CalEEMod

California Emissions Estimator Model

User Guide

Version 2022.1

Prepared for:
California Air Pollution Control Officers Association (CAPCOA)

Prepared by:
ICF
in collaboration with Sacramento Metropolitan Air Quality Management District, Fehr & Peers, STI, and Ramboll

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California Emission Estimator Model (CalEEMod)®

Version 2022.1

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Table of Contents

List of Appendices

List of Tables

List of Figures **Page**

1 Introduction

This User Guide to the California Emission Estimator Model (CalEEMod)® provides direction for appropriate use of the program and documents the detailed calculations and default assumptions. The purpose of CalEEMod is to provide a uniform platform for government agencies, land use planners, and environmental professionals to estimate ozone precursors, criteria pollutants, and greenhouse gases (GHG) (collectively referred to as "emissions") from land use development and linear projects in California. CalEEMod also integrates data from the Office of Environmental Health Hazard Assessment's (OEHHA) CalEnviroScreen® (CES) 4.0, the State of California's Cal-Adapt®, and the Public Health Alliance of Southern California's Healthy Places Index® (HPI) (November 2021) to identify potential climate risks and environmental burdens within the vicinity of a project. Measures to reduce emissions, climate risks, and environmental burdens are available for user selection and analysis.

1.1 Default Data and Assumptions

CalEEMod utilizes widely accepted methodologies for estimating emissions combined with default data that can be used when site-specific information is not available. Sources of these methodologies and default data include the United States Environmental Protection Agency's (USEPA) AP-42 emission factors, California Air Resources Board's (CARB) vehicle emission models, and studies commissioned by California agencies such as the California Energy Commission (CEC) and California Department of Resources Recycling and Recovery (CalRecycle). In addition, some local air districts provided customized values to support defaults and calculations for projects located in their jurisdictions. When no customized information was provided, and no regional differences were defined for local air districts, statewide default values are utilized. Because resource data and regulations are constantly changing, local agencies should be consulted to determine whether there are any circumstances when updated values should be used in place of the defaults currently incorporated into CalEEMod. A majority of CalEEMod's default data associated with locations and land use development project subtypes are derived from surveys of existing land uses. For any project that substantially deviates from the types and features included in the surveys, site-specific data that are supported by substantial evidence should be used, if available. Default data and quantification methodologies for construction emissions of linear projects are integrated from the Sacramento Metropolitan Air Quality Management District's Road Construction Emissions Model (RCEM), version 9.0.0 (last updated in 2018).

There are several opportunities for the user to change the defaults in the model; however, the user is required to provide justification for all changes made to the default settings (e.g., reference more appropriate data sources) in the Justification box before the user will be able to proceed to the next screen. Justifications are typically attached to content associated with a single screen rather than individual fields. The user should make every effort to ensure that correct data is entered, including the application of specific mitigation measures.

1.2 Purpose of Model

CalEEMod provides a simple and integrated platform to quantify construction and operations emissions, assess climate hazards and vulnerabilities, identify environmental burdens, and evaluate benefits of various emission reduction, climate risk reduction, and health and equity measures. Air pollution, climate change, and equity are not mutually exclusive—they are interrelated and, as such, demand integrated and comprehensive solutions. CalEEMod incorporates data from CES, Cal-Adapt, and HPI to better support climate adaptation and equity considerations during project-level emissions review.

Specific to emissions, CalEEMod calculates construction and operations emissions from land use development projects and construction emissions from linear projects. The model quantifies maximum daily, average daily, average quarterly, and annual emissions, which can be used to support preparation of air quality and GHG analyses in California Environmental Quality Act (CEQA) documents, such as environmental impact reports (EIRs) and mitigated negative declarations (MNDs). In addition, air districts may rely on the model's emission estimates to show compliance with local agency rules. The emissions inventory modules also contain default values for estimating utility consumption (e.g., water, electricity, natural gas) that may be useful for preparing hydrology and energy analyses in other sections of a CEQA document.

CalEEMod displays data for extreme heat, extreme precipitation, wildfire, and sea level rise through an application programming interface (API) with Cal-Adapt. Based on the Cal-Adapt data and user inputs, the model provides a method to quantify and score the vulnerability of a project to projected climate change. CalEEMod presents environmental and health burdens relevant to a project area. These data are obtained from CES 4.0 and the HPI. CalEEMod also identifies if the project is in a Senate Bill (SB) 535–designated disadvantaged community, Assembly Bill (AB) 1550–designated low-income community, or AB 617–designated community.

The model provides the following primary functions.

- Calculates short-term construction emissions from land use development and linear projects associated with demolition, site preparation, grading, building construction, paving, and architectural coating from the following sources:
  - Exhaust emissions from off-road construction equipment.
  - Exhaust emissions from on-road mobile vehicles (workers, vendors, hauling, and onsite trucks).
  - Fugitive dust emissions from grading, bulldozing, truck loading, demolition, and on-road vehicles traveling along paved and unpaved roads.[1]
  - Evaporative volatile organic compound (VOC) emissions from architectural coating and paving activities.
  - Indirect GHG emissions from electricity consumption.
- Calculates operations emissions for land use development from the following sources:
  - Exhaust emissions from on-road mobile vehicles, hearths (e.g., stoves, fireplaces), off-road (e.g., forklifts, cranes) equipment, landscaping (e.g., mowers) equipment, and stationary sources (e.g., emergency generators, fire pumps, and process boilers).
  - Fugitive dust emissions associated with on-road mobile vehicle travel along roadways.
  - Evaporative VOC emissions from architectural coating activities, consumer products, parking lot degreasers, and fertilizers/pesticides.

[1] Fugitive dust from windblown sources, such as storage piles and inactive disturbed areas, as well as fugitive dust from off-road vehicle travel, are not quantified in CalEEMod, which is consistent with approaches taken in other comprehensive models.

  - Indirect GHG emissions from electricity and water consumption and direct GHG emissions from natural gas consumption.
  - Fugitive GHG emissions from decomposition of landfilled solid waste and avoided indirect GHG emissions from combusted biogas used for cogeneration.
  - Fugitive GHG emissions from refrigerants used in air conditioning and refrigeration equipment.

- Calculates changes in carbon and GHG emissions from the following vegetation changes:
  - Soil and aboveground and belowground biomass.
  - New tree plantings and/or removals.
- Displays projected extreme heat, precipitation, sea level rise, and wildfire risks to a project based on data from Cal-Adapt.
- Displays environmental and health indicator scores for a project based on data from CES 4.0 and HPI.
- Quantifies and scores the vulnerability of a project to projected climate change across eight hazards.
- Identifies priority climate hazards of most concern to a project and location.
- Provides a database of measures to reduce emissions, climate risks, and environmental burdens. Many of the measures described in the California Air Pollution Control Officers Association's (CAPCOA) *Handbook for Analyzing Greenhouse Gas Emission Reductions, Assessing Climate Vulnerabilities, and Advancing Health and Equity: Designed for Local Governments, Communities, and Project Developers* (Handbook)[2] have been incorporated into CalEEMod.
- Identifies climate risk reduction measures applicable to a project based on the project scale, land use type(s), and location.
- Identifies measures to address the environmental and health burdens of the project site based on the CES 4.0 indicator scores and the project scale and land use type(s).

1.3 Structure of the Model

CalEEMod is structured into five main components, as shown in the left-hand side bar navigation panel of the tool. Clicking on the **Home** button will automatically return the user to the **Home** component's corresponding screen. The **Map, Inputs, Results,** and **Report** components include one or more modules, submodules, or screens, which will appear in an expanded side bar navigation panel when the user clicks on any of the activated component buttons. The project name is displayed at the top of the expanded panel for easy reference. The user may collapse the expanded panel by clicking the arrow to the right of the project name.

Figure 1 illustrates the structure of CalEEMod and hierarchy among the components, modules, submodules, and screens (see Chapter 4, *Detailed Program Components, Modules, Submodules, and Screens*). Certain aspects of the model require information from preceding screens, and, therefore, the intention of the model is that the user progresses through each screen in the order presented.

[2] Available: https://www.caleemod.com/handbook/index.html.

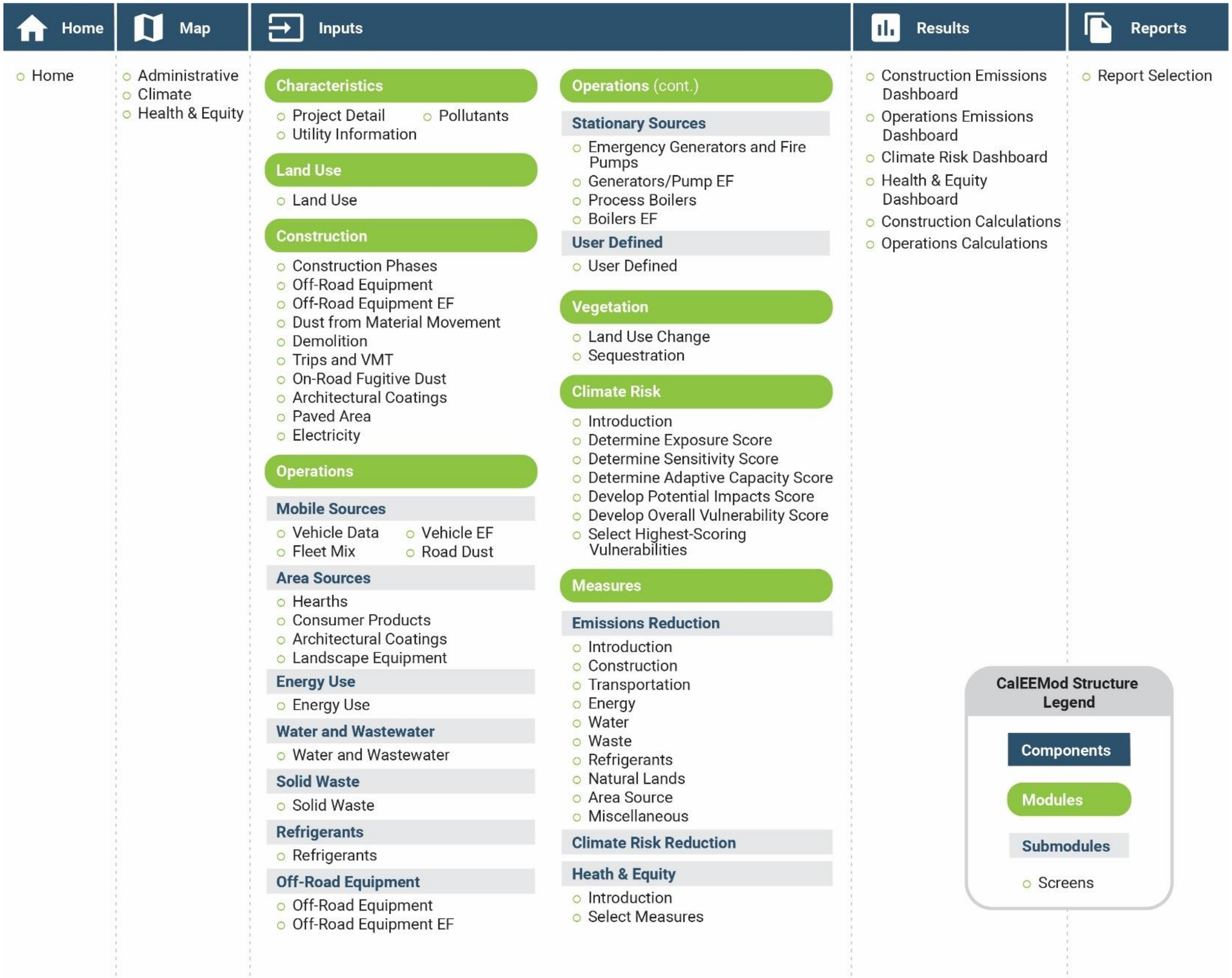


Figure 1. Structure of CalEEMod

2 Accessing CalEEMod

CalEEMod is available at https://www.caleemod.com/. CalEEMod is now accessed directly through a browser and requires an internet connection. This web-based version of CalEEMod does not require downloading or installation. A user can save, manage, and share multiple projects that will be retained in the browser cache. The user is encouraged to export projects that they wish to retain long term. Saved projects can be uploaded to CalEEMod, as discussed further in Section 3.2, *Creating and Uploading a Project*. Cached projects will be erased when the browser cache is cleared.

3 Using CalEEMod

3.1 Key Features

CalEEMod comprises a series of screens within modules and submodules, each designed with an individual purpose to define features of a project (e.g., construction schedule and equipment, operational activity). Projects may include new land use developments, new or expanded roadways, linear infrastructure improvements, or various plan-level developments, such as master, specific, and general plans (see Section 3.3, *Defining a Project*, for more information on the two scales at which projects can be defined in CalEEMod). Efficiencies were built into the model to prepopulate defaults when possible based on simple user entries. For example, a user defines a project location in the **Map** component, which will automatically propagate location-based information such as air district, utilities, windspeed, and precipitation. The user has control over which defaults are overridden with more accurate, project-specific information, and how changes to those values affect other, linked inputs in the model. As noted in Section 1.3, *Structure of the Model*, the user must work through each screen in the order they are presented. The user will, however, be able to return to screens that have already been completed.

The following are key features of CalEEMod, some of which are further described in this Guide. Screenshots are provided for easy reference.

1. *Top Bar*: Current or past model runs can be accessed and managed using the "My Projects" menu (three horizontal bars) in the upper right-hand corner. Once selected (checked), projects can be downloaded or deleted (see Figure 2). Additionally, new projects can be created or uploaded directly from this window.
2. *Side Navigation Bar*: This resource contains the five core model components—**Home**, **Map**, **Inputs**, **Results**, and **Report** (see Figure 3). Initially, the user will be required to enter project information sequentially to activate certain components of the model. Once a screen is complete, a check mark will appear to the left of the screen name in the Side Navigation Bar. Users can return to previously completed screens as they work through the model. Once a model run is complete, the user can also use the Side Navigation Bar to move between any of the components. The "Back" and "Next" browser buttons operate in a similar manner.

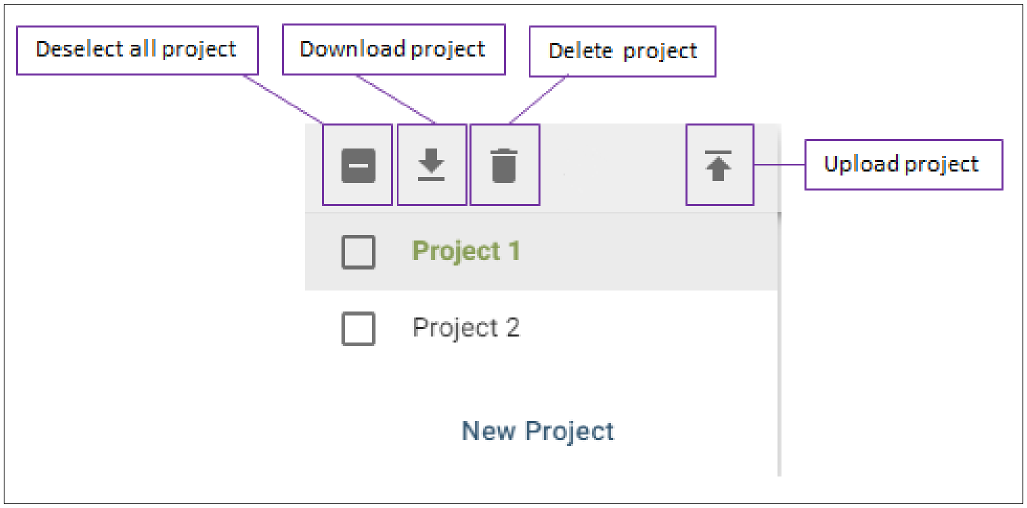


Figure 2. Select, Download, Delete, and Upload Projects

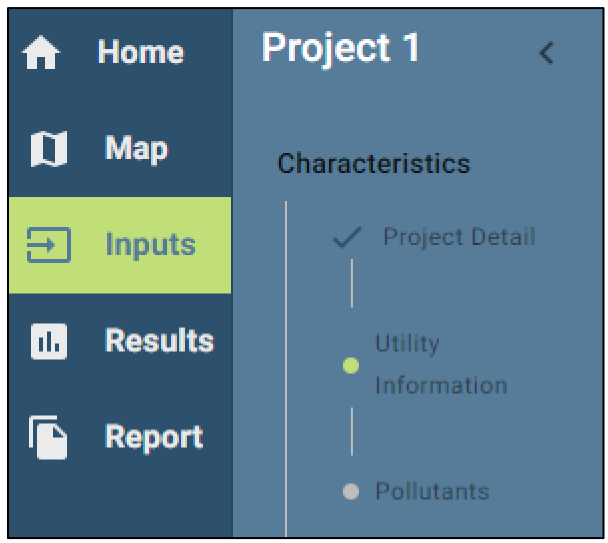


Figure 3. Side Navigation Bar

3. *Automatic Saving*: The user is not required to save projects as the user progresses through the model because projects are automatically cached during the process. This means that if there is an internet outage or the computer unexpectedly powers down, the project will still be available. Automatically saved projects can be accessed in the "My Projects" menu in the upper right of the screen. The browser cache can be cleared, so once completed, projects should be downloaded and saved in a secure location for future use.
4. *Automatic Updates to Default Values*: CalEEMod is a complex information model that requires the user to input a certain level of project detail. Some inputs have later dependencies that are assumed, such as trip lengths based on Traffic Analysis Zone (TAZ). The user then can override these assumptions as they move through the model. Because the model was built for flexibility so that a user is not "locked in" once they make an entry, they do have the ability to move back and make changes. These changes can then have implications on their dependencies, which may or may not have already had an override. Because a user may

have different interests in how these dependencies are handled, the model was built with three update options that can be set in the **Project Detail** screen. Be advised that a change made to the automatic update input will set how defaults and overrides are tracked moving forward but not retroactively (see Section 4.3.1.1, *Project Detail Screen*).

5. *Required vs. Recommended Inputs*: While defaults are available for most inputs, CalEEMod requires a certain amount of user-provided information. CalEEMod denotes required user inputs with red underline and text (see Section 4.3.2.1, *Land Use Screen*). The user must supply this information for the model to function properly. CalEEMod also identifies recommended user inputs with blue underline and text. Providing values for recommended inputs is not required for the model to output results but doing so will improve the accuracy of the analysis. For example, as discussed further in Section 4.3.2.1, *Land Use Screen*, defining the special landscape area will provide for a more accurate quantification of operational outdoor water.

6. *Pencil Edit and Delete Row*: CalEEMod uses a combination of dropdown menus and direct cell inputs to obtain primary information from the user. In certain instances, when defaults are automatically loaded based on prior user inputs, the cells cannot be directly overridden. The user must click the pencil icon to the right of the data to modify defaults (Figure 4). When the pencil icon is clicked, an override splash screen will appear for user input (Figure 5). The pencil edit function was deliberately programmed to avoid unintentional edits to default cells. The pencil edit function is often provided at the row level, with the splash screen covering multiple related inputs. Be sure to click the check mark to save all edits and close the pencil edit widget. The user may delete an entire row by clicking the trash can icon located on the right-hand side of the screen (Figure 4).

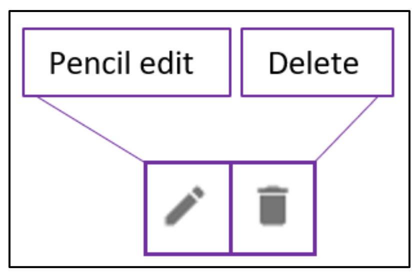


Figure 4. Pencil Edit and Delete Functions

7. *"i" Messages*: CalEEMod contains many features and inputs that may not be obvious to the user. For this reason, "i" messages were added throughout the model, when possible, to provide additional content and instruction. These can be viewed by hovering over the "i" icons found next to many entry fields (Figure 5).

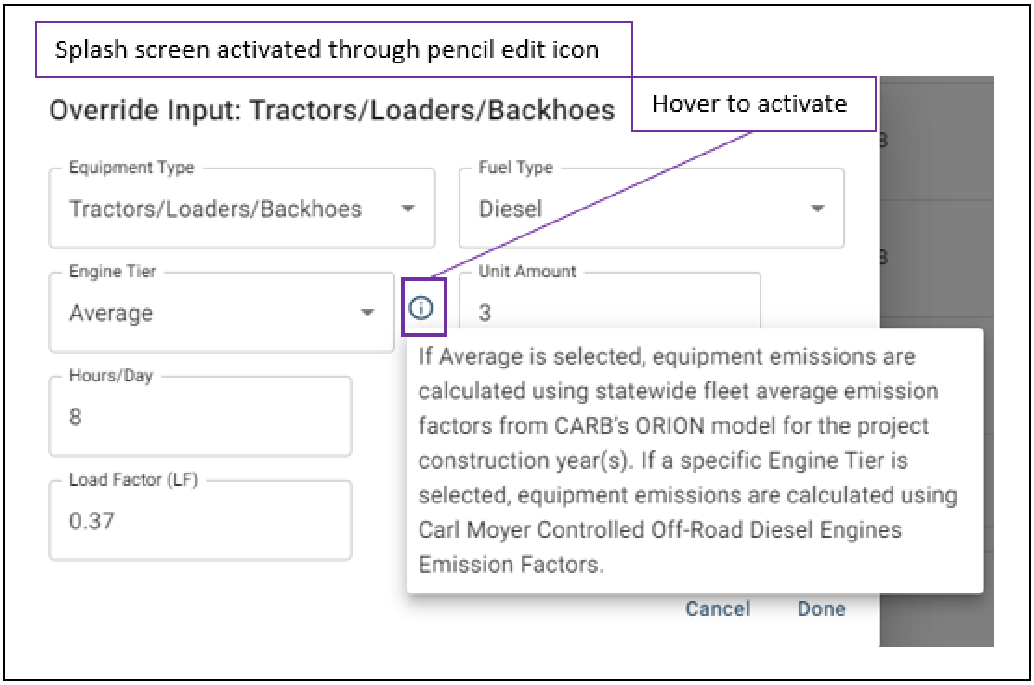


Figure 5. Splash Screens and Informational ("i") Messages

8. *Tabular View and Data List View*: Many entry screens contain the option to view tables in two different modes, depending on user preference. Some users may prefer to work through a large table, whereas others may prefer to think about one element at a time. Where available, the user can switch between tabular data and list view by clicking the icons in the upper right-hand corner of the screen (Figure 6). Note that some toggles and additional features are only available in the tabular data view mode.

Figure 6. Tabular and List View Options

3.2 Creating and Uploading a Project

The user can create a new project or upload an existing project on the **Home** screen. The user should select "New Project" to create a new project or select "Upload Project" to open a project that was previously created and saved as a .json file (see Figure 2). Note that projects previously created are automatically saved in the user's browser cache and can be accessed by clicking the "My Projects" menu in the upper right-hand corner of the screen (see Section 3.1, *Key Features*). Once the user clears their browser cache, previous projects will no longer be available in the "My Projects" menu and the user must upload the .json file to access prior model runs.

Clicking New Project will load the **Start a New Project** splash screen where the user can start defining a project.

3.3 Defining a Project

It is recommended that the user begin defining their project on the **Start a New Project** splash screen (Figure 7). At a minimum, this screen requires the user to name the project and define the applicable land use scale before moving forward. The user is encouraged to answer the optional question to define the land use types and subtypes for their project.

The land use scale defines the geographic extent of the project and influences the applicability of various measures. The user should select from one of the following land use scales.

- Project/Site: Projects that occur at the scale of a parcel, business, or individual development smaller than a neighborhood.
- Plan/Community: Projects that occur at the scale of a neighborhood (e.g., specific plan, general plan, climate action plan), corridor, or entire municipality (e.g., city- or county-level).

