ +(VMT * CO2\_RUNEX(Pavley\ I + LCFS))_{LDT2} + (VMT * CO2\_RUNEX(Pavley\ I + LCFS))_{MDV}\end{array}}{Sum\ (VMT)}$$

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

$$= \frac{\begin{array}{l}(VMT * CO2\_STREX(Pavley\ I + LCFS))_{LDA} + (VMT * CO2\_STREX(Pavley\ I + LCFS))_{LDT1} \\ +(VMT * CO2\_STREX(Pavley\ I + LCFS))_{LDT2} + (VMT * CO2\_STREX(Pavley\ I + LCFS))_{MDV}\end{array}}{Sum\ (VMT)}$$

The Auto Trip Start Factor in grams/trip is calculated by dividing the Auto Start Factor by 6 trips/vehicle/day[14] as follows:

$$Auto\ Trip\ Start\ Factor\ (ATSEF) = \left(\frac{Auto\ Start\ Factor}{6}\right)$$

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:

$$Running\ Factor = CO2\_RUNEX(Pavley\ I + LCFS)$$

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]

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[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:

$$Total\ Project\ GHG\ Emission\ Reductions\ in\ MTCO2$$
$$= Project\ Life\ GHG\ Reductions\ (from\ CalEEMod, Section\ B)$$
$$+ Project\ Life\ GHG\ Reductions (from\ Bus, Section\ C)$$
$$+ Project\ Life\ GHG\ Reductions\ (from\ Vanpools, Section\ C)$$
$$+ Project\ Life\ GHG\ Reductions\ (from\ Bicycle, Section\ C)$$
$$+ Project\ Life\ GHG\ Reductions\ (from\ Pedestrian, Section\ C)$$

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

$$\underline{Total\ Project\ GHG\ Emission\ Reductions\ in\ Metric\ tons\ (MT)\ of\ CO2\ over\ the\ project\ life}$$
$$GGRF\ Funds\ Requested\ (\$)$$

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.)
- 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