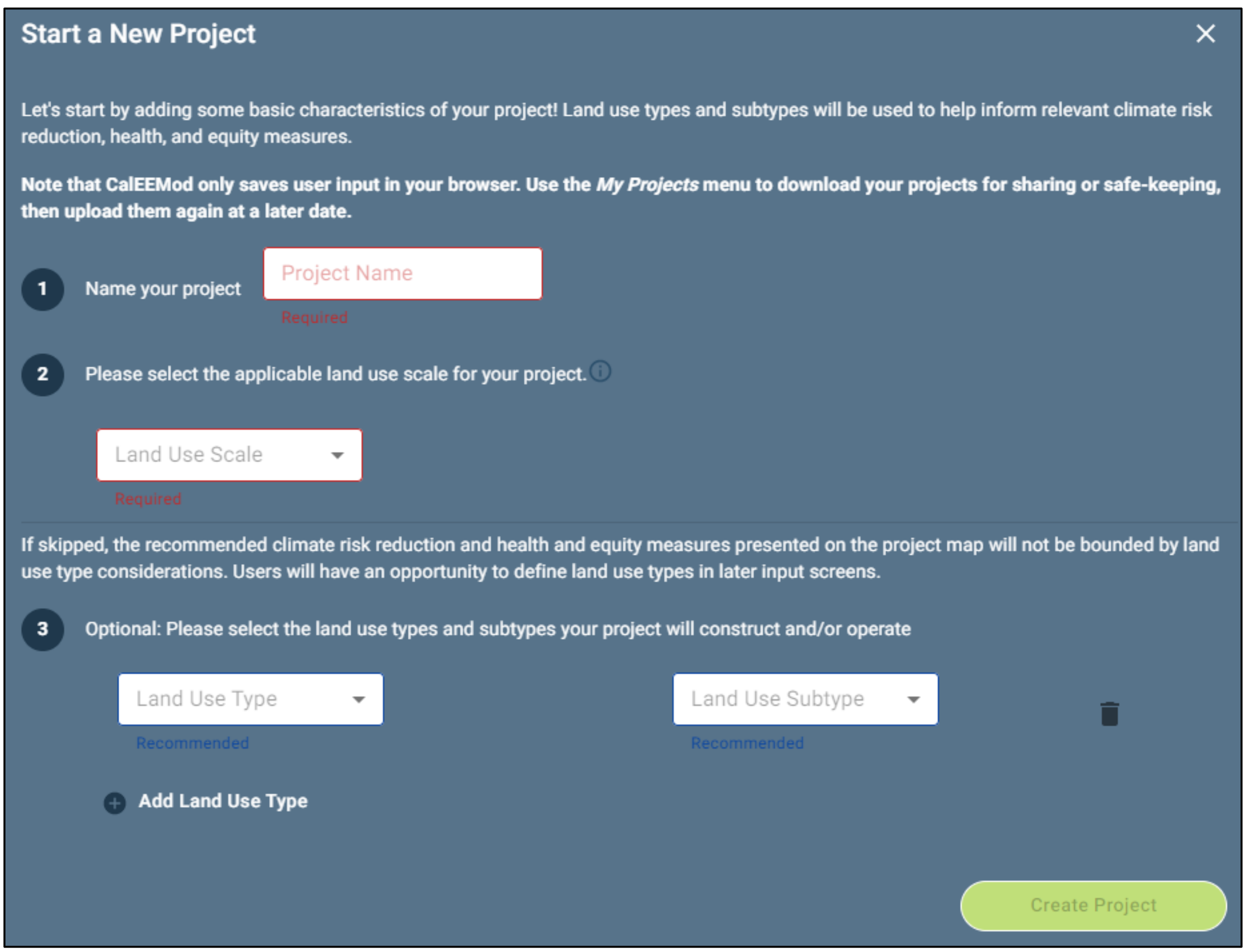


Figure 7. Start New Project Splash Screen

The land use type and land use subtype menus allow the user to identify the land use(s) that will occur at the project site. The user may select from any of the following eight primary land use types: Commercial, Educational, Industrial, Linear, Parking, Recreational, Residential, and Retail. Each of these land use types includes several more detailed land use subtypes (e.g., Single

Family Housing). The 79 different land use subtypes for development projects were chosen for inclusion in CalEEMod because each has an established trip rate, which is critical for mobile source calculations, as discussed further below in Section 4.3.4.1, *Mobile Sources Submodule*. The four land use subtypes for linear projects were directly incorporated in CalEEMod from the RCEM. The user will have an opportunity to further define the selected land use types and subtypes in **Land Use** screen (see Section 4.3.2, *Land Use Module*). Refer to Table 1 in Section 4.3.2.1.2, *Land Use Subtype*, for a complete description of all land use types and subtypes included in CalEEMod.

If the land use types and subtypes are not defined on the **Start a New Project** splash screen, the available and relevant measures analyses in the **Map** component will not be able to identify measures that are applicable to the project based on climate hazard and existing health and environmental burden analysis.

3.4 Defining the Project Location

The project location is critical to ensuring accurate emissions quantification and representation of climate risks and environmental burdens. Specifically, the location determines the electric utility emissions factor, building energy zones, trip lengths and generation rates, and other critical variables. It is also used to identify the applicable grid cell and census tract to enable spatial analysis of projected climate risks and environmental burdens from Cal-Adapt and CES 4.0 and the HPI, respectively. The user can define the project location using any of the following options.

- Pin the location by clicking directly on the map. Use the zoom-in feature to place the pin with greatest accuracy.
- Type the project address in the input box.
- Type the project latitude/longitude coordinates in the input box.

It is recommended for linear projects and larger development projects, including plan-level analyses (e.g., specific plans, general plans), that the user identify the center point of their project area to define the project location. Please note that many of the model parameters are defined at the census tract resolution or smaller (e.g., TAZ). Therefore, modeled results may not be reflective or inclusive of larger project areas, particularly predicted climate risks and environmental burdens.

After the project location is entered, contextual spatial information will be returned in the **Map** component (see Section 4.2, *Map Component*). If the user would like to adjust the project location, they should click the "Change Location" button at the top of the left-hand navigation bar. Changing the project location will reset dependent default values.

3.5 Altering Default Data

CalEEMod was designed with default assumptions supported by substantial evidence to the extent available at the time of programming. The functionality and content of CalEEMod is based on fully adopted methods and data. However, CalEEMod was also designed to allow the user to change the defaults to reflect site- or project-specific information, when available, provided that the information is supported by substantial evidence. When a default is overridden, an "i" message will appear below the input on most screens, indicating that the field has been changed.[3] Overrides to defaults can be reverted to the original value by clicking the "reset" button (see Figure

[3] When a default is changed on the **Land Use** screen, a return arrow instead of an "i" message will appear to the right of the input. Clicking the arrow will revert the field back to the original value.

8). If the user chooses to modify any defaults, an explanation will be required in the Justification box. Modifications to defaults and the explanations are noted in the output report. Comments are important because they show the user's justification for the modifications, which allows reviewers the ability to determine whether the modifications are appropriate and sufficiently justified. Be sure to click "Save Justification" to record all remarks made in the Justification box.

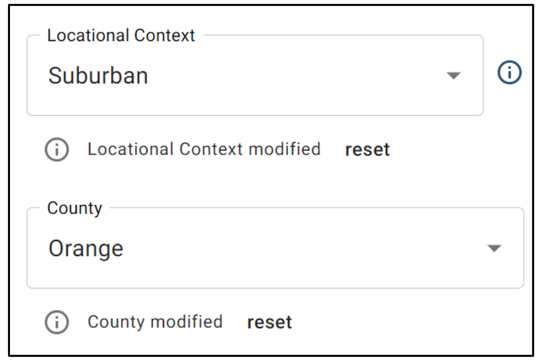


Figure 8. Change to Defaults Notification

3.6 Selecting Measures

CalEEMod includes 138 emission reduction measures, 99 climate risk reduction measures, and 50 health and equity measures. Emission reduction measures are categorized as either "Quantified" or "Qualitative or Supporting Measures." CalEEMod includes analytics to estimate emission reductions and some co-benefits achieved by quantified measures. Emissions benefits of qualitative or supporting measures are not currently quantified by CalEEMod. Methods for quantifying these measures have not yet been developed, are not fully supported by available research, or require specific details that are difficult to address under a methodology with general applicability. Although not quantitatively evaluated, qualitative or supporting measures may achieve emissions reductions and co-benefits on their own or may enhance the ability of quantified measures to attain expanded reductions and co-benefits. User-selected qualitative or supporting measures are noted in the output report.

Most of the measures are from CAPCOA's Handbook, with CalEEMod directly incorporating (with some deviations) the quantification methods, assumptions, and defaults, as appropriate. As noted in the Handbook, the list of available measures reflects a wide range of strategies that are frequently used to reduce GHG emissions, bolster communities against expected climate impacts, and enhance community health and equity. This does not mean that other measures should not be considered or may not be effective or quantifiable. CAPCOA encourages the user to be bold and creative as they approach mitigation and measure selection. If measures are not available as options in CalEEMod, the user can alter program inputs that would be affected to account for mitigation measures that may be less common. This will require creating separate CalEEMod files to properly account for unmitigated and mitigated scenarios (see Section 4.3.7, *Measures Module*).

3.7 Using the Dashboards

The dashboards are an interactive tool that allows the user to quickly view key emissions, climate, and health and equity results for their project. There are two dashboards for emissions reporting: construction results and operations results. There is one dashboard for climate risks and one dashboard for health and equity. The dashboards allow the user to customize and filter the presentation of results using a combination of tables, graphs, and icons. The user may also view selected measures, as available. The user must complete all required inputs in the **Emissions** and **Climate Risk** modules for the dashboards to function. Once all inputs are satisfied, the dashboards are automatically updated based on real-time user changes to the model (see Section 4.4, *Results Component*).

3.8 Running Reports

The **Report** component allows the user to select the type of report desired for the project (i.e., detailed, summary, quarterly, custom). A preview of the reports can be viewed on screen and then saved as a Microsoft Excel (.xls), comma-separated value (.csv), or Adobe Acrobat (.pdf) file. The .pdf file meets accessibility requirements as expressed under AB 434 (see Section 4.5, *Reports Component*).

4 Detailed Program Components, Modules, Submodules, and Screens

As displayed in Figure 1, CalEEMod is organized in a hierarchy of structural elements, consisting of components, modules, submodules, and screens. This section summarizes each of the structural elements, explains how to navigate the corresponding user interface, and explains key terms and concepts that appear in the interface. For more detailed information on certain subjects mentioned in this chapter, the user should refer to the following appendices.

- **Appendix A, *Glossary*:** Definitions of all terms.
- **Appendix B, *Acronym List*:** List of acronyms.
- **Appendix C, *Emission Calculation Details for CalEEMod*:** Emissions and activity quantification methods and sources. This appendix also describes potential limitations that the user should consider in their CalEEMod applications with respect to mobile source emissions modeling.
- **Appendix D*, Technical Source Documentation for Emissions Calculations*:** Additional technical emissions quantification methods and sources.
- **Appendix E, *Support Documentation for Climate Change Analyses*:** Vulnerability assessment methodology and technical information on climate risk reduction measures.
- **Appendix F, *Support Documentation for Health and Equity Association Scoring*:** Specific scoring criteria for health and equity measures and instructions for completing the **Health and Equity Evaluation Scorecard**.
- **Appendix G, *Default Data Tables*:** Tabular data queried by CalEEMod to return available defaults in the user interface and calculate emissions.
- **Appendix H, *Comparison to CalEEMod Version 2020.4.0:*** Compares key functions and features between CalEEMod Version 2022.1 and the prior version of CalEEMod (Version 2020.4.0).

4.1 Home Component

4.1.1 Home Screen

The **Home** screen is the landing page for the model and is where the user can create a new project or upload an existing project (see Figure 2). The **Home** screen includes links to this Guide and prior desktop versions of CalEEMod. The user can also access training videos for the model.

4.2 Map Component

The **Map** component displays geospatial information relevant to the emissions, climate risk, and health and equity analyses. To access the **Map** component, the user must first define the project location (see Section 0, *Defining the Project Location*). Once the project location is defined, the user is advanced to the **Administrative** map screen, which is the first of three map screens. The user can navigate among the three screens using the "Back" and "Next" buttons located at the bottom of the left-hand navigation bar, or by clicking the screen name listed in the horizontal bar located above the map interface. Where geospatial layers are available on each screen, the user can display these layers by clicking the open circle located to the right of the layer name presented in the left-hand navigation bar.

4.2.1 Administrative Map Screen

The **Administrative** map screen displays geospatial information relevant to the quantification of construction and operations emissions. The screen displays layers for the county, city, and TAZ in which the project is located. In addition to these layers, the **Administrative** map screen identifies the applicable locational context, air basin, air district, gas utility, and electric utility for the project location. These data are presented in the left-hand navigation bar. Geospatial layers for these data are not currently available. The user may adjust any of the default administrative model inputs determined by the project location on the **Project Detail** screen (see Section 4.3.1.1, *Project Detail Screen*).

The locational context refers to the level of development for the census tract. The locational context is used to determine the applicability of emission reduction measures in the transportation sector. The three locational contexts identified in CalEEMod are suburban, urban, and rural. A "NA" value will be returned for the locational context if the project census tract is identified as "preserve land" or if the project census tract is not mapped in the locational context geospatial domain. If the locational context is reported as "NA" or the user would like to modify the default, they should contact the local land use planning agency (e.g., city), transportation agency (e.g., metropolitan planning organization), or air district for the region where the project is located for additional guidance.

4.2.2 Climate Map Screen

The **Climate** map screen displays climate risks relevant to the project area. Geospatial layers for four climate hazards are available—extreme heat, precipitation, sea level rise, and wildfire (refer to Appendix E, *Support Documentation for Climate Change Analyses*). If the climate hazard is applicable to the project location, its map layer will display the midcentury (2040–2059 average) risk for the grid cell in which the project is located.

In addition to displaying climate risks applicable to the project location, the **Climate** map screen identifies the climate risk reduction measures most applicable to the project type and location.

This function is only available when the land use subtype(s) are defined in the **Start a New Project** splash screen (Figure 7). Click the "Select Available Measures" button on the bottom of the left-hand navigation bar to view the list of measures on the **Climate Measures** splash screen. CalEEMod identifies applicable measures based on the relevant climate hazards, project scale, and project land use subtype(s). Checking a measure on the **Climate Measures** splash screen will automatically preselect the measure in the **Climate Risk Reduction** submodule. Additional information on the measure applicability analysis is presented in Appendix E, *Support Documentation for Climate Change Analyses*.

4.2.3 Heath & Equity Map Screen

The **Health & Equity** map screen displays environmental and health burdens relevant to the project census tract. Data are obtained from CES 4.0 and the HPI (refer to Appendix F, *Support Documentation for Health and Equity Association Scoring*). The user can view geospatial layers for the overall CES 4.0 score and HPI composite score. Click the "See individual CES 4.0 scores" button presented in the left-hand navigation bar to view the **CES 4.0 Indicator Scores** splash screen**,** which shows the individual indicator scores for the project census tract that make up the overall CES 4.0 score. Similarly, click the "See individual HPI scores" button to view the **HPI Indicator Scores** splash screen**,** which shows the scores for the project census tract that make up the HPI composite score.

In addition to CES 4.0 and HPI layers, the **Health & Equity** map screen identifies if the project location is in a disadvantaged community, low-income community, or Community Air Protection Program community. (Definitions for these three community areas are provided in Appendix A, *Glossary*.) The "Yes" or "No" response is presented in the left-hand navigation bar. Geospatial layers for these data are not currently available in CalEEMod.

The **Health & Equity** map screen also identifies the five most relevant emissions reduction, climate risk, and health and equity measures that address the environmental and health burdens of the project site. This function is only available if the land use subtype(s) are defined by the user in the **Start a New Project** splash screen (Figure 7). Click "Relevant Measures" to view the list of measures on the **Relevant Measures** splash screen. CalEEMod selects the top five measures with the strongest associations to the existing health and equity conditions in each census tract. The splash screen also identifies the remaining additional applicable measures. Checking a measure on the splash screen will automatically preselect the measure in the **Climate Risk Reduction** submodule and **Health & Equity Measures** submodule. Refer to the measure applicability and association analysis in Appendix F, *Support Documentation for Health and Equity Association Scoring*, for additional information.

4.3 Inputs Component

The **Inputs** component is the largest component in CalEEMod, requiring the user to input various required project data and review available defaults to determine if they can be changed to reflect site- or project-specific information, if available, provided that the information is supported by substantial evidence (see Section 3.5, *Altering Default Data*). The screens are grouped together in the **Characteristics, Land Use, Construction, Operations** (includes submodules), **Vegetation, Climate Risk, and Measures** (includes submodules) modules.

4.3.1 Characteristics Module

The **Characteristics** module is comprised of three screens—**Project Detail**, **Utility Information**, and **Pollutants**. Inputs to the **Characteristics** module will trigger numerous project-appropriate default data to populate on subsequent screens.

4.3.1.1 Project Detail Screen

The **Project Detail** screen displays the project name and key locational information from the **Administrative** map screen, including the county, locational context, and TAZ. The user may override any of these locational defaults. If a map-intersect for the project location is not available and geospatial information does not load from the **Map** component, users will be required to input the information on this screen. The required inputs will be denoted with red underline and text (see Section 3.1, *Key Features*). If applicable and desired, the user may identify the lead agency for the project on this screen.

Based on the project location, CalEEMod generates default inputs for the windspeed, precipitation frequency, and CEC electricity demand forecast zone (EDFZ). The user should carefully review these defaults to confirm their applicability to the project. The user can override all defaults with project-specific data, where available and appropriate.

- *Windspeed (m/s)*: Windspeed, in meters per second (m/s), influences the intensity of emission factors related to fugitive dust generated during project construction. CalEEMod includes average annual windspeeds based on hourly data from 1996 to 2006 for various monitoring stations throughout California from the Western Regional Climate Center (2021). CalEEMod selects the nearest monitoring station to the project location and reports the associated windspeed as the default for the model run.
- *Precipitation Frequency (days)*: Precipitation frequency influences the intensity of emission factors related to fugitive dust generated during project construction and from vehicles travelling on paved and unpaved roads during construction and operation. Precipitation frequency represents the average annual days with precipitation greater than 0.1 inch based on data from 2015 to 2019 for various monitoring stations throughout California (NOAA 2021). CalEEMod selects the nearest monitoring station to the project location and reports the associated number of "wet days" as the default for the model run.
- *CEC Electricity Demand Forecast Zone*: The CEC has designated major electricity planning areas across the state for use in their geospatial energy analyses. The planning areas are further divided into 28 EDFZs. The EDFZ influences default calculations for building energy consumption and the effectiveness of emission reduction measures in the energy sector. Note that the EDFZs are different from the building climate zones that were developed by CEC for the Title 24 Standards. The EDFZs are identified in CalEEMod instead of the building climate zones because the default building energy consumption estimates are based on consumption datasets organized by EDFZ (see Section 4.3.4.3, *Energy Use Screen)*. The user may confirm the default EDFZ by reviewing Figure D-1 in Appendix D5, *Analysis of Building Energy Use Data*. An interactive version of the figure is also available from the CEC (2021a).[4]

CalEEMod will automatically quantify emissions for construction and project operations. The user may deselect either if they are not applicable to the project, or both if they are only interested in climate or health and equity elements of the model. The appropriate selection may be made by

[4] Available: https://cecgis-caenergy.opendata.arcgis.com/datasets/CAEnergy::california-electricity-demand-forecast-zones/about.

clicking the dropdown menu under the "Quantify emissions for" data field, or by clicking directly on Construction or Operations. Use the green toggle to completely skip the emissions model (i.e., you do not want to quantify either construction or operations emissions). Deselecting construction or operations (or both) will deactivate the corresponding module(s) within CalEEMod and then preclude the analysis from the results and reports. Depending on user selection, certain inputs on the **Project Detail** screen may also be deactivated.

If applicable, the user should identify the start date of construction and operational year for their project. The start date for construction triggers a rolling calendar that begins with the construction start date, followed by various construction phases that will be populated with default date ranges in the **Construction Phases** screen (see Section 4.3.3.1, *Construction Phases Screen*). The operational year is typically the first year following construction when the project is fully operational. CalEEMod relies on the initial operational year to apply the appropriate emission factors in all operational module calculations. CalEEMod can accommodate construction and operational years from 2010 through 2050. This wide range of dates allows the user to analyze a project for a year that occurs in the past or further into the future. It is important to note that the selection of years is limited to minimize the file size associated with the vehicle emission factors associated with each operational year. For a project that consists of multiple operational phases with emissions-generating activities expected to change across years, the user is recommended to run the model multiple times for the various input parameters for each operational year.

The "Analysis Level for Defaults" input on this screen has significant influence on default values on subsequent screens. This input defines the geographic extent of many defaults, including on-road vehicle emission factors, solid waste disposal rates, percent of vehicle travel on unpaved/paved roads, days of landscaping equipment use, VOC content of architectural coatings, and hearth usage. CalEEMod defaults to the "County" analysis level, which provides the most locationally-specific data. The user may override this default and select air basin, air district, or statewide, in which case default inputs would be derived based on aggregated data over the larger geography. If uncertain about what region to choose for the analysis level, the user should consult their lead agency.

The "Automatic Updates to Default Values" input on this screen is another important feature that has significant influence on default values on subsequent screens. Depending on the user selection from the dropdown menu, the model will change its response when a user updates an input that is linked to another input. For example, default building energy consumption (see Section 4.3.4.3, *Energy Use Screen*) is determined, in part, based on the land use subtype (see Section 4.3.2.1, *Land Use Screen*). Consider a scenario where a user inputs their land use subtype as "Single Family Housing" on the **Land Use** screen, navigates to the **Energy Use** screen to override the default electricity consumption values with project-specific information, and then returns to the **Land Use** screen to update the land use subtype to "Apartments High Rise." If the user then navigates back to the **Energy Use** screen, the electricity consumption values may or may not be updated for the "Apartments High Rise" land use subtype, depending on the user's original selection for the "Automatic Updates to Default Values" input. There are three update options.

- *Always*: Automatically updates linked inputs based on real-time user input. In the above example, the user-overridden electricity consumption would be updated to default values based on the new "Apartments High Rise" land use subtype.
- *Never*: Freezes automatic downloading of programmed defaults for all inputs. In the above example, the user-overridden electricity consumption would be retained. In fact, when the user first navigates to the **Energy Use** screen to override the default electricity consumption for the

"Single Family Housing" land use subtype, there would have been no default consumption value for them to override.

- *If not overridden*: Freezes automatic downloading of only those linked inputs the user has overridden. In the above example, the user-overridden electricity consumption would be retained. However, if the user had retained the default natural gas use values on the **Energy Use** screen associated with the "Single Family Housing" land use subtype and then returned to the screen after updating the land use subtype to "Apartments High Rise," the previous default natural gas use would be updated to new default values based on the new "Apartments High Rise" land use subtype.

4.3.1.2 Utility Information Screen

The **Utility Information** screen displays the electric utility and gas utility for the project location. The user should confirm the utilities before moving forward. The user may select a different utility from the dropdown menu. If the project utility is not included in the dropdown menu, the user may select "User Defined."

CalEEMod includes carbon intensities for several electric utilities throughout California (California Utilities 2021). If carbon intensities for the selected utility are not available, CalEEMod will default to the statewide average carbon intensity (USEPA 2021). Electricity emissions can be quantified using the latest year with reported carbon intensity data, which is 2019. Alternatively, the user may elect to use forecasted future year carbon intensities that reflect utility-specific planning considerations, including future integration of renewables. It is important to note that the forecasted factors are not exclusive to just renewable integration; they reflect many other considerations made by the utility in projecting future supplies and generation. For this reason, forecasted factors may not always decline relative to the prior year.

If "Forecasted Factors" is toggled on, CalEEMod will use the forecasted carbon intensities applicable to the operational year. Forecasted electricity emission factors are only available for a subset of utilities and years. No future year emission factors are available for the statewide default. Where future year data are not available for a utility or year, toggling the "Forecasted Factors" button will not yield any changes to the emission factors shown on the screen. A similar toggle is provided in the **Electricity** screen for construction electricity consumption (see Section 4.3.3.10, *Electricity Screen*). It is recommended that the user consult their local electricity provider for updated emission factors available at the time of their analysis before proceeding with the defaults.

The selected natural gas utility is provided for informational purposes only and does not influence the carbon intensity of natural gas combustion. Emission factors for natural gas combustion are from the USEPA (1998a) AP-42 and the CARB (2020a).

4.3.1.3 Pollutants Screen

CalEEMod quantifies criteria pollutants and GHGs. The model automatically selects all criteria pollutants and GHGs in the **Pollutants** screen for quantification. The user should uncheck any pollutants they do not want quantified before moving forward. Unchecked pollutants will be excluded from the dashboards and the reports.

The **Pollutants** screen also allows the user to insert analysis thresholds for each pollutant. Thresholds can be input in terms of pounds per day, short tons per quarter, short tons per year, and metric tons (MT) per year, depending on the timescale and pollutant. Identification of thresholds is optional. The user input thresholds will appear in the dashboards and reports to be compared with the project emissions, as applicable.

4.3.1.3.1 Criteria Pollutants

Criteria pollutants are a group of six common air pollutants for which the federal and state governments have set national ambient air quality standards (NAAQS) and California ambient air quality standards (CAAQS), respectively. The standards are set to protect public health and welfare and the environment. The federal criteria pollutants are ozone (O_3), carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and particulate matter (PM), which consists of particulates 10 microns in diameter or less (PM10) and 2.5 microns in diameter or less (PM2.5). Definitions of these pollutants are provided in Appendix A, *Glossary*.

CalEEMod quantifies all criteria pollutants except Pb, O_3, and NO_2. Pb is associated with some industrial sources and processes. Specific details to support broad quantification of these emissions are not currently available for CalEEMod. O_3 is not directly emitted into the atmosphere. Rather, it is naturally formed through photochemical reactions between reactive organic gases (ROG) and nitrogen oxides (NO_X) (O_3 precursors). CalEEMod quantifies both ROG[5] and NOx emissions, with NOx encompassing NO_2. CalEEMod also quantifies total organic gases (TOG), of which ROG is a subset. Separate emission estimates are provided for fugitive PM10 and PM2.5 and exhaust PM10 and PM2.5.

4.3.1.3.2 Greenhouse Gases

The principle anthropogenic (human-made) GHGs contributing to global warming are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated compounds, including sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs). The most common GHGs emitted by land use developments and linear construction projects, which are quantified by CalEEMod, are CO_2, CH_4, and N_2O.[6] CalEEMod also quantifies common refrigerant GHGs (abbreviated to "R" in the model) used in air conditioning and refrigeration equipment, some of which are HFCs. Definitions of these pollutants are provided in Appendix A, *Glossary*.

Methods have been set forth to describe emissions of GHGs in terms of a single gas to simplify reporting and analysis. The most accepted method to compare GHG emissions is the global warming potential (GWP) methodology defined in Intergovernmental Panel on Climate Change (IPCC) reference documents. IPCC defines the GWP of various GHG emissions on a normalized scale that recasts all GHG emissions in terms of carbon dioxide equivalent (CO_2e), which compares the gas in question to that of the same mass of CO_2 (CO_2 has a global warming potential of 1 by definition). CalEEMod uses GWPs for CO_2, CH_4, and N_2O from IPCC's (2007) *Fourth Assessment Report*, consistent with statewide GHG emissions reporting protocol. GWPs for refrigerants are from the IPCC (2007), CARB (2020b), and World Meteorological Organization (2018).

[5] CalEEMod uses the term VOC when referring to emissions from the application of architectural coatings, consistent with local regulations. VOCs are organic compounds that can evaporate into an organic gas. VOC can be either reactive or non-reactive. Over the years, non-reactive VOCs have been exempted from regulation. Both VOC and ROG are precursors to ozone, so they are summed in the CalEEMod output under the header ROG.

[6] PFCs may be generated by certain industrial and manufacturing processes but are not currently quantified by CalEEMod. Likewise, CalEEMod does not quantify SF_6, which is a human-made chemical commonly used as an electrical insulating fluid for power distribution equipment.

4.3.2 Land Use Module

4.3.2.1 Land Use Screen

The **Land Use** module includes the **Land Use** screen where the user can identify the land use(s) that will be built on the project site. The land use types and subtypes, unit, size, lot acreage, building square feet, landscape area, special landscape area, and population fields determine the default variables that are used in the quantification of construction and operations emissions. In addition, depending on the project land use type, additional data fields will appear on this screen. Recreational land use types have an input for the recreational building area and Linear land use types have an input for the predominant soil type.

When the user arrives on the **Land Use** screen, the land use types and subtypes that the user previously defined in the **Start a New Project** splash screen will automatically be prepopulated. The user can identify additional land use types by clicking the "Add Land Use Type" button. Finally, if desired, the user may enter a description of each land use subtype in the "description" column, which may be helpful to easily tell apart two entries of the same land use subtype. This description will be included in the CalEEMod output. Figure 9 presents the layout of the **Land Use** screen with some example land use subtypes selected, highlighting the required, recommended, and nonapplicable data fields.

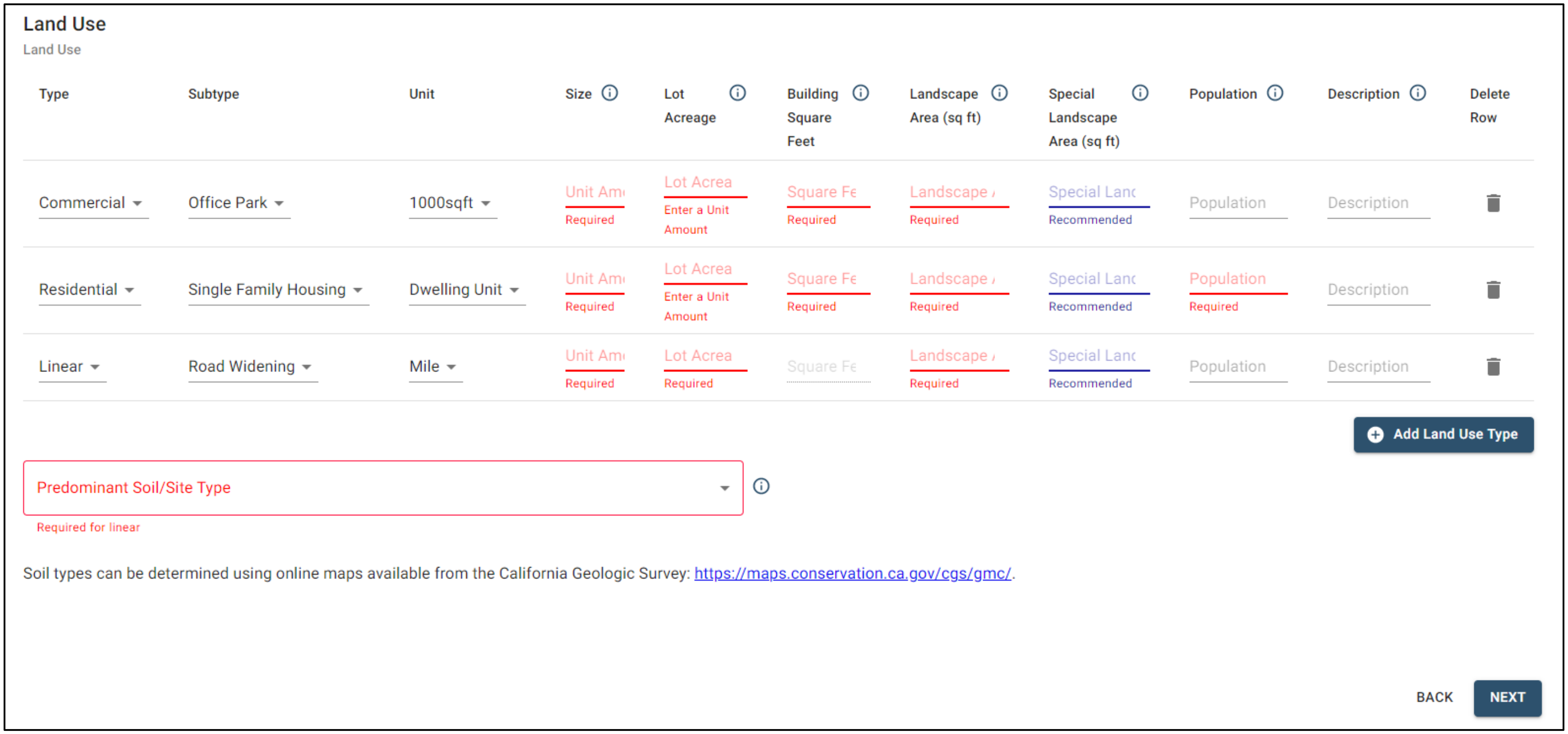


Figure 9. Land Use Screen

4.3.2.1.1 Land Use Type

The land use "type" column allows the user to select any of the following primary land use types from a dropdown list.

- Commercial
- Educational
- Industrial
- Linear
- Parking
- Recreational
- Residential
- Retail

As discussed in Section 4.3.2.1.2, *Land Use Subtype*, these land use types are further subdivided into 79 land use subtypes that are primarily based on land use classifications from the Institute of Transportation Engineers (ITE). CalEEMod also contains Linear land use subtypes, as defined by the Sacramento Metropolitan Air Quality Management District's RCEM.

4.3.2.1.2 Land Use Subtype

The land use "subtype" column allows the user to select from 79 land use subtypes. Subtypes for non-linear (i.e., land use or vertical) land uses are based primarily on the land use definitions from the ITE's (2017a) *Trip Generation Manual, 10th Edition*, which are used to inform default trip generation rates for operational mobile sources.[7] In some cases, similar generalized land uses or surrogate data were mapped to some of the non-linear land use subtypes to generate the default data needed for various screens. The four land use subtypes for linear projects were directly incorporated in CalEEMod from the RCEM. The user also has the option to select a "user defined" land use subtype; however, there are no default data (including size) available on the **Land Use** screen for user defined land use subtypes. The user will need to manually enter all information to support emissions quantification.

Descriptions of the CalEEMod land use subtypes are provided in Table 1. The table identifies the corresponding ITE land use code, where applicable.

[7] The default trip generation rates included in CalEEMod are a subset of a larger compilation of data that can be obtained from ITE (https://www.ite.org/technical-resources/topics/trip-and-parking-generation/).

Table 1. CalEEMod Land Use Subtypes

Land Use Subtype	Description	ITE Land Use Code
COMMERCIAL		
Bank (With Drive-Through)	Drive-in banks provide banking facilities for motorists who conduct financial transactions from their vehicles; many also serve patrons who walk into the building.	912
General Office Building	A general office building houses multiple tenants where affairs of businesses, commercial or industrial organizations, or professional persons or firms are conducted. If information is known about individual buildings, it is suggested that this land use be used instead of the more generic office park.	710
Government (Civic Center)	A group of government buildings that are interconnected by pedestrian walkways.	733
Government Office Building	This is an individual building containing either the entire function or simply one agency of a city, county, state, federal, or other governmental unit.	730
Hospital	A hospital is any institution where medical or surgical care and overnight accommodations are provided to non-ambulatory and ambulatory patients. However, it does not refer to medical clinics or nursing homes.	610
Medical Office Building	This is a facility that provides diagnoses and outpatient care on a routine basis but is unable to provide prolonged in-house medical and surgical care. One or more private physicians or dentists generally operate this type of facility.	720
Office Park	Office parks are usually suburban subdivisions or planned unit developments containing general office buildings and support services, such as banks, restaurants and service stations, arranged in a park-or campus-like atmosphere. This should be used if details on individual buildings are not available.	750
Pharmacy/Drugstore W/O Drive Thru	These are retail facilities that primarily sell prescription and non-prescription drugs. These facilities may also sell cosmetics, toiletries, medications, stationery, personal care products, limited food products and general merchandise. The drug stores in this category do not contain drive-through windows.	880
Pharmacy/Drugstore with Drive Thru	These are retail facilities that primarily sell prescription and non-prescription drugs. These facilities may also sell cosmetics, toiletries, medications, stationery, personal care products, limited food products and general merchandise. The drug stores in this category contain drive-through windows.	881

Land Use Subtype	Description	ITE Land Use Code
Research & Development	R&D centers are facilities devoted almost exclusively to R&D activities. The range of specific types of businesses contained in this land use category varies significantly. R&D centers may contain offices and light fabrication areas.	760
User Defined Commercial	User defined Commercial land use subtype.	—
EDUCATIONAL		
Day-Care Center	A day care center is a facility where care for preschool age children is provided, normally during the daytime hours. Day care facilities generally include classrooms, offices, eating areas and playgrounds.	565
Elementary School	Elementary schools typically serve students attending kindergarten through the fifth or sixth grade. They are usually centrally located in residential communities to facilitate student access and have no student drivers.	520
High School	High schools serve students who have completed middle or junior high school.	530
Junior College (2Yr)	This land use includes 2-year junior, community, or technical colleges.	540
Junior High School	Junior high (or middle) schools serve students who have completed elementary school and have not yet entered high school.	522
Library	A library is a facility that consists of shelved books; reading rooms or areas; and sometimes meeting rooms.	590
Place of Worship	A place of worship is a building in which public worship (religious) services are held (e.g., church, synagogue, mosque, etc.). A place of worship is comprised of an assembly hall or sanctuary; it may also house meeting rooms, classrooms and occasionally dining catering or party facilities.	560
University/College (4Yr)	This land use includes 4-year universities or colleges that may or may not offer graduate programs.	550
User Defined Educational	User defined Educational land use subtype.	—
INDUSTRIAL		
General Heavy Industry	Heavy industrial facilities usually have a high number of employees per industrial plant and are generally limited to the manufacturing of large items.	140

Land Use Subtype	Description	ITE Land Use Code
General Light Industry	Light industrial facilities are free-standing facilities devoted to a single use. The facilities have an emphasis on activities other than manufacturing and typically have minimal office space. Typical light industrial activities include printing, material testing and assembly of data processing equipment. This land use subtype must be less than 50,000 square feet. [a]	110
Industrial Park	Industrial parks contain several industrial or related facilities. They are characterized by a mix of manufacturing, service and warehouse facilities with a wide variation in the proportion of each type of use from one location to another. Many industrial parks contain highly diversified facilities.	130
Manufacturing	Manufacturing facilities are areas where the primary activity is the conversion of raw materials or parts into finished products. It generally also has office, warehouse, and R&D functions at the site.	140
Refrigerated Warehouse-No Rail	This is a warehouse that has refrigeration but no rail spur.	157
Refrigerated Warehouse-Rail	This is a warehouse that has refrigeration and a rail spur.	157
Unrefrigerated Warehouse-No Rail	This is a warehouse that does not have refrigeration and no rail spur.	150
Unrefrigerated Warehouse-Rail	This is a warehouse that does not have refrigeration but has a rail spur.	150
User Defined Industrial	User defined Industrial land use subtype.	—
LINEAR		
Bridge/Overpass Construction	Construction or modification of a bridge or overpass.	—
Road Construction	Construction of new roadway.	—
Road Widening	Widening of an existing roadway.	—
User Defined Linear	User defined Linear land use subtype.	—
PARKING		
Enclosed Parking Structure	This is an enclosed parking structure that may be above or below ground. It is not covered in asphalt. This land use will require lighting and ventilation and will have more than one floor with no elevator.	—
Enclosed Parking with Elevator	This is an enclosed parking structure that may be above or below ground. It is not covered in asphalt. This land use will require lighting and ventilation and will have more than one floor with an elevator.	—

Land Use Subtype	Description	ITE Land Use Code
Other Asphalt Surfaces	This is an asphalt area not used as a parking lot (e.g., long driveway, basketball court, etc.)	—
Other Non-Asphalt Surfaces	This is a non-asphalt area (e.g., equipment foundation, loading dock area, etc.).	—
Parking Lot	This is a typical single surface parking lot typically covered with asphalt. This land use will require lighting.	—
Unenclosed Parking Structure	This is an unenclosed parking structure that may be above or below ground. It is not covered in asphalt. This land use will require lighting but not ventilation. It will have more than one floor with no elevator.	—
Unenclosed Parking with Elevator	This is an unenclosed parking structure that may be above or below ground. It is not covered in asphalt. This land use will require lighting but not ventilation. It will have more than one floor with an elevator.	—
User Defined Parking	User defined Parking land use subtype.	—
RECREATIONAL		
Arena	Arenas are large indoor structures in which spectator events are held. These events vary from professional ice hockey and basketball to non-sporting events such as concerts, shows, or religious services. Arenas generally have large parking facilities, except when located in or around the downtown of a large city.	460
City Park	City parks are owned and operated by a city.	411
Fast Food Restaurant W/O Drive Thru	This land use includes fast-food restaurants without drive-through windows. Patrons generally order at a cash register and pay before they eat.	933
Fast Food Restaurant with Drive Thru	This category includes fast-food restaurants with drive-through windows.	934
Golf Course	Golf courses include 9-, 18-, 27- and 36-hole courses. Some sites may also have driving ranges and clubhouses with a pro shop, restaurant, lounge and banquet facilities.	430
Health Club	These are privately-owned facilities that primarily focus on individual fitness or training. Typically, they provide exercise classes; weightlifting, fitness and gymnastics equipment; spas; locker rooms; and small restaurants or snack bars.	492
High Turnover (Sit Down Restaurant)	This land use consists of sit-down, full-service eating establishments with turnover rates of approximately one hour or less. This type of restaurant is usually moderately priced and frequently belongs to a restaurant chain.	932

Land Use Subtype	Description	ITE Land Use Code
Hotel	Hotels are places of lodging that provide sleeping accommodations and supporting facilities such as restaurants; cocktail lounges; meeting and banquet rooms or convention facilities; limited recreational facilities and other retail and service shops.	310
Motel	Motels are places of lodging that provide sleeping accommodations and often a restaurant. Motels generally offer free onsite parking and provide little or no meeting space and few supporting facilities.	320
Movie Theater (No Matinee)	Movie theaters consist of audience seating, single or multiple screens and auditoriums, a lobby and a refreshment stand. Movie theaters without matinees show movies on weekday evenings and weekends only; there are no weekday daytime showings.	444
Quality Restaurant	This land use consists of high quality, full-service eating establishments with typical turnover rates of at least one hour or longer. Quality restaurants generally do not serve breakfast, some do not serve lunch; all serve dinner. This type of restaurant usually requires reservations and is generally not part of a chain. Patrons commonly wait to be seated, are served by a waiter, order from menus and pay for meals after they eat.	931
Racquet Club	These are privately-owned facilities that primarily cater to racquet sports.	491
Recreational Swimming Pool	This is a typical recreational swimming pool that may be associated with community centers, parks, swim clubs, etc.	495
User Defined Recreational	User defined Recreational land use subtype.	—
RESIDENTIAL		
Apartments High Rise	High-rise apartments are units located in rental buildings that have more than 10 levels and most likely have one or more elevators.	222
Apartments Low Rise	Low-rise apartments are units located in rental buildings that have 1–2 levels.	220
Apartments Mid Rise	Mid-rise apartments in rental buildings that have 3–10 levels.	221
Condo/Townhouse	These are ownership units that have at least one other owned unit within the same building structure.	220
Condo/Townhouse High Rise	These are ownership units that have 3 or more levels.	221

Land Use Subtype	Description	ITE Land Use Code
Congregate Care (Assisted Living)	These facilities are independent living developments that provide centralized amenities such as dining, housekeeping, transportation and organized social/recreational activities. Limited medical services may or may not be provided.	254
Mobile Home Park	Mobile home parks consist of manufactured homes that are sited and installed on permanent foundations and typically have community facilities such as recreation rooms, swimming pools and laundry facilities.	240
Retirement Community	These communities provide multiple elements of senior adult living. Housing options may include various combinations of senior adult housing, congregate care, assisted living, and skilled nursing care aimed at allowing the residents to live in one community as their medical needs change.	255
Single Family Housing	All single-family detached homes on individual lots typical of a suburban subdivision	210
User Defined Residential	User defined Residential land use subtype.	—
RETAIL		
Automobile Care Center	An automobile care center houses numerous businesses that provide automobile-related services, such as repair and servicing; stereo installation; and seat cover upholstering.	942
Convenience Market (24 Hour)	These markets sell convenience foods, newspapers, magazines and often beer and wine. They do not sell or dispense motor vehicle fuels (i.e., gasoline and diesel).	851
Convenience Market with Gas Pumps	These markets sell or dispense motor vehicle fuels (e.g., gasoline and diesel), convenience foods, newspapers, magazines and often beer and wine. This includes convenience markets with motor vehicle fueling dispensers where the primary business is the selling of convenience items, not the fueling of motor vehicles.	853
Discount Club	A discount club is a discount store or warehouse where shoppers pay a membership fee to take advantage of discounted prices on a wide variety of items such as food, clothing, tires and appliances. Many items are sold in large quantities or in bulk.	857
Electronic Superstore	These are free-standing facilities that specialize in the sale of electronic merchandise.	863
Free-Standing Discount Store	Discount stores offer centralized cashiering and sell products that are advertised at discount prices. These stores offer a variety of customer services and maintain long store hours seven days a week.	815

Land Use Subtype	Description	ITE Land Use Code
Free-Standing Discount Superstore	The discount superstore is similar to the free-standing discount stores with the addition that they also contain a full-service grocery department under the same roof that shares entrances and exits with the discount store area.	813
Gasoline/Service Station	This land use includes service stations where the primary business is the fueling of motor vehicles. They may also have ancillary facilities for servicing and repairing motor vehicles.	944
Hardware/Paint Store	These stores sell hardware and paint supplies and are generally free-standing buildings.	816
Home Improvement Superstore	These are free-standing facilities that specialize in the sale of home improvement merchandise.	862
Regional Shopping Center	A shopping center is an integrated group of commercial establishments that is planned, developed, owned and managed as a unit. A shopping center's composition is related to its market area in terms of size, location and type of store.	820
Strip Mall	Small strip shopping centers contain a variety of retail shops and specialize in quality apparel, hard goods and services such as real estate offices, dance studios, florists and small restaurants.	826
Supermarket	Supermarkets are free-standing retail stores selling a complete assortment of food: food preparation and wrapping materials; and household, cleaning items. Supermarkets may also contain the following products and services: ATMs, automobile supplies, bakeries, books and magazines, dry cleaning, floral arrangements, greeting cards, limited-service banks, photo centers, pharmacies and video rental areas.	850
User Defined Retail	User defined Retail land use subtype.	—

[a] For a project with a lot size greater than 50,000 square feet, the user will need to select a different land use type such as general heavy industry, industrial park, or manufacturing.
ATM = automatic teller machine; ITE = Institute of Transportation Engineers; R & D = research & development.

4.3.2.1.2.1 Accounting for Parking Area

For all land use subtypes except single-family housing, the user should designate parking areas as a separate "parking" land use type (e.g., enclosed parking structure). No separate parking land use for a driveway or garage needs to be identified for the single-family housing subtype because parking is already included in the default lot acreage. Figure 10 shows how CalEEMod treats parking area based on the footprint and lot acreage for a single-family housing land use subtype compared to all other land use subtypes. As depicted, the lot acreage of a single-family housing land use includes both the parking and building footprint. For all other land uses, the lot acreage is the same as the building footprint, so parking needs to be entered as a separate land use.

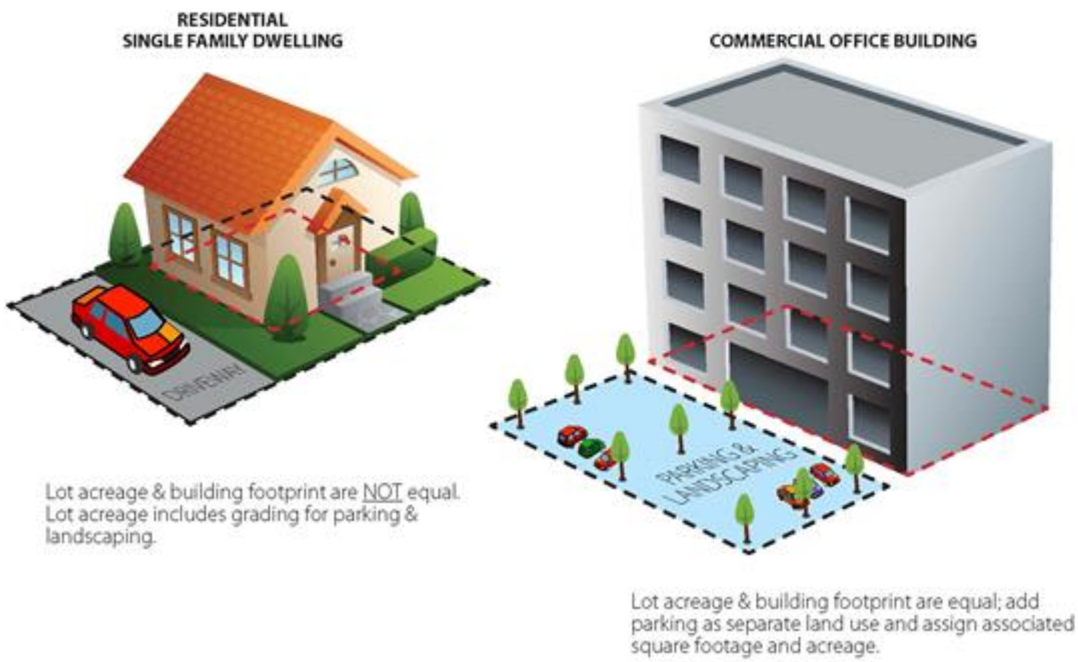


Figure 10. CalEEMod Default Parking Area and Lot Acreage

For the Parking land use type, the land use subtypes are grouped into two primary options: parking lot or parking structure (e.g., garage). There are four types of parking structures: (1) enclosed, (2) enclosed with an elevator, (3) unenclosed; and (4) unenclosed with an elevator. The reason for these specific descriptions is so that the model properly accounts for energy impacts associated with ventilation and elevator operations (see Appendix D6, *Assessment of Energy Emissions Associated with Parking Lots and Structures*).

4.3.2.1.2.2 User-Defined Land Use Subtypes

The user may select "user defined" to characterize project land use subtypes that are not included in CalEEMod or accurately represented by the available default land use subtypes. If a "user defined" land use subtype is selected, the user will need to manually provide inputs to all data fields on the **Land Use** screen. Emissions will not be calculated for the "user defined" land use subtype if the required data fields are left blank. Also, inputs on other screens linked to the user defined unit and size (e.g., electricity and natural gas consumption) will default to 0 and require manual inputs. An alternative approach to entering a "user defined" land use subtype would be to choose a land use subtype that most closely fits the project and allow the model to prepopulate the data fields with the defaults. Then, the user can go back through the model and modify the defaults with any known specific project information and enter the required Justification to explain why the defaults are modified.

4.3.2.1.3 Unit and Size

After selecting the land use subtype, the default value for the "Unit" will be prepopulated if there is only one option available (e.g., the only unit for the "Single Family Housing" land use subtype is Dwelling Unit [DU]). If the land use subtype has more than one potential unit (e.g., a "Golf

Course" land use subtype's size can be defined by the number of acres or number of holes), the user must select the unit from the dropdown menu.

Next, the user must input the corresponding "Size." For example, a Residential land use type could be 5 DUs, a Linear land use type could be 5 miles, a Hospital land use subtype could be 200 beds, an Industrial Park land use subtype could be thirty 1,000 square feet (which equates to 30,000 square feet, which is calculated in the "Building Square Feet" data field), etc. For most land use types, the combination of unit and size may prepopulate the default values for the "Lot Acreage," "Building Square Feet," and "Population" data fields on this screen. It is important to note that the square footage, which is used for calculating emissions from sources such as architectural coatings and energy use, relates to the total building square footage and not the building footprint or lot acreage.

4.3.2.1.4 Lot Acreage

The lot acreage of the proposed development is used to estimate housing density and assign construction default data (e.g., grading, site preparation). For most land use types, CalEEMod generates defaults for the lot acreage based on user inputs for the land use subtype, unit, and size. If actual lot acreage data is available, the user should override the default value. For Linear land use types, there is no default lot acreage based on the unit and size (e.g., project site length in miles). This is because no default project site width is assumed for Linear land use types, which is needed to calculate the area.

CalEEMod limits the total lot acreage for all land use subtypes combined in one model run to less than or equal to 10,000 acres.

Table 2 contains default housing density data per Residential land use in terms of DUs per acre. By using these data, CalEEMod estimates the number of acres for Residential land use subtypes. For example, if the user enters 10 DUs in the Apartments Low Rise land use subtype, then the lot acreage would be 0.63 acre (10 DU divided by 16 DUs/acre).

Table 2. Default Housing Density [a]

Land Use Subtype	Density (Dwelling Units/Acre)
Single Family Housing	3
Apartments Low Rise	16
Apartments Mid Rise	38
Apartments High Rise	62
Condo/Townhouse	16
Condo/Townhouse High Rise	64
Mobile Home Park	8
Retirement Community	5
Congregate Care (Assisted Living)	16

[a] Based on the density assumed in Institute of Transportation Engineers *Trip Generation 8th Edition*.

The user should adjust the default lot acreages if the project is a *mixed-use, multi-story building*. There is no mixed-use land use subtype available in CalEEMod, and the user will need to input two or more land use subtypes (e.g., Apartments High Rise and Strip Mall) to capture all uses.

For these projects, the default lot acreage value for the Residential land use subtype should be retained and the lot acreage values for all non-residential land use subtypes should be zeroed out. If the mixed-use, multi-story building includes only non-residential land uses, whichever land use subtype has the highest default lot acreage value should be retained and the acreage values for all other land use subtypes should be zeroed out. Figure 11 provides an example of a mixed-use project and instructions for applying the appropriate square footage and acreage.

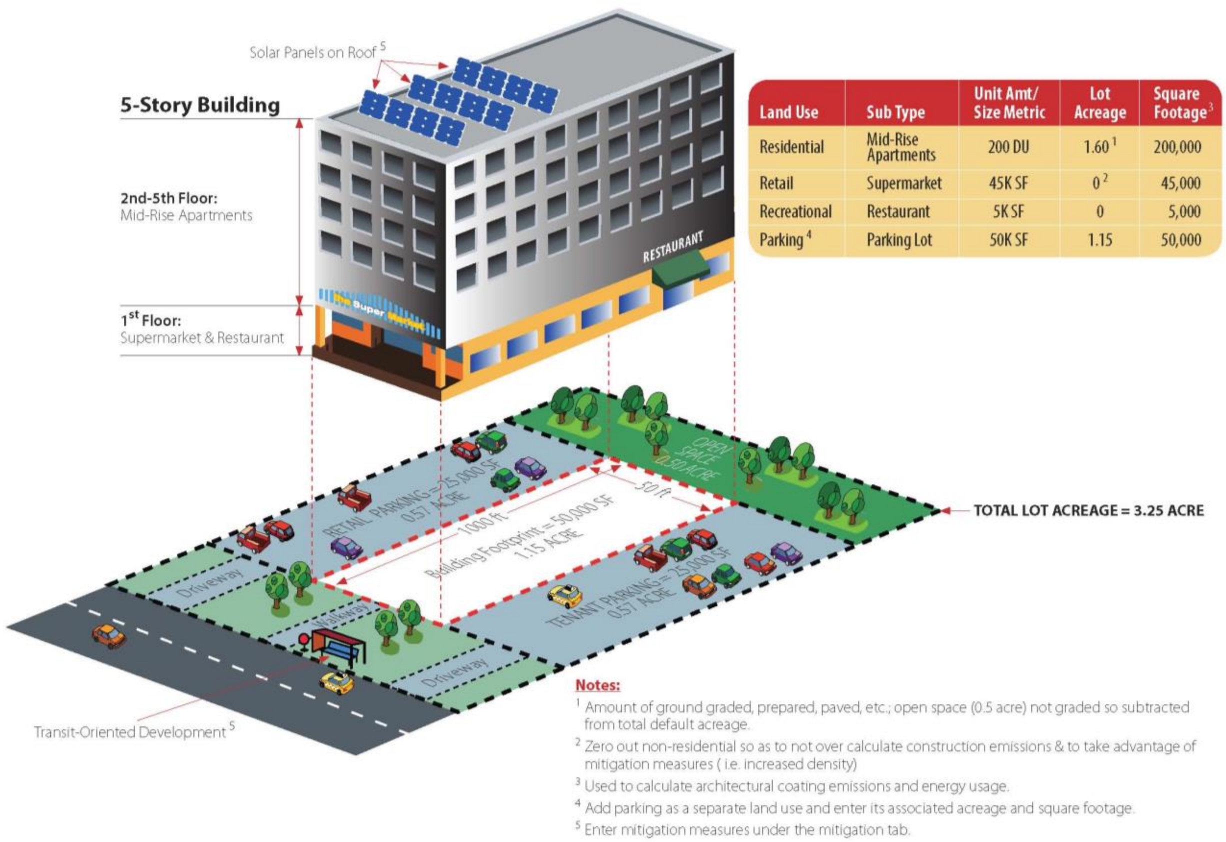


Figure 11. Example of Mixed-Use Project in CalEEMod

4.3.2.1.5 Building Square Feet

CalEEMod generates default inputs for residential building square footage using the average area of a DU for each Residential land use subtype, based on the 2019 Residential Appliance Saturation Survey (CEC 2020). For non-residential land use types where the unit selected is a measure of area (e.g., 1,000 square feet, acre), the building square footage is the product of the unit and size. For example, an industrial park with an input of 30 for size and 1,000 square feet for unit equates to a building square footage of 30,000 square feet. For non-residential land use types where the unit selected is not the area (e.g., number of beds, employees, students), the building square footage is calculated based on land use-specific conversion factors (e.g., square feet per employee) derived from Table B1 of the U.S. Energy Information Administration's Commercial Building Energy Consumption Survey (2016) and land use statistics from the South Coast Air Basin (See Appendix D, *Technical Source Documentation for Emissions Calculations*). No building square footage is assumed for Parking land use subtypes with no structure (e.g., Parking Lot land use subtype) and the city park and golf course land use subtypes. Accordingly, the building square footage for these land use subtypes is locked at 0 and cannot be overridden.

The building square feet data field is not applicable to Linear land use types used for roadway projects. Accordingly, the building square footage is locked at 0 and cannot be overridden.

4.3.2.1.6 Landscape Area and Special Landscape Area

Landscape area and special landscape area (see Appendix A, *Glossary*) are defined per the Model Water Efficient Landscape Ordinance (MWELO). Note that landscape area should include water features and all planting and turf areas in a landscape design plan, including special landscape area. Defaults for the landscape area are only available for the single-family housing land use subtype. The user must provide the landscaping area for all other land use subtypes. Leaving the input for landscaping area blank will exclude quantification of outdoor water consumption and associated emissions.

CalEEMod assumes 0 special landscape area as a default for all land use subtypes except city park, golf course, elementary school, high school, junior college (2 yr.), junior high school, and university/college (4 yr.). For these uses, the default special landscape area is equal to the user input for landscape area (i.e., the model assumes 100 percent of the landscape area is classified as special landscape area). Unlike the landscaping area data field, leaving the input for special landscape area blank will not prohibit the model from calculating outdoor water consumption emissions. However, defining the special landscape area (if any) is recommended, as it will provide for a more accurate quantification of operational outdoor water use given the different water use rates for special landscape area and landscape area.

4.3.2.1.7 Population

For Residential land use types, the population field will be prepopulated with a default estimate based on the number of DUs, using a conversion factor of residents per DU. The conversion factor is based on statewide residential data for the year 2020 derived from the California Department of Finance (2020). If the actual population is known, the user should override the default value. The population is used to determine the Residential land use subtypes' default solid waste generation rate.

For all non-Residential land use types, CalEEMod assumes 0 population. Because the population is not used to determine the non-Residential land use subtypes' default solid waste generation rate, or any other data field, the user can retain the default value of 0 without modeling repercussions.

4.3.2.1.8 Recreational Building Area

If the user selects a City Park, Recreational Swimming Pool, and/or Golf Course land use subtype, a column will appear that will prompt the user to enter the square footage of only the buildings associated with these land uses (e.g., restrooms/changing rooms, pro-shop). The user must input site-specific building square footage data because there are no default values for building footprints for these land use types. By excluding the entire lot size for these three land use types, and instead only using the square footage of the buildings, the calculations for consumer product use (see Section 4.3.4.2.2, *Consumer Products Screen*) will provide a more accurate representation of how and where these materials are used and avoid incorrectly attributing consumer products use and architectural coatings to greenspaces and pool water.

4.3.2.1.9 Predominant Soil/Site Type

This data field will only appear on the screen if the user selects a Linear land use type. The predominant soil/site type is a required user input that affects the construction schedule phasing durations. The user can select one of three options from the dropdown menu. The California Geological Survey provides an online geologic map that helps determine the appropriate option.[8]

4.3.3 Construction Module

The **Construction** module includes 10 screens that cover the different types of sources that contribute to construction emissions. To move from one screen to another, the user can use the "Next" and "Back" buttons or click on any of screen names in the left-hand menu.

4.3.3.1 Construction Phases Screen

The **Construction Phases** screen is where the user can enter the type of each construction phase and the date range for each phase. CalEEMod generates default construction phases and schedule inputs based on user inputs in the **Land Use** screen. For non-Linear land use types, construction surveys performed by the South Coast Air Quality Management District (South Coast AQMD) are used to define the default phases and durations based on the total project acreage (see Appendix D, *Technical Source Documentation for Emissions Calculations*). For Linear land use types, the "Linear Land Use Type Construction Workdays" data field will appear on the screen. This field represents the total number of workdays for all construction phases of all Linear land use types. This data field requires a user input. Combined with the user selection of the predominant soil/site type on the **Land Use** screen, these inputs determine the default construction phase durations (Ramboll 2016).

CalEEMod automatically populates the "Phase Name" and "Phase Type" columns. The default phase types differ for non-Linear and Linear land use types. Definitions of the default phase types are provided in Table 3. If Linear and non-Linear land use types are identified on the **Land Use** screen, the default assumptions will be generated for all phase types. Depending on the project being modeled, not all phases may be necessary, so the user may need to delete phases that are not applicable to the project. For example, not all projects require demolition. In addition, the user may need to add multiple phases of similar types for large projects with staged build out scenarios. The inclusion of specific construction phases will define the types of calculations and default assumptions that occur in subsequent screens.

[8] Available: https://maps.conservation.ca.gov/cgs/gmc/.

Table 3. CalEEMod Default Construction Phases [a]

Phase Type	Description
NON-LINEAR LAND USE TYPES (VERTICAL CONSTRUCTION)	
Demolition	Involves removing buildings or structures.
Site Preparation	Involves clearing vegetation (grubbing and tree/stump removal) and removing stones and other unwanted material or debris prior to grading.
Grading	Involves the cut and fill of land to ensure that the proper base and slope is created for the foundation.
Building Construction	Involves the construction of the foundation, structures, and buildings.
Paving	Involves the laying of concrete or asphalt such as in parking lots, roads, driveways, or sidewalks.
Architectural Coating	Involves the application of coatings to both the interior and exterior of buildings or structures, the painting of parking lot or parking garage striping, associated signage and curbs, and the painting of the walls or other components such as stair railings inside parking structures.
LINEAR LAND USE TYPES (LINEAR CONSTRUCTION)	
Linear, Grubbing & Land Clearing	Involves clearing vegetation (grubbing and tree/stump removal) and removing stones and other unwanted material or debris prior to grading for linear projects.
Linear, Grading & Excavation	Involves the cut and fill of land to ensure that the proper base and slope is created for the linear project.
Linear, Drainage, Utilities & Sub-Grade	Involves installation of drainage features, utilities, and any associated sub-grading.
Linear, Paving	Involves the laying of concrete or asphalt.

[a] In additional to these default phases, CalEEMod includes a trenching phase. While trenching is a phase option, there are currently no defaults for this phase. If a project includes trenching, the user must enter site-specific inputs on all screens, where relevant.

The start and end dates are automatically populated with a default construction schedule starting with the demolition phase, with subsequent phases starting the day after the previous phase's end date. The default "Start Date" for the demolition phase is the "Start of Construction" date defined on the **Project Detail** screen. The same is true for Linear land use type projects, with the exception that the first phase type is "Linear, Grubbing & Land Clearing." Because CARB's emission factors vary from year to year, when the user inserts the start and end dates for each construction phase, the model will select the correct emission factors for the year when each piece of off-road equipment will be utilized.

The user can select from a dropdown box the number of days per week that construction will occur. CalEEMod automatically defaults to 5 days per week. Five days per week assumes that construction will occur from Monday through Friday. Selections of less than 5 days per week assume construction occurs anytime between Monday and Friday. Six days per week assumes that construction will occur Monday through Saturday. The selected number of days per week influences the calculation of total workdays.

The "Total Work Days" field indicates the number of working days that it will take to complete a particular construction phase. The "Start Date," "End Date," and "Days/Week" columns are dynamically linked. When the “Enable Auto-Scheduler” toggle located at the top of the screen is toggled on, changes to any one of these columns will trigger automatic adjustments among the fields.

If desired, the user may enter a description of each construction phase in the “Phase Description” column.

4.3.3.2 Off-Road Equipment Screen

The **Off-Road Equipment** screen allows the user to select the type and quantity of off-road equipment needed for each construction phase and to define the daily usage schedule. CalEEMod generates default equipment assumptions based on user inputs in the **Land Use** and **Construction Phases** screens. CalEEMod will populate the default equipment list for all construction phases. For each equipment type, CalEEMod will generate defaults for the fuel type, engine tier, number of equipment operating per day, daily operational hours per equipment, and the equipment horsepower and load factor. For non-Linear land use types, the South Coast AQMD construction survey is used to inform the default equipment lists (including number of required equipment and daily operating hours), which are based on total project acreage as calculated from the lot acreage(s) entered on the **Land Use** screen for the land use type(s) (see Appendix D, *Technical Source Documentation for Emissions Calculations*). The default construction equipment is determined to be the most appropriate for the size and types surveyed. Some data in the South Coast AQMD survey was extrapolated to create default values for project sizes that were not in the survey. For Linear land use types, a survey of 11 road construction projects (Tetra Tech 2013) is used to inform the default number and type of equipment per phase, which are based on the land use subtype and maximum area disturbed per day. The maximum area disturbed per day is calculated as the lot acreage divided by the number of workdays in the linear grading phase.

Because the majority of off-road equipment used for construction projects is diesel fueled, CalEEMod assumes all equipment in the default list is diesel-powered. The exception is electric signal boards associated with Linear land use types, which are assumed to be powered by grid electricity. Likewise, CalEEMod defaults to using calendar year average equipment emission factors as opposed to tier-specific rates (e.g., Tier 1). Using the pencil button to the right of each entry of an equipment type, the user may override any defaults for “Fuel Type” and “Engine Tier” if project-specific information is available. Available fuel options are diesel, gasoline, compressed natural gas, and electric. Available engine tier options are Tier 1, Tier 2, Tier 3, Tier 4 interim, Tier 4 final, and statewide average for the calendar year.

Defaults for the equipment “Horsepower” and “Load Factor” fields are automatically populated with the default average values from CARB’s OFFROAD2007 and OFFROAD2011.

If the project requires the use of off-road equipment that is not specifically listed in the dropdown list, the user can select from three generalized equipment categories to add customized equipment to the analysis: (1) Other Construction Equipment, (2) Other General Industrial Equipment, and (3) Other Material Handling Equipment. In addition, the user may choose to select a surrogate equipment type that has a similar horsepower rating and load factor. To include water trucks and cement trucks in the analysis, the user needs to first determine if these trucks are off-road or on-road vehicles. If they are only driven off-road, then the user can select the Off-Highway Trucks category in the Off-Road Equipment column. If the trucks are driven on-road, the user can account for the on-road emissions by entering this information as additional vendor trips on the **Trips and VMT** screen (see Section 4.3.3.6, *Trips and VMT Screen*).

4.3.3.3 Off-Road Equipment Emission Factors Screen

The **Off-Road Equipment Emission Factors** screen provides the equipment-specific emission factors for user review and confirmation. Only those pollutants associated with off-road construction equipment are shown in the screen. Calendar year average emission factors for diesel, gasoline, and compressed natural gas off-road equipment are derived from CARB's OFFROAD2017-ORION v1.0.1. Tier-specific emission factors for diesel equipment are obtained from CARB's (2017a) Carl Moyer Program Guidelines. Default emission factors for electric equipment show as 0 because emissions are quantified in the **Electricity** screen using utility specific emission factors (see Section 4.3.3.10, *Electricity Screen*). If the user inputs an equipment horsepower that falls outside the maximum horsepower range for an equipment type programmed in the model, a red warning message will appear, and CalEEMod will apply emission factors from the maximum-programmed horsepower range to the equipment.

4.3.3.4 Dust from Material Movement Screen

The **Dust from Material Movement** screen calculates, by default, the following fugitive dust emissions associated with the site preparation and grading phases for non-Linear land use types and all phases except paving for Linear land use types.[9]

1. Dozers moving dirt.
2. Graders or scrapers leveling the land.
3. Loading or unloading dirt into haul trucks.

These methods have been adapted from USEPA's (1998b, 2006a) AP-42 method for Western Coal Mining. Once the user enters the amount of material imported and exported to the site, CalEEMod will estimate the number of hauling trips associated with material transport activities and prepopulate it as a default on the **Trips and VMT** screen (refer to Appendix D, *Technical Source Documentation for Emissions Calculations,* for suggested material movement quantities by project land use type and size). The user may define the material transport size metric in terms of short ton of debris or cubic yards. The user may also select whether the import/export of material is phased (e.g., the same truck that arrives with material departs with another load of material to export in one round trip or two one-way trips). The calculations for non-phased material import/export trips assume that one truck arrives empty and departs full and a different truck arrives full for a total of two round trips (or four one-way trips). Thus, phasing of material import and export trips reduces the number of haul trips. Emissions from on-road truck travel are included in the **Trips and VMT** screen (see Section 4.3.3.6, *Trips and VMT Screen*).

For land use development projects, the total acres graded column represents the cumulative distance traversed on the property by the grading equipment, assuming a blade width of 12 feet. To properly grade a piece of land, multiple passes with grading equipment may be required. So even though the lot size is a fixed number of acres, the total acres graded could be an order of magnitude higher than the footprint of the lot. The default area is calculated based on the equipment list (including number of equipment), the number of days needed to complete the default phases listed on this screen (e.g., grading), and the maximum number of acres a given piece of equipment can traverse in an 8-hour workday. For Linear land use types, the total acres graded is equal to the user input for lot acreage in the **Land Use** screen.

[9] While certain construction phases appear on this screen by default, the user can model dust emissions from material movement under any phase in the construction schedule by clicking "Add Phase." The user must define the total acres graded for all non-default phases.

If applicable, the user may select the "Water Exposed Area" toggle to account for dust control as part of the project design. Default PM emission reduction efficacies are available for watering exposed surfaces at frequencies of two or three times per 8-hour workday (Countess Environmental 2006:Table 3-7). If the user selects a frequency of "Other" from the dropdown menu, the PM reduction defaults to 0 and requires a user input.[10] If the "Water Exposed Area" toggle is selected, the reduction efficacies will be applied to the calculation of unmitigated fugitive dust. If any dust control strategies are selected on this screen, the user will not be able to select them in the **Measures** module as this would be double counting. Only select dust control strategies on this screen if they are part of the project design. If the project will implement dust control as mitigation, select the measures in the **Measures** module**.**

4.3.3.5 Demolition Screen

The **Demolition** screen calculates, by default, fugitive dust emissions from building demolition for non-Linear land use types. The user must define the amount of demolished material that is expected to be generated during one or more construction phases. The user can select the size metric to define the amount of demolished material in terms of short ton of debris or building square footage. The calculation of fugitive dust emissions during demolition is derived from the methodology described in the report prepared for the USEPA by Midwest Research Institute (MRI) (1988).

Like the calculation for dust from material movement, the user may select the "Water Demolished Area" toggle to account for dust control as part of the project design. Default **PM emission** reduction efficacies are available for watering during demolition at a frequency of two times per 8-hour workday (Countess Environmental 2006:Table 3-7). If the user selects a frequency of "Other" from the dropdown menu, the PM reduction defaults to 0 and requires a user input. Only select dust control on this screen if the strategy is part of the project design. If the project will implement dust control as mitigation, select the measure in the **Measures** module.

4.3.3.6 Trips and VMT Screen

The **Trips and VMT** screen calculates exhaust and mechanical (i.e., tirewear and brakewear) emissions from trips and vehicle miles traveled (VMT) of construction workers, vendors, haul trucks, and onsite haul trucks. Depending on the user inputs for several data fields across the **Characteristics** module, **Land Use** module, and prior screens in the **Construction** module, for certain trip types and phases, the number of trips, trip length, and vehicle class for worker, vendor, and hauling trips will be prepopulated with default values.

CalEEMod quantifies the default number of construction worker one-way trips per day by multiplying 2.5 times the number of pieces of equipment for all phases (except building construction and architectural coating). For the building construction phase, the number of workers is derived from a study conducted by the Sacramento Metropolitan Air Quality Management District that determined the number of workers needed for various types of land uses and corresponding project size. This study and its analysis are included in Appendix D, *Technical Source Documentation for Emissions Calculations*. For the architectural coating phase, the number of worker trips is approximately 20 percent of the number of worker trips needed during the building construction phase.

For Linear land use types, defaults for the number of one-way vendor trips per day are available for all construction phases. The vendor trip rate accounts for water trucks but no other types of

[10] Local air districts may have suggestions for reduction efficacies in their CEQA guidelines.

vendors (e.g., cement trucks). If the Linear land use construction requires other types of vendor trips, the user will need to add those trips to the defaults quantified for water trucks. For non-Linear land use types, the default number of vendor trips is only available for the building construction phase. The trip rates are derived from the Sacramento Metropolitan Air Quality Management District construction survey (see Appendix D, *Technical Source Documentation for Emissions Calculations*). The survey defines vendor trips as those made by cement and water trucks. If the building construction phase requires other types of vendor trips, the user will need to add those trips to the defaults quantified for cement and water trucks. The user must also provide vendor trips rates for all other land use development phases requiring this type of vehicle trip. Appendix D includes suggested vendor trip rates for construction phases where defaults are not currently programmed.

The default values for hauling trips are based on the amount of material that is demolished (as defined in the **Demolition** screen) or imported or exported (as defined in the **Dust from Material Movement** screen), assuming that a truck can haul 20 short tons (or 16 cubic yards) of material per load. If one load of material is delivered, CalEEMod assumes that one haul truck importing material will also have a return trip with an empty truck (e.g., two one-way trips). Similarly, a haul truck needed to export material is assumed to have an arrival trip in an empty truck and a loaded departure truck (e.g., two one-way trips). Thus, each trip to import and export material is considered as two separate round trips (or four one-way trips). However, if the "Material Import/Export Phased?" box is checked in the **Dust from Material Movement** screen, the same haul truck that imported the material will be assumed to be the same haul truck that exports material resulting in one round trip (or two one-way trips). There are no trip rate defaults for onsite trucks. The user must enter site-specific assumptions when a project includes onsite truck trips. Refer to Appendix D, *Technical Source Documentation for Emissions Calculations*, for suggested onsite trip rates and lengths.

The user can select the type of vehicle mix for each of the four construction trip types (e.g., worker). The construction vehicle mix class descriptors are defined in Appendix A, *Glossary*.

Default trip length estimates for workers and vendors are based on the 2015 California Statewide Travel Demand Model (CSTDM) and regional travel demand models from local metropolitan planning organizations (MPO) or Regional Transportation Planning Agencies (RTPA), where available. If MPO/RTPA data are available for the project location, the user may select either data source by clicking the appropriate toggle. The hauling trip length default is set at 20 miles. There are no trip length defaults for onsite trucks.

4.3.3.7 On-Road Fugitive Dust Screen

The **On-Road Fugitive Dust** screen defines the variables that will be used to determine fugitive dust emissions from on-road vehicles driving over paved and unpaved roads during construction. CalEEMod automatically prepopulates the roadway and vehicle characteristic fields based on USEPA's AP-42 (2006b, 2011). The default percentage of VMT on paved roadways is available by air basin, air district, county, and statewide and will therefore prepopulate based on the user-selected analysis level defined on the **Project Detail** screen. All onsite trucks trips are assumed to occur within the project construction boundary and, therefore, exclusively on unpaved roads.

If applicable, the user may select the "Control Strategy" toggle to account for dust control as part of the project design. Default PM reduction efficacies are provided for a range of control strategies (Countess Environmental 2006:Tables 3-7, 6-6, and 5-5). If the "Control Strategy" toggle is selected, the reduction efficacies will be applied to the calculation of unmitigated fugitive dust. Only select dust control on this screen if the strategies are part of the project design. If the project will implement dust control as mitigation, the user should select the measure(s) in the **Measures** module.

4.3.3.8 Architectural Coatings Screen

The **Architectural Coatings** screen calculates VOC emissions from painting the interior/exterior of residential and non-residential buildings. The screen also calculates VOC emissions from parking lot painting or striping for Linear land use types. The user may override any of the default surface areas estimated. In addition, each of these surface types has a different emission factor indicating the VOC content of the paint in grams per liter (g/L). The emissions associated with parking structures are included in the non-residential interior/exterior square footage, whereas the emissions associated with parking lot striping are accounted for in a separate parking category.

4.3.3.9 Paved Area Screen

The **Paved Area** screen calculates VOC emissions from asphalt paving. CalEEMod provides default inputs for area paved for the single-family housing land use subtype and all Linear and Parking land use subtypes. CalEEMod assumes 0 paved area for all other land use types. The user should override this value if their project includes additional paving. Because evaporative VOC emissions are only generated by asphalt paving, the user should also specify the percentage of area paved with asphalt as opposed to another material (e.g., concrete). The default asphalt percentage is 100 percent for all Linear and Parking land use subtypes (except for Non-Asphalted Surfaces) and 0 percent for all other land use types.

4.3.3.10 Electricity Screen

The **Electricity** screen calculates GHG emissions from the consumption of electricity during construction. This screen includes the linked input for the electric utility from the **Utility Information** screen. And, similar to operational electricity inputs (discussed in Section 4.3.1.2, *Utility Information Screen*), the GHG emission factors (electricity) toggle allows the user to choose between emission factors from the latest year with reported data (2019) or the forecasted future year carbon intensities applicable to each construction year, reflective of implementation of SB 100.

If the user selected electric-powered off-road equipment in the **Off-Road Equipment** screen, CalEEMod prepopulates the Electricity input with the associated annual electricity consumption in this screen. If a project includes non-equipment sources of electricity consumption, the user should sum the additional electricity with the default equipment-based electricity. CalEEMod does not estimate electricity consumption for any source other than user defined electric-powered equipment (e.g., mobile offices, electric haul trucks).

4.3.4 Operations Module

The **Operations** module includes four submodules and 19 screens that cover the various types of sources that contribute to operations emissions. Please note that CalEEMod only quantifies operational mobile, area, energy, water, wastewater, and water emissions for non-Linear land use types (e.g., Commercial, Residential). If a linear project includes operational sources with these emission types, the user may quantify the emissions outside of CalEEMod and insert them in the **User Defined** screen. Alternatively, the user may consider selecting a non-Linear land use type on the **Land Use** screen to characterize the non-linear operational component of a Linear land use type project.

4.3.4.1 Mobile Sources Submodule

The **Mobile Sources** submodule consists of four screens to gather the information necessary to estimate emissions from trips and VMT from on-road vehicles associated with the project land use types.

4.3.4.1.1 Vehicle Data Screen

This screen includes several data fields related to vehicles trips and VMT. The number of trips affect the calculation of starting exhaust and evaporative emissions. The VMT affects the calculation of running exhaust, brake wear, tire wear, and fugitive dust from paved and unpaved roads.

The user can define the project vehicle trip and VMT data in one of two ways. If the user clicks "Generate Default Trips and VMT" on this screen, CalEEMod prepopulates default vehicle trip and VMT inputs based on various user inputs on the **Land Use** screen. The user may override any of the default trip and VMT inputs. Alternatively, if the user would like to manually define project-specific trip and VMT inputs from a traffic study or other source, they should click "Enter VMT and Trips Manually." If after making their selection the user would like to change methodologies, they should click the "Generate Default VMT and Trips Instead / Enter VMT and Trips Manually Instead" button located near the top left side of the screen.

If the "Enter Trips and VMT Manually" button is clicked, this screen provides data fields for the user to input daily trips and VMT for weekdays, Saturday, and Sunday, as well as annual trips and VMT. The user is required to, at minimum, input vehicle data at either the daily timescale or annual timescale. If only daily traffic data are available, annual trips and VMT will be upscaled assuming 365 days of vehicle activity per year. Likewise, if only annual traffic data are available, daily trips and VMT will be averaged over 365 days per year. However, it is recommended the user input vehicle data at both timescales.

If the "Generate Default Trips and VMT" button is clicked, this screen displays the default trip rates, trip lengths, trip purpose, and trip type percentages for each land use subtype of the project.

Default vehicle trip rates are based primarily on ITE's (2017a) *Trip Generation Manual, 10th Edition*. They are expressed in terms of the size metric (thousand square feet or DU) defined on the **Land Use** screen and are listed for weekday, Saturday, and Sunday.

Depending on what the user selects on the "CSTDM / MPO/RTPA" toggle, default vehicle trip lengths for primary trips will be populated using data from the 2015 CSTDM or local MPO/RTPA, where available. Diverted trips represent the typical diversion from a freeway to adjacent highway commercial uses for urban/suburban areas and are assumed to take a slightly different path than a primary trip. Diverted trips are assumed to be 2 miles per trip. Pass-by trips are assumed to be 0.1 mile per trip, and are a result of no diversion from the primary route.

For each land use subtype, there are nine data fields for the trip link type percentages, grouped into three sets (weekday, Saturday, and Sunday) of three data fields organized by trip link type: primary, diverted, and pass-by. The default percentages are based on data from ITE's (2017b) *Trip Generation Handbook, 3rd Edition*. The sum of the inputs for each set must equal 100 (i.e., weekday primary plus weekday diverted plus weekday pass-by is 100 percent).

For each land use subtype, there are six data fields for the trip type percentages, grouped into two sets (residential and non-residential). The three residential trip types are defined in one of three ways: home-work (H-W), home-shop (H-S), and home-other (H-O). Non-residential trip types also defined in one of three ways: H-W, work-other (W-O), and other-other (O-O). See Appendix A, *Glossary*, for definitions of the trip types. The default percentage of each trip by type is based on either the 2015 CSTDM or local MPO/ RTPA, where available, as selected by the user. The sum of the inputs for each set must equal 100 (i.e., residential H-W plus residential H-S plus residential H-O is 100 percent).

4.3.4.1.2 Fleet Mix Screen

The **Fleet Mix** screen displays for the operational analysis year each land use subtype's vehicle fleet mix by season (Annual, Winter, and Summer). The fleet mix is comprised of the 13 vehicle types from EMFAC2021 using the EMFAC2007 vehicle category classifications. The user can hover their cursor over the "i" icon located to the right of the data field name to view the full vehicle type name.

The default fleet mix is derived from EMFAC2021 v1.0.1 based on the user input to the "Analysis Level for Defaults" data field on the **Project Detail** screen. For example, if the user selects County as the analysis scale, and the project is in Sacramento County, the default fleet mix will reflect the operational year fleet mix-average for Sacramento County. If the user selects Air Basin as the analysis scale, the default fleet mix will reflect the operational year fleet mix-average for the Sacramento Valley Air Basin. The default fleet mix is not sensitive to the land use subtype (i.e., the same defaults are generated for all land use subtypes in the project run). Input fields are provided by land use subtype to provide flexibility if the user would like to override defaults and supply land use subtype specific information.

4.3.4.1.3 Vehicle Emission Factors Screen

The **Vehicle Emission Factors** screen contains the detailed vehicle emission factors for the operational analysis year by EMFAC2007 vehicle type. There are separate tabs for annual, summer, and winter emission factors. Only those pollutants associated with on-road vehicles are shown on the screen. All vehicle emission factors, except those for HFCs, are based on EMFAC2021 v1.0.1 (CARB 2021a). HFC emission factors are based on a combination of EMFAC2021 v1.0.1 vehicle data and information provided by CARB (2017b). Emission factors are dependent on the user input to the "Analysis Level for Defaults" data field on the **Project Detail** screen, similar to the fleet mix.

Default emission factors were generated from the most recent version of EMFAC available at the time of model development, which was EMFAC2021 (v1.0.1) released in April 2021. This rule accounts for the Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule, which was repealed in December 2021.[11] As new versions of EMFAC are released and/or as new regulations change expected future year emission factors, it is recommended that the user consider overriding the default data on this screen with the latest emission factor model data.

4.3.4.1.4 Road Dust Screen

The **Road Dust** screen displays data fields used to calculate fugitive emissions from paved and unpaved roads based on USEPA's AP-42 methodology (2006b, 2011). The default percentage of VMT on paved roadways is available by air basin, air district, county, and statewide and will

[11] The SAFE rule was finalized in 2020 and changed the national fuel economy standards for light duty vehicles from 46.7 miles per gallon (mpg) to 40.4 mpg in future years. However, on April 22, 2021, the National Highway Traffic and Safety Administration (NHTSA) issued a notice of proposed rulemaking to repeal the rule. The repeal was finalized on December 21, 2021. NHTSA is in process of adopting more stringent corporate average fuel economy (CAFE) standards for model year 2024–2026 vehicles.

therefore prepopulate based on user input to the "Analysis Level for Defaults" data field on the **Project Detail** screen.

The default values for the data fields related to unpaved road dust (i.e., material silt content, material moisture content, and mean vehicle speed) are statewide averages except for projects in the San Luis Obispo region. For projects in the San Luis Obispo Air Pollution Control District (SLOAPCD), the model defaults to parameters provided by the air district. The user can override the statewide and SLOAPCD defaults if data specific to the project location is known. Local jurisdictions can also provide guidance on defaults that properly reflect known regional road dust parameters.

If the user turns on the toggle button located at the top of the screen, the unpaved road dust emission factors from CARB's statewide emission inventory (CARB 2004, 2009; MRI 2005) will be used to calculate paved road dust instead of the data fields from the USEPA AP-42 paved road dust quantification method. CARB emission factors are recommended for projects in the Sacramento Metropolitan Air Quality Management District.

4.3.4.2 Area Sources Submodule

The **Area Sources** submodule consists of four screens that gather the information necessary to estimate emissions from hearths, consumer products, architectural coatings, and landscaping equipment. Each of these emission sources is represented on an individual screen, as discussed below. Please note that natural gas emissions are associated with both hearths, shown within the **Area Sources** submodule, and building energy, shown on the **Energy Use** screen (see Section 4.3.4.3, *Energy Use Screen*) that appears after this submodule.

4.3.4.2.1 Hearths Screen

This screen allows the user to enter the number and types of wood stoves and fireplaces as well as the usage of these devices. Wood stoves are separate from fireplaces since a home may have both and these devices may have different use patterns. For each type of device, the number of devices entered represents the total number of devices installed in all DUs for a particular land use subtype. Default numbers of hearths and stoves by Residential land use subtypes are available for most locations based on data provided by local air districts. The defaults reflect current air district rules regarding hearths and wood stoves in new residences. Commercial land uses are assumed by default to have no hearths or wood stoves. However, the user may manually input hearth and stove data for any non-Residential land use types included in their model run.

4.3.4.2.2 Consumer Products Screen

The data fields on this screen are used to calculate the VOC emissions from various consumer products. Consumer products are various solvents used in non-industrial applications that emit VOCs during use. These typically include cleaning supplies, kitchen aerosols, cosmetics, and toiletries. CalEEMod also quantifies VOC emissions from pesticides/fertilizers used at City Parks and Golf Courses and from parking surface degreasers. Note that CalEEMod assumes that there will be no VOC emissions from the actual pool surface area for the Recreational Swimming Pool land use subtype because the chemicals used for pool maintenance are not considered to be VOCs. Details of how the consumer product VOC emission factors were determined can be found in Appendix D3, *Consumer Products Use*, and Appendix D4, *Degreaser, Fertilizer/Pesticides Use Analysis*.

4.3.4.2.3 Architectural Coatings Screen

This screen provides data fields for the reapplication rate, VOC coating content, and coated area for each building surface type and parking surface. The reapplication rate is the percentage of the total surface area that is repainted each year. A default of 10 percent is used, meaning that 10 percent of the surface area is repainted each year (i.e., all surface areas are repainted once every 10 years). The annual emissions are divided by 365 days per year to determine average daily emissions. This is based on assumptions used by South Coast AQMD in their district rules regarding architectural coatings. Some districts provided details on their coating regulations that phase-in over time, which have been incorporated to the extent feasible, given the general classifications of paint (interior or exterior for residential and non-residential plus parking surfaces). Coating VOC contents from state regulations are used for air districts that did not provide specific architectural coating information. The user should consult their local air district for suggested values that may be lower than the state regulations.

4.3.4.2.4 Landscape Equipment Screen

CalEEMod can generate landscaping emissions based on statewide average equipment emission intensities for the number of snow and summer days for the project location. The user should click “Generate Default” to enable this function. Alternatively, the user can manually define a landscaping equipment inventory by clicking “Enter Manually.”

If the “Generate Default” button is clicked, the screen will display data fields for the number of snow days and summer days applicable to the project location, which are assumed to represent the number of equipment operational days per year. The number of days is applied to a statewide average weighted landscape equipment emission factor derived from CARB’s Small Off-Road Engines Model v1.1 (SORE2020) (CARB 2020c).

If the “Enter Manually” box is checked, the screen will display blank data fields for the user to define for each land use type the number of pieces of equipment, fuel type, and hours of operation per day and per year for each selected equipment type. Defaults from SORE2020 are available for equipment HP and load factor.

4.3.4.3 Energy Use Screen

The **Energy Use** screen is used to gather the information necessary to estimate the emissions associated with building electricity and natural gas usage (non-hearth). Electricity use is in units of kilowatt hours (kWh) per year for each land use subtype. Natural gas use is in units of a thousand British Thermal Units (KBTU) per year for each land use subtype.

Title 24 of the California Code of Regulations, known as the California Building Standards Code or Title 24, contains energy conservation standards applicable to all new or altered residential and non-residential buildings throughout California. Within CalEEMod, building electricity and natural gas use is divided into two categories: (1) end uses subject to Title 24 standards, and (2) end uses not subject to Title 24 standards. The distinction is required to enable accurate calculation of several energy sector reduction measures.

CalEEMod generates default electricity and natural gas consumption based on the EDFZ input on the **Project Detail** screen and the land use subtypes and building square feet input on the **Land Use** screen. The user can override these defaults and input total annual electricity and natural gas consumption by project land use subtype or disaggregated Title 24 and non-Title 24 electricity and natural gas consumption. If the user changes any of the consumption values, the recalculate button to the right of all inputs must be selected to process the change (Figure 12).

The recalculate function will ensure total consumption equals the sum of Title 24 and non-Title 24 consumption. Note that the recalculate energy use button is only available in the tabular data view mode.

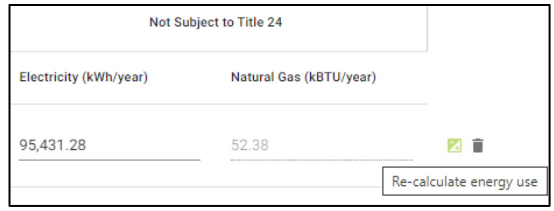


Figure 12. Recalculate Building Energy Use Button

Default electricity and natural gas consumption is based on 2019 consumption estimates using the CEC's (2020, 2021b) 2018–2030 Uncalibrated Commercial Sector Forecast and 2019 Residential Appliance Saturation Survey (see Appendix D, *Technical Source Documentation for Emissions Calculations*). If project-specific energy estimates are available, it is recommended the user manually input the total annual electricity and natural gas consumption, especially for projects with operational years far into the future.

4.3.4.4 Water and Wastewater Screen

The **Water and Wastewater** screen determines the GHG emissions associated with supplying and treating water and wastewater used and generated by the project land uses. This screen is used to enter the amount of water in gallons used indoors and outdoors for each land use subtype. Default consumption estimates are automatically generated for all land use subtypes. Outdoor water consumption defaults are calculated using the Maximum Applied Water Allowance (MAWA) method established under the California Department of Water Resources' (DWR) 2015 MWELO (California Code of Regulations [C.C.R.], Title 23, Division 2, Chapter 2.7). Indoor water consumption defaults are based on studies published by the Water Research Foundation (2016), Pacific Institute (Gleick et al. 2003), and American Water Works Association (Dziegielewski et al. 2000). The quantity of indoor water is used to estimate the amount of wastewater.

The **Water and Wastewater** screen also shows the electricity intensity factors for various phases of providing water: supply, treatment, distribution, and wastewater treatment. Supply means bringing the water from its primary source such as the ground, river, or snowpack to the treatment plant. Distribution means bringing the water from the treatment plant to the end users. The electricity intensity factors vary depending on the hydrologic region where the project is located. GHG emissions are calculated from this screen by multiplying the electricity intensity factors by the utility GHG emissions intensity factors input on the **Utility Information** screen. The default electricity intensity factors are based on a study published by The Pacific Institute (Szinai et al. 2021). Since the electricity intensity of water supply can vary greatly based on location, the user should override these values if they have more specific information regarding their specific water supply and treatment.

Wastewater may also result in direct emissions of GHGs. These depend on the type of wastewater treatment system (i.e., septic, aerobic, or lagoon) used. Therefore, the wastewater treatment type percentages are displayed as data fields on the screen. The sum of the inputs for the wastewater treatment type must equal 100 (i.e., septic plus aerobic plus facultative lagoon is 100 percent).

In addition, the model calculates GHG emissions if wastewater solids are digested either through an anaerobic digester or with co-generation from combustion of digester gas. Each wastewater solid treatment type has associated GHG emission factors. Some of these emissions may be classified as biogenic. Note that not all the biogenic emissions from wastewater treatment are accounted for in CalEEMod because there are not adequate emissions factors at this time.

4.3.4.5 Solid Waste Screen

The **Solid Waste** screen determines the GHG emissions at landfills associated with disposal of solid waste generated for each project land use subtype. To estimate GHG emissions from solid waste disposed by a land use subtype annually, the total amount of CO_2 and CH_4 that would be generated through decomposition over the span of 20 to 30 years is calculated (USEPA 2016a:1-2). This is based on CARB's (2010) methods for quantifying GHG emissions from solid waste using the degradable organic content of waste. Waste disposal rates by land use subtype are primarily based on CalRecycle (n.d.) data. The amount of CH_4 emitted depends on characteristics of the landfill, and therefore the default percentage of CH_4 emitted is based on the types of landfills assumed by CARB in their GHG emissions inventories. Portions of these emissions are biogenic.

The defaults for the gas capture (e.g., no capture, flaring, energy recovery) are statewide averages except for Santa Barbara APCD, which has a 100 percent landfill capture gas flare. The sum of the inputs for the "No Gas Capture" and "Capture Gas Flare" must equal 100 percent. The user should override the defaults if the gas capture at the landfill to be used by the project is known. Local jurisdictions can also provide guidance on default values that properly reflect known regional solid waste gas capture.

4.3.4.6 Refrigerants Screen

The **Refrigerants** screen is used to gather the information necessary to estimate the fugitive GHG emissions associated with building air conditioning (A/C) and refrigeration equipment. Different types of refrigeration equipment are used by different types of land uses. For example, an office may use various types of A/C equipment, while a supermarket may use both A/C equipment and refrigeration equipment. All equipment that uses refrigerants has a charge size (i.e., quantity of refrigerant the equipment contains), operational and service refrigerant leak rates (from regular operation and routine servicing), and number of times serviced per lifetime. Each refrigerant has a GWP that is specific to that refrigerant. CalEEMod automatically generates a default A/C and refrigeration equipment inventory for each project land use subtype based on industry data from the USEPA (2016b). CalEEMod quantifies refrigerant emissions from leaks during regular operation and routine servicing over the equipment lifetime and then derives average annual emissions from the lifetime estimate. Note that CalEEMod does not quantify emissions from the disposal of refrigeration and A/C equipment at the end of its lifetime.

4.3.4.7 Off-Road Equipment Submodule

4.3.4.7.1 Off-Road Equipment Screen

The **Off-Road Equipment** screen allows the user to identify any off-road equipment (e.g., forklifts, cranes, loaders, generator sets, pumps, pressure washers) used during operational activities at the project site. Because such equipment cannot be assumed for a particular land use project, the user must provide these inputs for CalEEMod to calculate the associated emissions. Once the user identifies an equipment type, all other data fields are prepopulated with default values, except for the amount of equipment per day. The model assumes default operation activity of 8 hours per day and 260 days per year. Similar to off-road equipment used for construction activities (see Section 4.3.3.2, *Off-Road Equipment Screen*), the default equipment "Horsepower" and "Load Factor" data are prepopulated based on the operational year and equipment type based on the default average values from CARB's OFFROAD2007 and OFFROAD2011. The model assumes diesel fuel and calendar year average emissions rates, but a dropdown menu is provided to allow the user to select fuel and engine tier type, if known.

4.3.4.7.2 Off-Road Equipment Emission Factors Screen

The information in Section 4.3.3.3, *Off-Road Equipment Emission Factors Screen*, listed for off-road equipment used for construction activities applies the same to this screen, except that for this screen, the operational year is used to determine the default emission factors instead of the construction year(s).

4.3.4.8 Stationary Sources Submodule

The **Stationary Sources** submodule consists of four screens to gather the information necessary to estimate emissions from emergency generators and fire pumps and process boilers. Each of these screens is discussed below. Consult with the local air district to determine if permitted stationary sources should be included in the project analysis using CalEEMod.

4.3.4.8.1 Emergency Generators and Fire Pumps Screen

This screen allows the user to define emergency generators and fire pumps and associated operating information. This type of equipment operates only for maintenance and testing, or during emergency situations, such as power failures. To calculate emissions, the user must enter the equipment type, fuel type, engine rating (in horsepower), the anticipated maximum daily usage, and the anticipated maximum annual usage. The user may change the default load factor.

4.3.4.8.2 Generators/Fire Pumps Emission Factors Screen

This screen displays the default emission factors for the emergency generators and/or fire pumps identified by the user on the **Emergency Generators and Fire Pumps** screen. Only those pollutants associated with emergency generators and fire pumps are shown in the screen.

4.3.4.8.3 Process Boilers Screen

This screen allows the user to define process boilers and associated operating information. Do not use this option for boilers providing space heating or building hot water, as these uses are already included in building energy use (see Section 4.3.4.3, *Energy Use Screen*). To calculate process boiler emissions, the user must input the number of boilers, fuel type, boiler rating (in million BTU/hr) and maximum anticipated daily and annual heat inputs.

4.3.4.8.4 Boilers Emission Factors Screen

This screen displays the default emission factors for the user-identified process boilers. Only those pollutants associated with process boilers are shown in the screen.

4.3.4.9 User Defined Screen

The **User Defined** screen allows the user to input emissions estimates for any project source not captured by prior screens. Emissions for this source would include any other miscellaneous sources that typically require permits to operate issued by an air district. Emissions may be manually entered, either by transferring values from the permits to operate, or by calculating emissions outside of CalEEMod. Any emissions entered in the screen will be transferred to the appropriate reports.

4.3.5 Vegetation Module

The **Vegetation** module includes two screens to estimate GHG emissions (or removals) from land use change and changes in sequestration from tree planting (or removal). Each of these screens is discussed below.

4.3.5.1 Land Use Change Screen

The **Land Use Change** screen estimates changes in CO_2 associated with both soil and aboveground and belowground biomass resulting from project-induced changes in land use and cover types.

To calculate soil carbon accumulation, the user must select from the dropdown menu the project's "Vegetation Land Use Type" and the "Vegetation Soil Type." The soil type for the project area can be obtained from UC Davis' SoilWeb online geospatial tool.[12] Based on these inputs, the default annual CO_2 accumulation per acre rate is prepopulated using resources published by CARB (2020d). CalEEMod uses the accumulation rates to calculate the net change in total CO_2 based on the user's inputs for the "Initial Acres" and "Final Acres" data fields.

To calculate above and belowground biomass carbon accumulation, the user must select from the dropdown menu the project's "Cover Type." Based on this input, the default annual CO_2 accumulation per acre rate is prepopulated using resources published by CARB (2021b). The net change in total CO_2 is calculated based on the user's inputs for the "Initial Acres" and "Final Acres" data fields.

Users can override the CO_2 accumulation default for specific vegetation land use types or cover types. Alternatively, users can select "Other" from the dropdown to manually define their vegetation land use or cover type and the associated CO_2 accumulation rate.

4.3.5.2 Sequestration Screen

The **Sequestration** screen directs the user to the U.S. Forest Service (USFS) (2021) i-Tree Planting tool.[13] The i-Tree Planting tool quantifies increased carbon sequestration from urban tree planting using species-based biomass equations that account for user defined site-specific variables and tree growth rates. The tool also quantifies GHG reductions from energy savings (e.g., kWh), if applicable. The user should directly copy the outputs from the i-Tree Planting Calculator to the applicable fields in the **Sequestration** screen. The user is also required to input the project "Operations Lifetime" in number of years.

4.3.6 Climate Risk Module

The **Climate Risk** module helps the user calculate the risks of their project to eight different climate-related hazards. To determine climate risks, the user will develop an overall vulnerability score, which consists of combining three elements: project exposure, sensitivity, and adaptive capacity (these concepts are defined in Appendix A, *Glossary)*. From there, the user can select the highest scoring vulnerabilities to identify appropriate climate risk reduction measures.

[12] Available: https://casoilresource.lawr.ucdavis.edu/gmap/.
[13] Available: https://planting.itreetools.org/.

The method for scoring climate risks is largely based on the guidance presented in Chapter 4, *Assessing Climate Exposures and Measures to Reduce Vulnerabilities*, of CAPCOA's Handbook. The user is encouraged to review this chapter before completing the **Climate Risk** module. As noted in the Handbook, the scoring analysis provided by CalEEMod should not replace a full climate vulnerability assessment performed using the State's *Adaptation Planning Guide* (APG) or other resources. Moreover, the scores alone should not be used to define or communicate the climate risks for a project. A climate vulnerability score of 5, for example, does not mean that a project will face certain climate catastrophe. Similarly, a score of 1 does not mean that a project will not face any climate hazards. The purpose of the scoring method is to aid the user in prioritizing the most significant climate risks so that they can select appropriate risk reduction measures for their project. If the user is seeking a more thorough or tailored analysis, then they should refer to the APG, the Resilient-CA website,[14] or other resources provided in the Handbook.

4.3.6.1 Introduction Screen

The **Introduction** screen offers a high-level outline of the process the user will go through to assess climate hazards and develop a vulnerability score. CalEEMod analyzes the eight climate hazards shown in Figure 13.

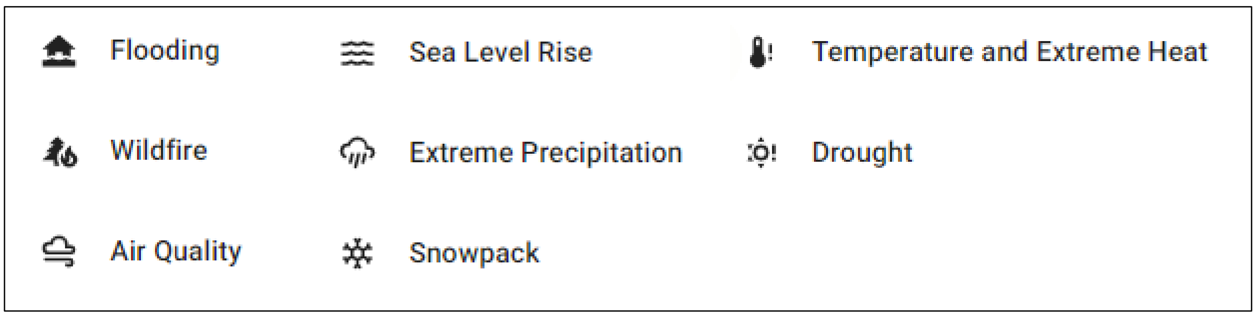


Figure 13. Climate Hazards

Based on the project's location, the screen presents climate hazards most applicable to the user's project based on anticipated climate change. For example, projects that lie along the coast would be exposed to sea level rise and, therefore, the sea level rise hazard would be automatically selected. The user can click on additional hazards to include them in the exposure analysis or uncheck hazards if they are not applicable to the project. Unchecking a hazard will preclude it from further analysis in the module. If the user is unsure whether a hazard is applicable, it is best to include the hazard and have later steps in the module determine the hazard's importance.

4.3.6.2 Determine Exposure Score Screen

This screen guides the user through scoring their project's exposure to each selected climate hazard. The hazards are scored on a scale of 1 to 5, with 1 being the least exposed (i.e., "low") and 5 being the most exposed (i.e., "high"). The module calculates an initial exposure score for the four Cal-Adapt hazards (sea level rise, temperature and extreme heat, extreme precipitation, and wildfire). Depending on the hazard, the user can adjust this initial exposure score by answering guiding questions. For the remaining four hazards (flooding, drought, snowpack, and air quality), the user will answer guiding questions to determine an exposure score.

[14] Available: https://resilientca.org/.

For all hazards, the user also has the option to manually refine the calculated exposure score by adjusting the slider. The user may make this adjustment if there are unique reasons that the module cannot capture why the calculated exposure score is not appropriate for the project.

When answering questions or manually refining the calculated exposure score, note that this screen determines the *exposure* of the project to the climate hazard. Project components related to sensitivity (the extent to which a project would be adversely affected by exposure to a hazard) and adaptive capacity (the ability to manage and reduce vulnerabilities from projected hazards) are considered in later screens. Thus, it is important for the user to focus only on exposure when going through this screen.

4.3.6.3 Determine Sensitivity Score Screen

This screen guides the user through scoring the sensitivity of their project to each selected climate hazard on a 1-3-5 scale (with 1 being the least sensitive and 5 being the most sensitive). The user will answer a series of questions to help determine the sensitivity score of their project to each hazard. Once again, the user has the option to manually refine the calculated sensitivity score by adjusting the slider. The user may make this adjustment if there are unique reasons that the module cannot capture why the calculated sensitivity score is not appropriate for the project.

4.3.6.4 Determine Adaptive Capacity Score Screen

This screen guides the user through scoring the adaptive capacity of their project to each selected climate hazard on a 1-3-5 scale (with 1 having “low” adaptive capacity and 5 having “high” adaptive capacity). The user will answer a series of questions to help determine the adaptive capacity score of their project to each hazard. Once again, the user has the option to manually refine the calculated adaptive capacity score by adjusting the slider. The user may make this adjustment if there are unique reasons that the module cannot capture why the calculated adaptive capacity score is not appropriate for the project.

4.3.6.5 Determine Potential Impact Score Screen

This screen presents the potential impact scores for each selected climate hazard. The potential impact score is the average of the exposure and sensitivity scores and is an intermediary step before the final calculation of overall vulnerability. Like prior screens, scores are given on a scale of 1 to 5, with 1 being the least impacted and 5 being the most impacted. Hazards that were not selected for analysis on the **Introduction** screen are excluded from this screen. The user does not make any changes here but can use this screen as reference to see how their past answers have influenced the potential impacts scores. If the user wants to change the potential impacts scores, they may return to the exposure and sensitivity screens to do so.

4.3.6.6 Determine Overall Vulnerability Score Screen

The screen combines the potential impacts score with the adaptive capacity score to form an overall vulnerability score for each climate hazard on a scale of 1 to 5. Hazards that were not selected for analysis on the **Introduction** screen are excluded from this screen. The user does not make any changes here but can use this screen as reference to see how their past answers have influenced the overall vulnerability scores. If the user wants to change the overall vulnerability scores, they may return to the exposure, sensitivity, and adaptive capacity screens to do so.

4.3.6.7 Select Highest-Scoring Vulnerabilities Screen

This screen shows overall vulnerability scores for all climate hazards and preselects those that have a vulnerability score of 3 or above. This helps the user focus on selecting risk reduction measures for the most relevant climate hazards to their projects. The user can click on additional hazards to include in risk reduction measure selection or uncheck preselected hazards based on their risk tolerance and/or other considerations (e.g., policy objectives). Hazards that were not selected for analysis on the **Introduction** screen are excluded from this screen.

4.3.7 Measures Module

The **Measures** module consists of three submodules covering emissions reduction, climate risk reduction, and health and equity. There are 287 measures across the three submodules for user review and consideration. Most of the measures are from CAPCOA's Handbook, with CalEEMod directly incorporating quantification methods, assumptions, and defaults, as appropriate. The following sections discuss specific details unique to each submodule. Consistent among all three submodules is the presentation of measure co-benefits. Co-benefits are additional benefits that will be achieved by the measure beyond the primary measure function (e.g., climate risk reduction). The co-benefit categories considered in CalEEMod include the following.

- **Improved air quality**. Criteria pollutant reductions (considered a co-benefit to a measure that targets GHG emissions reductions).
- **Energy and fuel savings**. Electricity, natural gas, refrigerant, propane, gasoline, or diesel reductions.
- **VMT reductions**. Reductions in vehicle miles traveled.
- **Water conservation**. Water use reductions.
- **Enhanced pedestrian or traffic safety**. Reduced collisions; pedestrian/bicyclist safety.
- **Improved public health**. Toxic air contaminant reductions (including exposure); increased physical activity; improved public safety; improved social determinants of health.
- **Improved ecosystem health**. Improved biological diversity and soil and water quality.
- **Enhanced energy security**. Systemwide load reduction; local energy generation; levelling out peaks.
- **Enhanced food security**. Stability of food systems; improved household access to food.
- **Social equity**. Address existing social inequities (e.g., housing/anti-displacement, community engagement, availability of disposable income).

CalEEMod assigns co-benefits to measures that are likely to result from measure implementation; however, it should be noted that the achievement of co-benefits is not guaranteed because many co-benefits are dependent on how the measure is implemented. Use the "Filter Measures" button to view measures that achieve desired co-benefits. Note that CalEEMod only includes analytics to quantify improved air quality, energy and fuel savings, VMT reductions, and water conservation from select emission reduction measures (see Appendix C, *Emission Calculation Details for CalEEMod*). All other co-benefits, and co-benefits from climate risk reduction and health and equity measures, are not currently quantified by CalEEMod, but will be noted in the output report, as applicable.

Any measures selected by the user on the **Climate Risk** or **Health and Equity** map screens will appear as preselected within the corresponding measure screen(s) for climate risk reduction and health and equity. Preselected measures will be italicized in the emission reduction screens. Another consistent presentation item among the three submodules and measure screens is the highlighting of the relevant measures from the **Health and Equity** map screen. The five most relevant measures for addressing environmental and health burdens of the project site are identified with an asterisk (*). These measures are further explained in the **Relevant Measures** splash screen on the **Health and Equity** map screen (see Section 4.2.3, *Health & Equity Map Screen*).

4.3.7.1 Emissions Reduction Submodule

The **Emissions Reduction** submodule consists of 10 screens that cover the different types of sources that contribute to construction and operations emissions. Within each screen, measures are categorized as either "quantified" or "qualitative or supporting measures." CalEEMod includes analytics to quantify emission reductions achieved by quantified measures. Emissions benefits of supporting or qualitative measures are not currently quantified by CalEEMod. User-selected supporting or qualitative measures are noted in the output report.

The user should click the checkboxes to select the measures that will be implemented by the project. The notepad icon to the right of the measure title links to the measure factsheet or measure description. Measure factsheets from the Handbook are available for most quantified measures and some qualitative or supporting measures. If a measure factsheet is not available, a narrative description of the measure is provided. Once a measure is selected, additional user input may be requested to enable quantification. Where available, default values are provided in the data fields. The user should review these defaults and confirm their applicability to the project analysis. All default values can be overridden with project-specific information, where available and appropriate.

Emissions reductions achieved by several measures may be quantified by equally applying the reduction efficacy to all land use subtypes in the model run, or through targeted application to specific land use subtypes. For example, the user may elect to install green roofs on all project land use subtypes by selecting "All Land Use Subtypes" under Measure E-5, *Install Green Roofs in Place of Dark Roofs*. Alternatively, the user may select "By Land Use Subtype" to identify a subset of project land use subtypes that will install green roofs (see Figure 14).

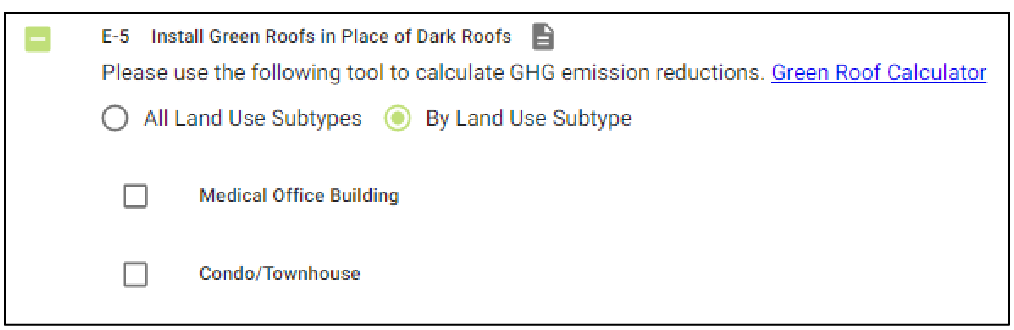


Figure 14. Applying Emission Reduction Measures by Land Use Subtype

Note that the user may be prevented from selecting specific measures based on prior inputs. For example, some measures are mutually exclusive. That is, selection of one measure precludes implementation of another. For example, the user cannot implement Measure T-5, *Implement Commute Trip Reduction Program (Voluntary)*, and Measure T-6, *Implement Commute Trip Reduction Program (Mandatory implementation and Monitoring).* Implementation of other measures may depend on selection of a prerequisite measure or action. For example, the user cannot implement Measure C-8, *Use Renewable Diesel*, unless they either also selected Measure C-5, *Use Advanced Engine Tiers*, or identified tier specific equipment in the **Off-Road Equipment** screen. Finally, some measures may be deactivated if the user have already selected the control strategy in prior screens. For example, the user cannot implement Measure C-9, *Dust Suppressants*, if the control is enabled on the **On-Road Fugitive Dust** screen. The checkboxes for measures that are not applicable to a project or cannot be quantified are shown in gray and cannot be selected (as discussed further in Appendix C, *Emission Calculation Details for CalEEMod*). Hover over the checkboxes for information on why the measure is not available, as illustrated in Figure 15.

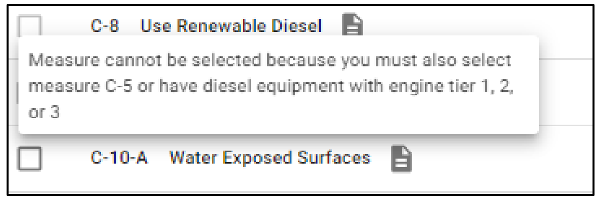


Figure 15. Nonapplicable Measure C-8 Messaging

Measures that were preselected on the **Climate** and **Health and Equity** map screens are *italicized*. The measures are not automatically checked because quantification of several measures depends on prerequisite user inputs in the **Construction** or **Operations** modules and/or user selection of other emission reduction measures. Accordingly, the necessary details underpinning quantification of some measures are not known until after the user has advanced beyond the **Map** component. The italics are provided as a reminder of user preference at the beginning of the analysis. The user will need to manually check all measures that can be implemented by the project.

4.3.7.2 Climate Risk Reduction Submodule

The **Select Climate Measures** screen provides 99 measures for the user to select from to reduce their vulnerability. Some measures may address multiple climate hazards. For example, Measure MH-4, *Strengthen Building Structures*, can bolster a project's resilience to extreme precipitation, flooding, and wildfire. The climate hazards addressed by each measure are shown using the icons identified in Section 4.3.6.1, *Introduction Screen*. Measures that address priority hazards identified in the **Select Highest-Scoring Vulnerabilities** screen within the **Climate Risk** submodule are shown first in the list of available measures. The icons for priority hazards are also shown in larger font.

Each measure could have one or more of the following risk reduction benefits.

- **Reduces exposure:** Reduces the presence of project elements in areas that are subject to climate hazards.
- **Reduces sensitivity:** Reduces the level to which a project element would be affected by exposure to a changing climate.
- **Increases adaptive capacity:** Increases the ability of a project element to moderate harm or exploit risk reduction opportunities.

The user should select the measures that will be implemented by the project. The caret icon to the left of the measure number can be clicked to show the measure description. Measures that were preselected on the **Climate** and **Health and Equity** map screens will be automatically checked. Measures not applicable to the project based on the user identified land use type(s) and project scale are shown in gray. While the model has identified these measures as not applicable to the project based on prior inputs, users may still select these measures. This differs from nonapplicable emissions measures, which cannot be selected by the user (as discussed further in Appendix C, *Emission Calculation Details for CalEEMod*).

For each measure selected, the user should review the three risk reduction benefit columns (reduces exposure, reduces sensitivity, increases adaptive capacity). Some measures may not accomplish any of the three functions, while other measures may accomplish a mix or all three. Measures that do not achieve the risk reduction benefit are given a score of 0, which cannot be modified by the user. For those measures that achieve a risk reduction benefit, CalEEMod identifies a range of potential reduction depending on implementation (e.g., 2 to 4). The user should select the appropriate reduction benefit score for the project using the dropdown menu. Hover over the “information” buttons for guiding questions to consider when scoring each benefit.

The user can select as many climate risk reduction measures as they wish. Measures are not additive, and a user’s exposure, sensitivity, and adaptive capacity score will not go below 0 or surpass 5. The selection of multiple measures will help provide the user more options to reduce their climate risk. The actual benefit of these measures will depend on how the project implements the chosen risk reduction measures.

4.3.7.3 Health & Equity Measures Submodule

The **Health & Equity** submodule presents two screens with the 50 available health and equity measures for user consideration and selection. The health and equity measures seek to promote health equity, progress toward racial equity, and inclusion of and solidarity with marginalized, underrepresented, and vulnerable communities. The measures are identified as either process measures or outcome measures. Process measures focus on facilitating greater community participation and decision-making in the process of land use planning, and outcome measures focus on enhancing the project features and operational practices that advance equitable outcomes.

There are 16 process measures organized into three categories: Community-Centered Development, Inclusive Engagement, and Accountability. There are 34 outcome measures organized into six categories: Construction Equity, Public Health and Air Quality, Inclusive Economics and Prosperity, Inclusive Communities, Anti-Displacement and Housing, and Climate Resilience.

4.3.7.3.1 Introduction Screen

The user may elect to identify health and equity measures that will be implemented by the project, or complete the **Health and Equity Evaluation Scorecard**. The **Health and Equity Evaluation Scorecard** provides a simple process to evaluate how well a project has adopted specific measures and practices to deliver greater health, equity, and other benefits to support the existing community. The scorecard includes all measures except those in the Anti-Displacement and Housing and Climate Resilience categories. These measures are excluded from the scorecard due to the spectrum of implementation strategies and requirements that defy simple scoring. The user can select if they would like to complete the **Health and Equity Evaluation Scorecard** by making the appropriate selection on this screen.

4.3.7.3.2 Select Measures Screen

The user who elects not to complete the **Health and Equity Evaluation Scorecard** should select the measures that will be implemented by the project. Measures that were preselected on the **Climate** and **Health and Equity** map screens will be automatically checked. Measures not applicable to the project based on the user identified land use type(s) and project scale are shown in gray. While the model has identified these measures as not applicable to the project based on prior inputs, users may still select these measures by clicking the pencil edit icon. This differs from nonapplicable emissions measures, which cannot be selected by the user (as discussed further in Appendix C, *Emission Calculation Details for CalEEMod*).

Users completing the **Health and Equity Evaluation Scorecard** must identify scores using the dropdown menus for all 40 measures. The user will be restricted from advancing forward until scores are identified for all measures. Users can select "N/A" for measures that are not applicable to the project. Most measures follow a 1 to 5 scoring range, with higher point values corresponding to increasing levels of action. Some measures adopt a modified scoring scheme within this range (e.g., 1-3-5 or a 3-4-5), again with higher point values corresponding to greater levels of action. A 0 should be given to measures that are applicable to a project but not included or implemented in a manner that is accepted by community members. Appendix F, *Support Documentation for Health and Equity Association Scoring*, provides more specific scoring criteria for each measure. The user should consult Appendix F when completing the **Health and Equity Evaluation Scorecard**. Scoring criteria can also be viewed by clicking the caret to the left of the measure number.

Note measures that were preselected on the **Climate** and **Health and Equity** map screens are given a starting score of 0. The user should adjust this score to appropriately reflect measure implementation for the project, if necessary. Measures not applicable to the project based on the user identified land use type(s) and project scale are highlighted gray with a score of "N/A." Users may add custom health and equity measures to the scorecard if additional strategies will be implemented by the project. Click the plus sign to the right of the category title to add a custom measure under that category. Users will need to provide a measure title and measure description and identify the entity sponsoring the additional measure. Custom measures can be scored within a range of 0 to 5.

4.4 Results Component

The **Results** component includes four dashboards that display key results for the model run and two emissions calculation screens. There are two dashboards for emissions results: construction and operations. Results for climate risk are displayed on a separate dashboard, as are results for health and equity. All four dashboards present summary information using a combination of charts, icons, and tables. The two calculation screens present a series of emissions results tables by source The user must complete all required inputs in the **Emissions** and **Climate Risk** modules for the dashboards and results screens to function. Once all inputs are satisfied, the dashboards and results screens are automatically updated based on real-time user changes to the model.

4.4.1 Construction Emissions Dashboard

The construction emissions dashboard displays construction emissions results. Figures 16a and 16b illustrate the primary components of the dashboard. The left-hand sidebar panel should be used to adjust the dashboard content. The results are displayed to the right of the panel based on user selections to the following parameters.

- Construction Year: Use the drop-down menu to select the construction year for the results.
- Pollutant Type: The pollutant type determines the emissions that are displayed in the pollutant cards. Selecting “Criteria Pollutant” will display result cards for TOG, ROG, NOx, CO, SO_2, PM10, and PM2.5. Selecting “Greenhouse Gas” will display result cards for CO_2, CH_4, N_2O, R, and CO_2e. Note that regardless of the pollutant type selected, result cards will only be generated for pollutants selected for quantification on the **Pollutants** screen.
- Calculation Type: The calculation type controls how emissions are displayed in the pollutant cards. Maximum daily emissions can be quantified and displayed using summer or winter emission factors (for emission sources with seasonally variable emission factor data). Winter emissions occur between October and March, and summer emissions occur between April and September. Select “Daily – Summer (Max)” or “Daily – Winter (Max).” If either of these calculation types are selected, the pollutant cards will display the highest (i.e., maximum) daily emissions quantified for the season and construction year. Users may also view daily results based on an average annual calculation by choosing “Daily (Average).” Annual emissions can be generated by selecting “Annual.”
- Condition: The condition controls whether unmitigated or mitigated emissions results are displayed in the temporal bar chart and construction category pie chart. Unmitigated results do not account for reductions achieved by user-selected measures. Mitigated results include quantified emissions reduction. The mitigated condition can only be selected if construction measures have been selected in the **Measures** module.
- Pollutant to Spotlight: The pollutant to spotlight controls the pollutant shown in the temporal bar chart and category pie chart. Results shown for the top three user-selected measures and remaining measures are also specific to the selected pollutant. Only those pollutants selected for quantification on the **Pollutants** screen will be available to select. If a pollutant was selected on the **Pollutants** screen, but no emissions would be generated for the selected construction year, the radio button for that pollutant will be locked. Because there are no emissions, the pollutant cannot be displayed in the temporal bar chart and category pie chart.

The pollutant cards at the top of the dashboard summarize the emissions results based on user selections for the construction year, pollutant type (criteria pollutants or GHGs), and calculation type. If the project run includes mitigation, both unmitigated and mitigated emissions will be displayed. The card shows the numeric emission(s) result. The horizontal bar depicts the relative magnitude of the emissions. The cards also display pollutant thresholds if they were entered by the user on the **Pollutants** screen. The horizontal magnitude bar will display red if emissions exceed the threshold and green if emissions do not exceed the threshold. This is also illustrated by the position of the vertical threshold bar relative to the emissions magnitude. The horizontal magnitude bar will display gray if there is no applicable threshold.

The temporal bar chart displays emissions results by construction phase and day based on user selections for the construction year, pollutant type, calculation type, condition, and pollutant to spotlight. The chart can only be generated for “Daily – Summer (Max) (lb/day)” and “Daily – Winter (Max) (lb/day)” calculation types. Use the slider to adjust the presentation scale for the x-axis (schedule). The chart defaults to the widest presentation option with the slider buttons on either end of the viewing pane. Moving the sliders closer together will adjust the presentation to as refined as a single day. Users may also select or deselect individual phases by clicking their colored box in the legend below the chart. Hovering over the chart will display the daily emissions contributions for each applicable construction phase.

The construction category pie chart displays the contribution of average daily emissions by source based on user selections for the construction year, pollutant type, condition, and pollutant to spotlight. Hover over the pie chart to see the source contribution in terms of percent of total emissions and mass emissions (average pounds per day). Users may also select or deselect individual sources by clicking their colored box in the legend to the right of the chart.

The selected measures box identifies the three user-selected construction measures that achieve the greatest reduction (in terms of total mass) over the entire duration of the construction period for the spotlighted pollutant. Fewer measures may be shown if the user selected fewer than three measures in the **Measures** module. The box to the right displays the total number of selected measures that reduce the selected pollutant and identifies if any additional measures are available and may be selected to achieve further reductions. Users can click the “Additional Strategies” button to return to the **Measures** module and revise measure selections, if desired.

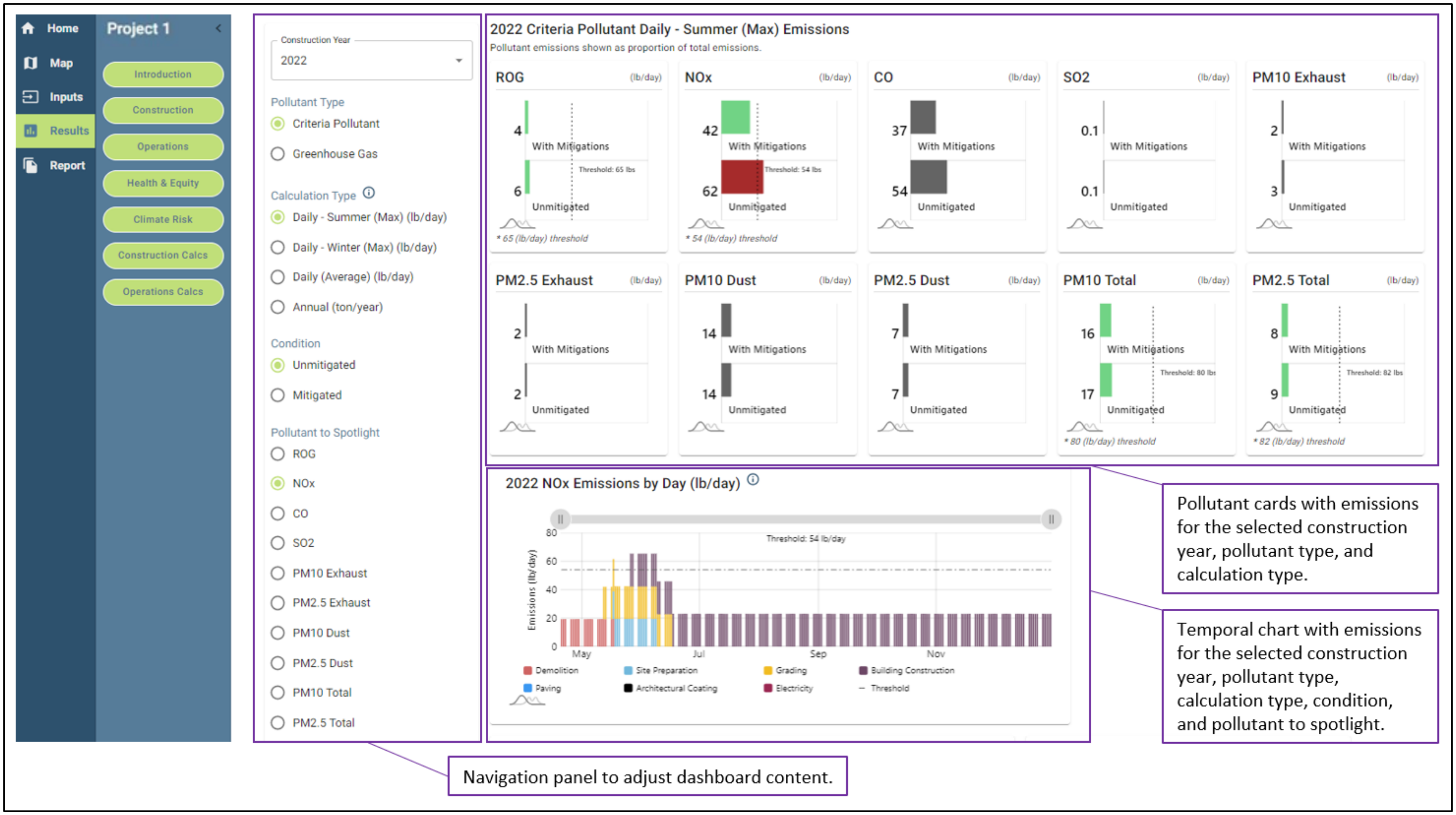


Figure 16a. Construction Emissions Dashboard

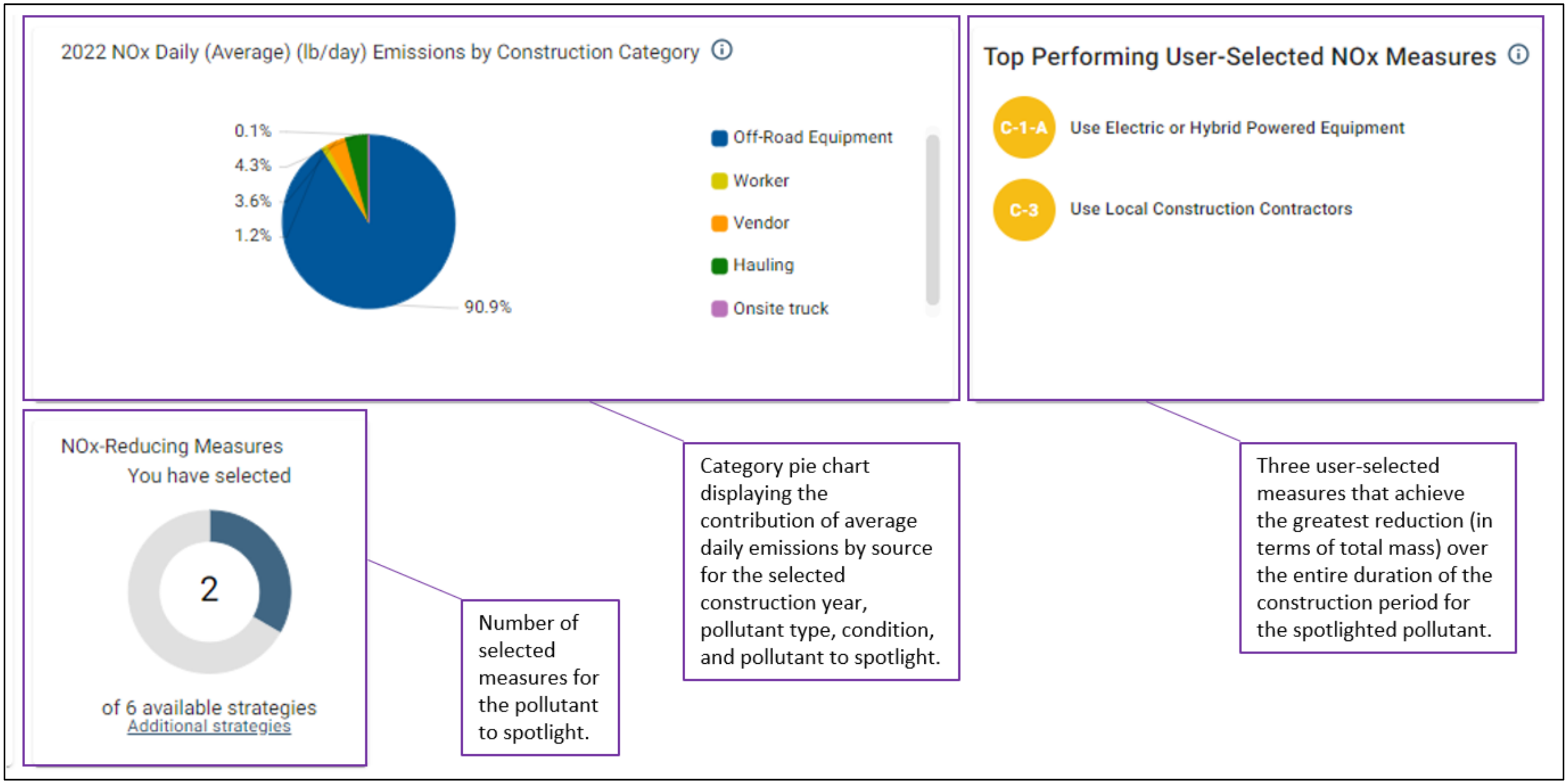


Figure 16b. Construction Emissions Dashboard

4.4.2 Operations Emissions Dashboard

The operations emissions dashboard displays operations emissions results for the operational year defined on the **Project Detail** screen. Figures 17a and 17b illustrate the primary components of the dashboard. The left-hand sidebar panel should be used to adjust the dashboard content. The results are displayed to the right of the panel based on user selections for the pollutant type, calculation type, condition, and pollutant to spotlight. These parameters are the same as described above in Section 4.4.1, *Construction Emissions Dashboard*.

The pollutant cards at the top of the dashboard summarize the emissions results based on user selections for the pollutant type and calculation type. The category pie chart displays the contribution of average daily emissions by source based on user selections for the pollutant type, condition, and pollutant to spotlight. The display of emissions and functionality of the pollutant cards and pie chart are the same as described above for the construction emissions dashboard.

The selected measures box identifies the three user-selected operations measures that achieve the greatest reduction (in terms of total mass) for the spotlighted pollutant. The top-three ranking does not consider how combining multiple measures could potentially reduce the effectiveness of an individual measure. In other words, the efficacy of each measure is analyzed in isolation for the measure ranking exercise on the dashboard. As noted in Section 7.1, *Emissions Reduction Submodule*, in Appendix C, *Emission Calculation Details for CalEEMod*, damping effects of measures are accounted for in the quantification of daily and annual mitigated emissions.

The selected measures box functions similarly to the measure box on the construction emissions dashboard (refer to Section 4.4.1, *Construction Emissions Dashboard*).

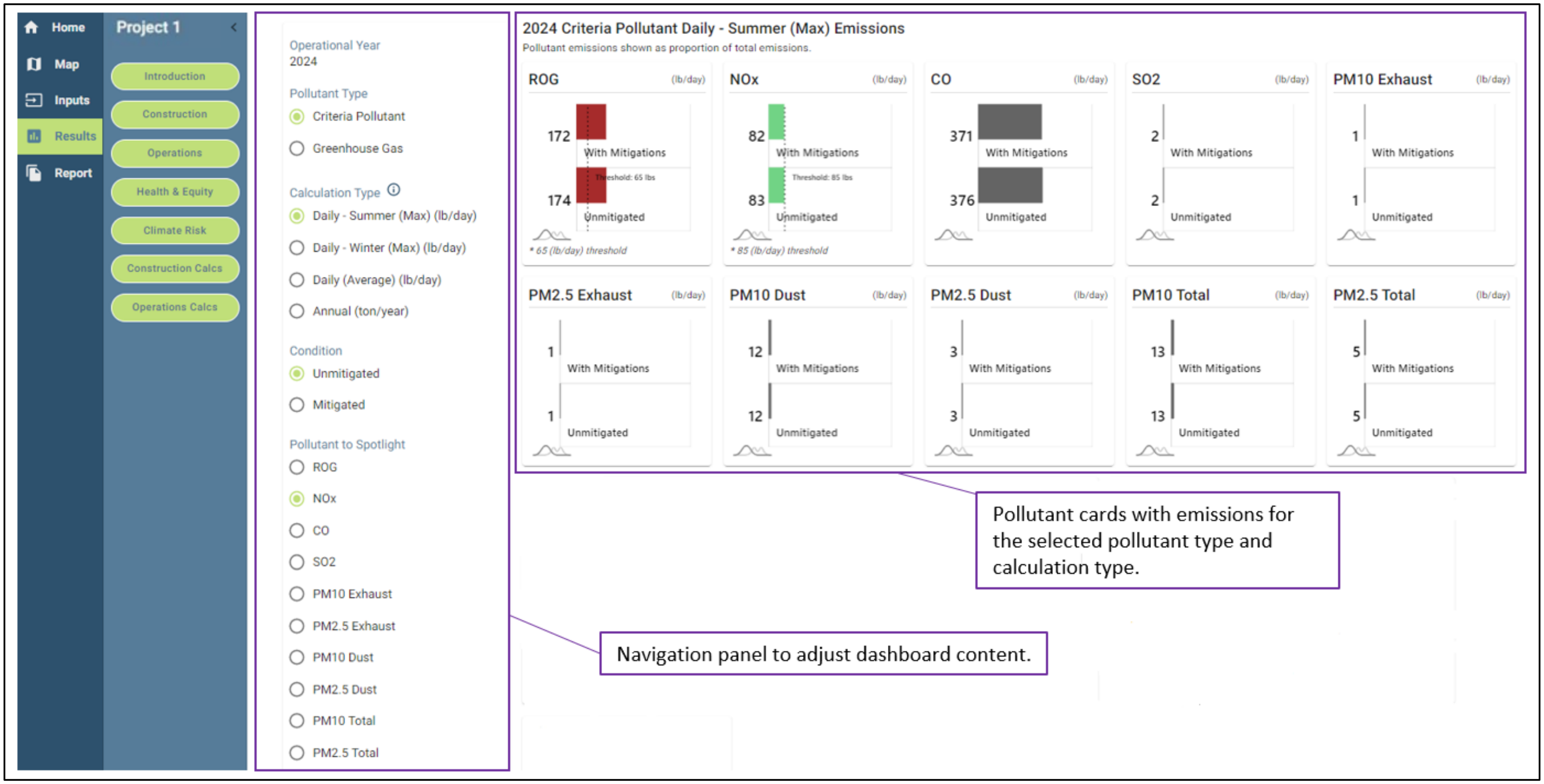


Figure 17a. Operations Emissions Dashboard

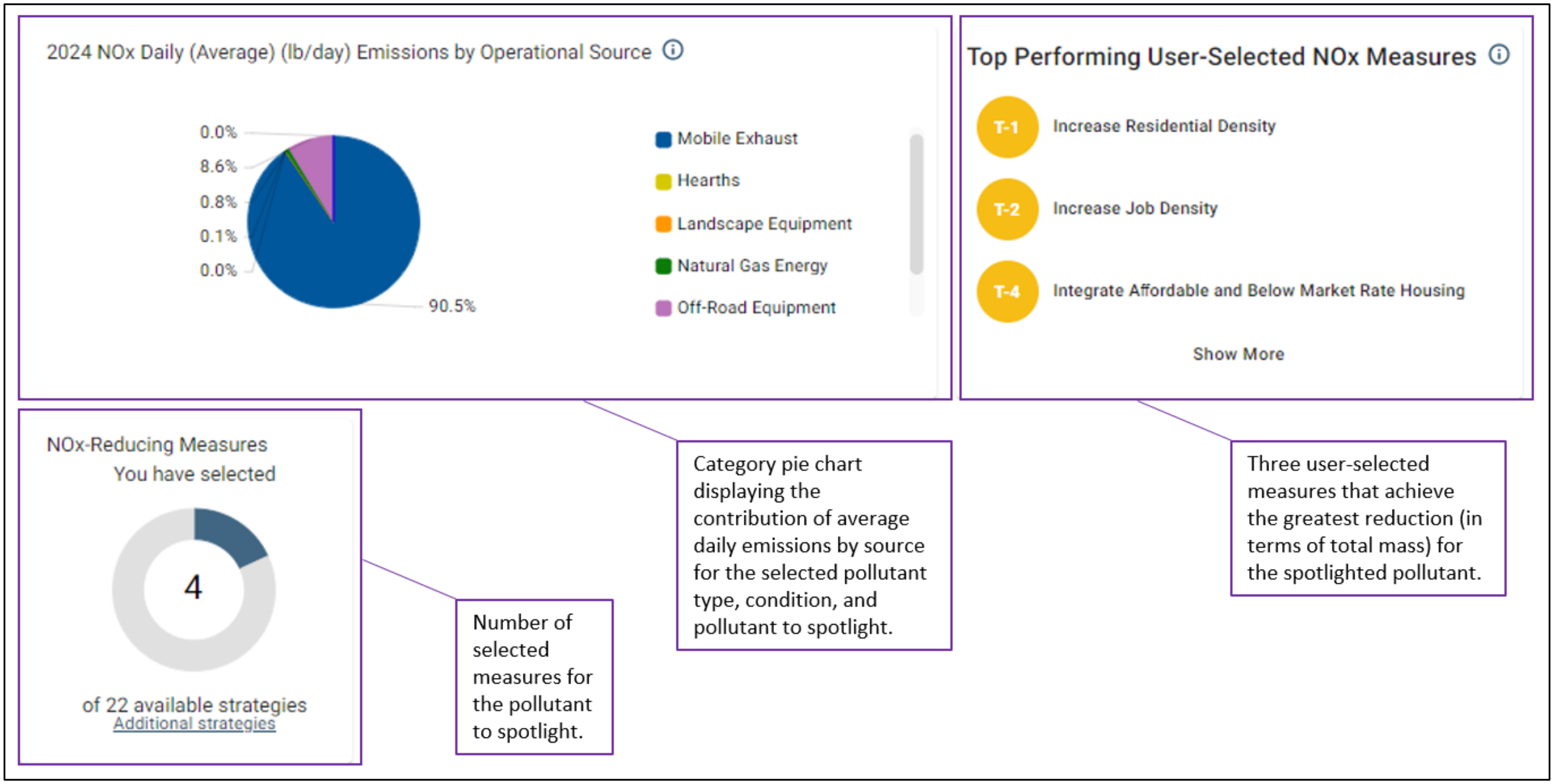


Figure 17b. Operations Emissions Dashboard

4.4.3 Climate Risk Dashboard

The climate risk dashboard displays results from the climate risk analysis. Figures 18a and 18b illustrate the primary components of the dashboard. Use the radio buttons in the left-hand sidebar to select the climate risk to display. Only those risks analyzed in the **Climate Risk** module (i.e., checked on the **Introduction** screen) can be viewed. The hazard icon (see Figure 13) and risk analysis results are presented to the right of the panel. Scores for exposure, sensitivity, adaptive capacity, and initial vulnerability are provided. An adjusted vulnerability score that accounts for measure benefits will also be displayed if climate risk reduction measures were selected in the **Measures** module. Refer to Appendix E, *Support Documentation for Climate Change Analyses*, for information on how CalEEMod calculates measure effects on the vulnerability score. All climate risk scores displayed on the dashboard are color-coded according to the matrix presented on the **Develop Overall Vulnerability Score** screen and in Figure E-1 in Appendix E.

The selected measures box identifies the three user-selected measures that achieve the greatest improvement in the vulnerability score. The box to the right of the top-three analysis displays the total number of measures selected by the user that address the climate risk and identifies if any additional measures are available to achieve further protection. These boxes function similarly to the measure boxes on the construction and operations emissions dashboards. Co-benefits that may be achieved by the selected measures are displayed below the measure boxes.

4.4.4 Health & Equity Dashboard

The health & equity dashboard displays the overall CES and HPI scores relevant to the project census tract and, if completed, the **Health and Equity Evaluation Scorecard**. Figures 19a and 19b illustrate the primary components of the dashboard. The overall CES and HPI scores are color-coded according to the color gradient displayed for these layers on the **Health & Equity** map screen. The two measure boxes function similarly to measure boxes on all other dashboards. As discussed in Appendix F, *Support Documentation for Health and Equity Association Scoring*, all measures are scored based on their potential to address specific health and equity indicators. These scores are multiplied by the indicator values from CES, yielding a single efficacy score for each applicable measure. The top-three measures box presents the three user-selected measures that achieve the highest score. The display of measure co-benefits is the same as shown on the climate risk dashboard.

If users have elected to complete the **Health and Equity Evaluation Scorecard** (see Section 4.3.7.3, *Health & Equity Measures Submodule*), the evaluation report will be presented at the bottom of the dashboard. The report presents the number of scored measures implemented by the project and total points earned by category. The maximum points possible is shown for each category, as well as the weighted category scores based on the maximum total points possible. Weighted categorical scores are also shown in a spider chart to facilitate analysis of a project's strong and weak points. Based on the overall weighted score, the dashboard presents the equity award tier for the project run. Refer to Appendix F, *Support Documentation for Health and Equity Association Scoring*, for additional information on the how CalEEMod generates the scorecard results.

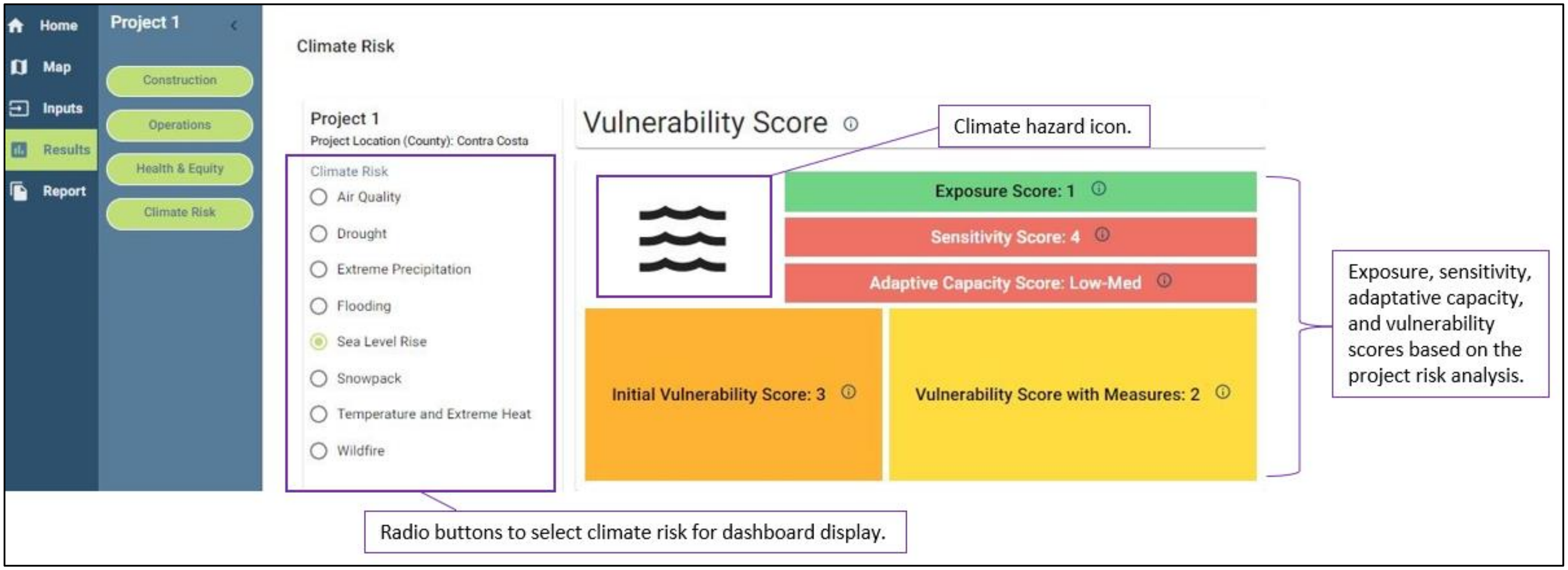


Figure 18a. Climate Risk Dashboard

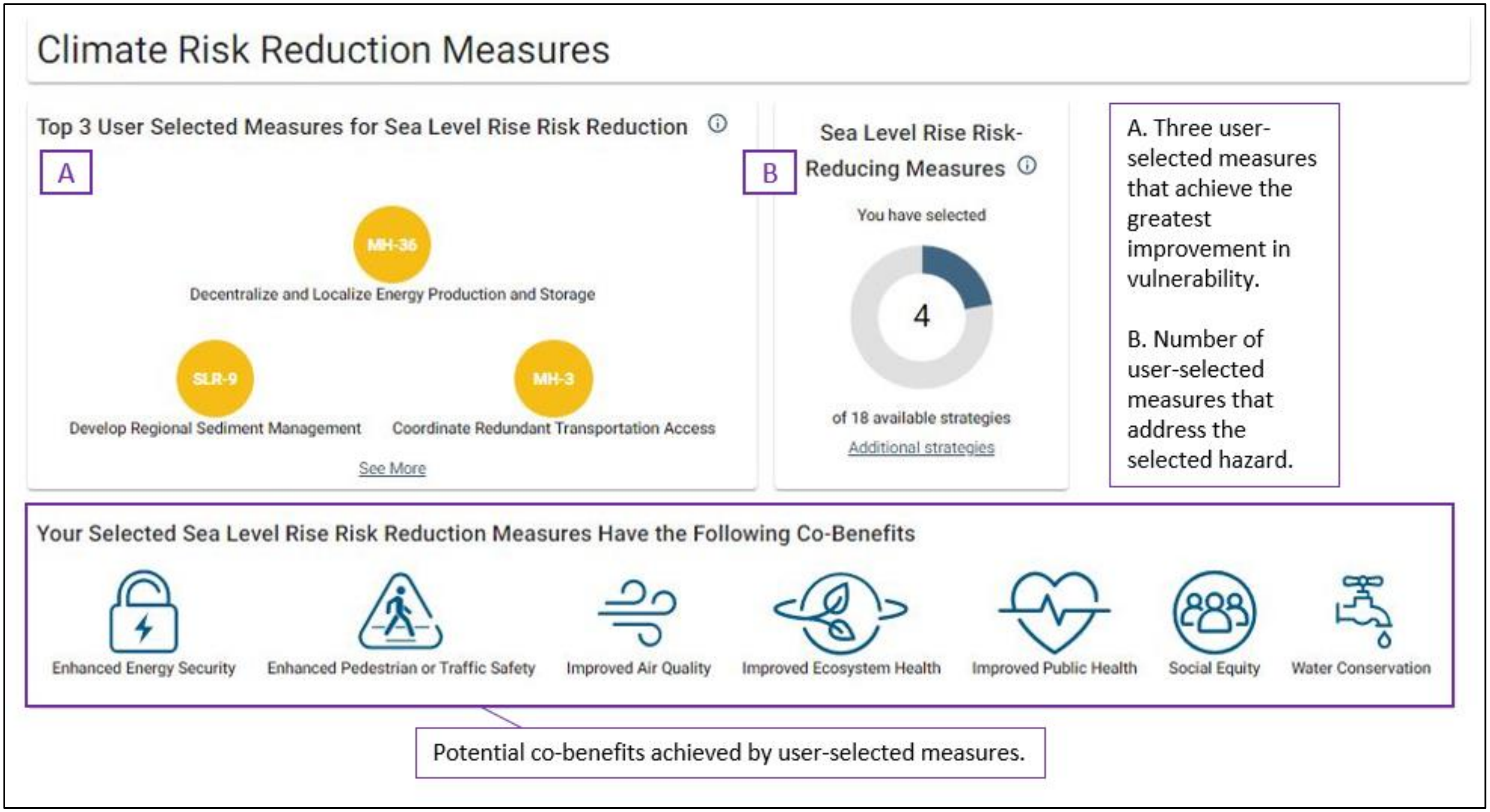


Figure 18b. Climate Risk Dashboard

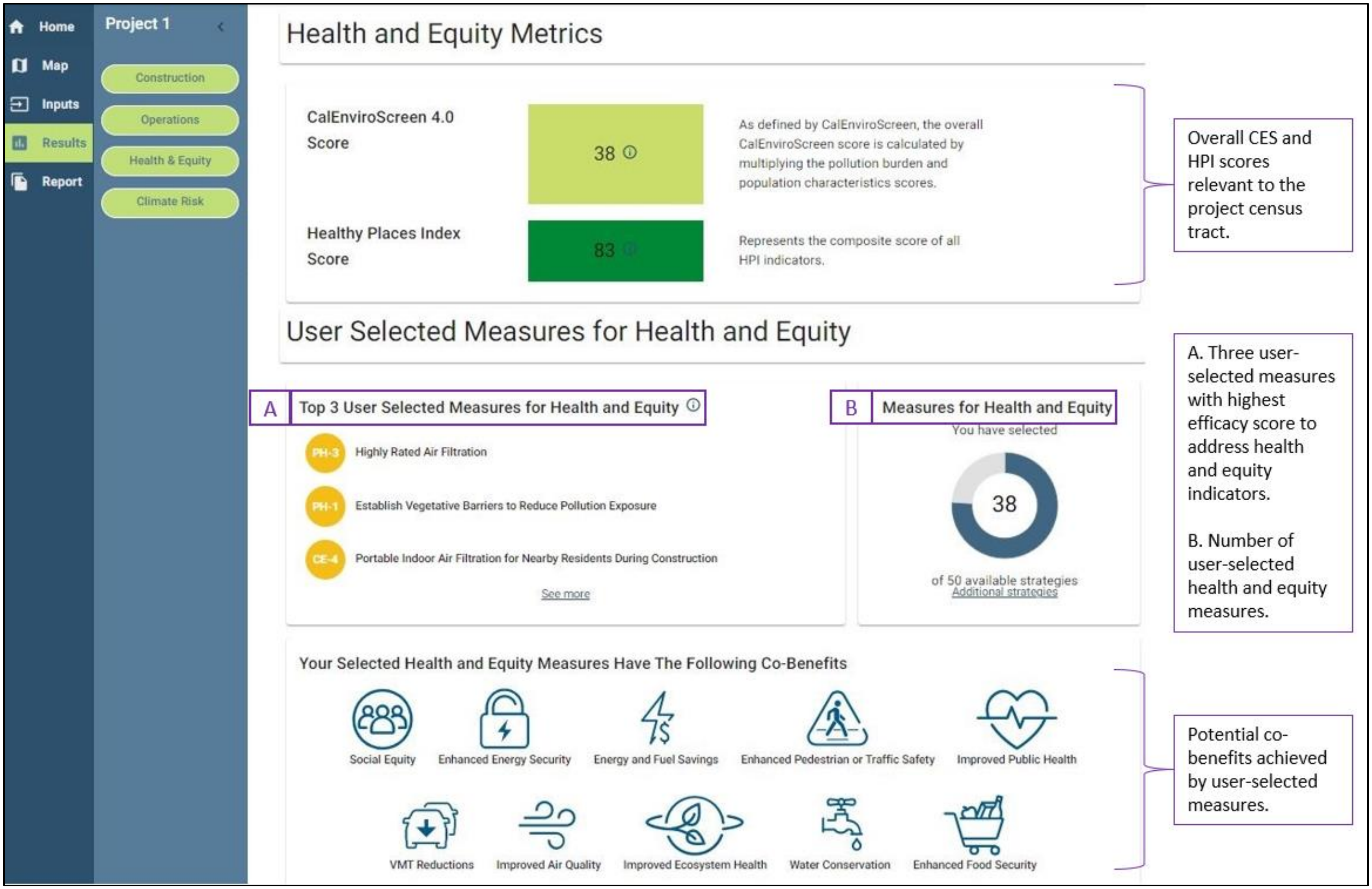


Figure 19a. Health & Equity Dashboard

Health and Equity Evaluation Scorecard

Category	Number of Applicable Measures	Total Points Earned by Applicable Measures	Max Possible Points	Weighted Score
Community-Centered Development	5	14	25	8
Inclusive Engagement	6	19	30	9
Accountability	5	15	25	9
Construction Equity	6	17	30	8
Public Health and Air Quality	4	10	20	7
Inclusive Economics & Prosperity	4	3	20	2
Inclusive Communities	7	13	35	5
Total	37	91	185	48

Evaluation report showing number of scored measures, points earned, maximum possible points, and weighted scores.

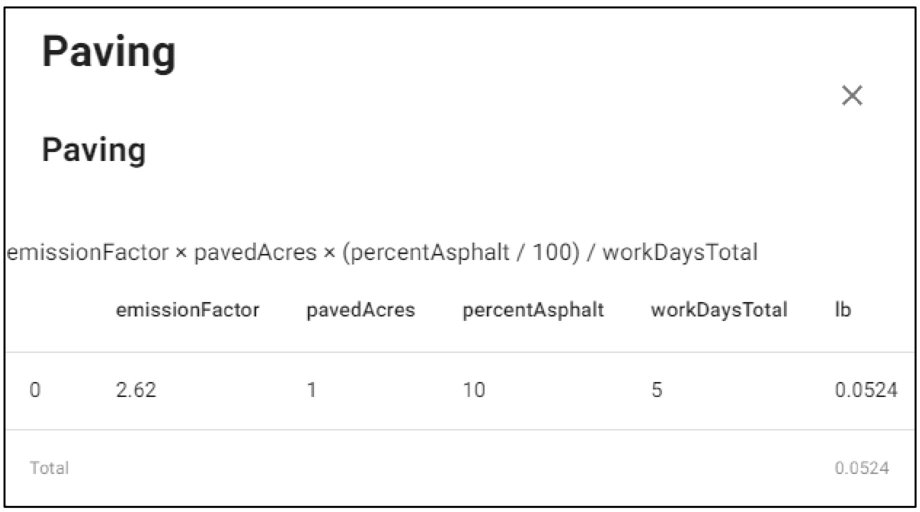
A. Spider chart displaying weighted category scores.

B. Equity tier awarded to the project based on the total weighted score.

Figure 19b. Health & Equity Dashboard

4.4.5 Construction Calculations

This screen displays total construction emissions from all sources and then individually by source (i.e., off-road equipment, dust from material movement, demolition, mobile exhaust, on-road fugitive dust, architectural coatings, paving, and electricity consumption). Where applicable, the source tables present emissions by process. For example, emissions from vehicle trips and VMT are presented separately within the mobile exhaust table. Users can view the equations and variables underpinning the results by clicking directly on any calculated emissions value in the tables. This will display a splash screen with the unformatted, raw calculation details (see Figure 20). Users can click the toggles at the top of the screen to display unmitigated or mitigated emissions for the daily or annual condition. Daily emissions can be presented for the winter or summer season. While the emissions displayed in the **Construction Calcs** screen can also be viewed in the construction emissions dashboard and **Reports** component, the screen enhances transparency by specifically identifying the equations and variables used by CalEEMod to quantify construction emissions by source and process.


Paving

Paving

emissionFactor × pavedAcres × (percentAsphalt / 100) / workDaysTotal

	emissionFactor	pavedAcres	percentAsphalt	workDaysTotal	lb
0	2.62	1	10	5	0.0524
Total					0.0524

Figure 20. Calculation Splash Screen for Daily ROG from Paving

4.4.6 Operations Calculations

This screen displays total operations emissions from all sources and then individually by source (i.e., mobile exhaust, on-road fugitive dust, hearts, consumer products, architectural coatings, landscape equipment, energy consumption, water and wastewater, solid waste, refrigerants, off-road equipment, emergency generators and fire pumps, process boilers, user-defined, land use change, and sequestration). The functionality of this screen is the same as described above for the construction calculations screen.

4.5 Reports Component

4.5.1 Report Selection Screen

The **Reports** module is where the user can select the desired output for the model run. The available reports include summary, detailed, quarterly, and custom. The summary and quarterly reports present high-level construction and operations results, consistent with the level of detail displayed on the construction and operations emissions dashboard screens. The summary and quarterly reports do not include any outputs related to climate risk or health and equity. The detailed report presents more comprehensive emissions data, with results displayed for individual emission sources (e.g., hearths, consumer products). The detailed report also includes quantified co-benefits (e.g., water consumption), activity data (e.g., VMT), changes to data field defaults, user input justification remarks, and results for the climate risk and health and equity analyses. If measures are selected by the user, both the summary and detailed reports will display unmitigated and mitigated results, as applicable. The custom report allows the user to identify sections to include/exclude from the report.

For the summary and detailed reports, daily emissions are quantified using both summer and winter emission factors (for emission sources with seasonally variable emissions factor data). As discussed further in Appendix C, *Emission Calculation Details for CalEEMod*, maximum daily construction emissions for the winter and summer seasons are presented separately. The calculation of maximum (i.e., highest) emissions during each season considers the start and end dates of individual construction phases. Only emissions generated by those construction phases that occur between October and March are included in the calculation of winter maximum emissions. Likewise, only those emissions generated by those construction phases that occur between April and September are included in the calculation of summer maximum emissions. The consideration of seasonality in the presentation of summer and winter outputs is new to version 2022.1 and can result in considerable differences in maximum daily summer and winter results. Annual emissions are quantified using average annual emission factors, as applicable. Note that, for all emissions results, negative values indicate an emissions decrease, or benefit.

CalEEMod will display a preview of the selected report on the screen. From this report preview, the user can print the report or save the report as a Microsoft Excel (.xls), comma-separated value (.csv), or Adobe Acrobat (.pdf) file. It is important to note that the data presented in the Excel file has already been calculated and the calculated results are placed in the grids as text. For this reason, the user cannot change an emission value presented in an Excel file and expect the report to calculate a revised value. These values, however, can be copied to a new Excel spreadsheet for any further desired calculations with the data. Also, the Adobe Acrobat file meets AB 434 accessibility requirements. Certain formatting considerations (e.g., use of dashes, non-merged cells) were made to achieve compliance.

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CalEEMod

California Emissions Estimator Model

Appendix A
Glossary

Prepared for:
California Air Pollution Control Officers Association (CAPCOA)

Prepared by:
ICF
in collaboration with
Sacramento Metropolitan Air Quality Management District, Fehr & Peers, STI, and Ramboll

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Adaptation (Climate Change)
Adjusting to a changing environment. Adaptation involves working to reduce or eliminate the impacts of climate change on a community. Adaptation can minimize harm and costs and take advantage of potential opportunities associated with the impacts of climate change. Adaptation includes addressing current and future natural hazards (i.e., wildfire, drought, cyclones, heat waves), as well as gradual changes (i.e., increasing temperatures, sea level rise) that could impact economic sectors, natural resources, and community well-being.

Adaptation Measure
An action that addresses a climate impact. A measure will reduce risk and/or vulnerability for a specific resource, asset, project component, or community.

Adaptive Capacity
A project's existing capacity to cope with the effects of climate change (an element of vulnerability). Adaptive capacity includes the policies, programs, plans, and practices that are already in place or can be easily implemented, which prepare a project, community, and individuals for climate change, and the financial resources to implement such actions.

Additionality
The reduction in emissions by sources or enhancement of removals by sinks that is additional to any that would occur in the absence of the project. The project should not subsidize or take credit for emissions reductions which would have occurred regardless of the project (IPCC 2001).

Albedo
The fraction of solar radiation reflected by a surface or object. Snow-covered surfaces have a high albedo, while vegetation-covered surfaces and oceans have a low albedo. The Earth's albedo varies, because of the dynamic nature of clouds, snow, ice, leaf area, and land cover changes. The normal albedo of snow, for example, is around 1.0, whereas the albedo of vegetation can be as low as 0.1. Human-made surfaces designed to have high albedos (i.e., near 1.0) reflect solar radiation and can help reduce the urban heat island effect. Other human-made surfaces, such as asphalt or conventional shingle roofs, have low albedo and increase the urban heat island effect (IPCC 2001).

Analysis Level for Defaults
Defines the geographic extent of many defaults, including on-road vehicle emission factors, solid waste disposal rates, percent of vehicle travel on unpaved/paved roads, days of landscaping equipment use, and hearth usage. CalEEMod defaults to the "County" analysis level, which provides the most locationally-specific data. Users may override this default and select air basin, air district, or statewide, in which case default inputs would be derived based on aggregated data over the larger geography.

Anthropogenic
Generally, environmental change caused or influenced by humans, either directly or indirectly. In the context of CalEEMod, it is used to describe human-caused GHG emissions.

Below Market Rate Housing
Housing rented at rates lower than the market rate. Below market rate housing is designed to assist lower-income families. When below market rate housing is provided near job centers or transit, it provides lower-income families with a desirable job/housing match or greater opportunities for commuting to work through public transit.

Biochemical Oxygen Demand
Represents the amount of oxygen that would be required to completely consume the organic matter contained in wastewater through aerobic decomposition processes. Under the same conditions, wastewater with higher biochemical oxygen demand (BOD) concentrations will generally yield more methane than wastewater with lower BOD concentrations. BOD_5 is a measure of BOD after five days of decomposition.

Biogenic Emissions
Carbon dioxide (CO_2) emissions that result from materials that are derived from living cells, as opposed to CO_2 emissions derived from fossil fuels, limestone, and other materials that have been transformed by geological processes. Biogenic CO_2 contains carbon that is present in organic materials, including wood, paper, vegetable oils, animal fat, and waste from food, animals, and vegetation (such as yard or forest waste) (CCAR 2009).

Building Climate Zone
Geographic areas of similar climatic characteristics, including temperature, weather, and other factors that affect building energy use. The California Energy Commission identified 16 Building Climate Zones for the Title 24 Standards. Building climate zones are different from Energy Demand Forecast Zones (EDFZs), which were developed by the California Energy Commission and used in the Residential Appliance Saturation Survey (RASS) and the 2018–2030 Uncalibrated Commercial Sector Forecast (Commercial Forecast).

Cal-Adapt®
Cal-Adapt is California's climate risk screening tool used for California's Fourth Climate Change Assessment. As defined by Cal-Adapt's developer, UC Berkeley's Geospatial Innovation Facility (GIF), Cal-Adapt provides "access to the wealth of data and information that has been, and continues to be, produced by State of California's scientific and research community. The data available on this site offer a view of how climate change might affect California at the local level" (CEC 2021).

CalEnviroScreen®
CalEnviroScreen is a mapping tool developed by the State of California to identify communities that are most affected by pollution sources and where people are often especially vulnerable to environmental hazards. CalEnviroScreen calculates an overall score for every census tract in the state using environmental, health, and socioeconomic data from state and federal sources. An area with a higher CalEnviroScreen score experiences higher cumulative impacts from pollution burden and socioeconomic factors than areas with low scores.

California Environmental Quality Act
A statute passed in 1970 that requires state and local agencies to identify the significant environmental impacts of their actions, to avoid or mitigate those impacts, and for projects with significant impacts to consider alternatives. The statute also requires public participation in the review of environmental documents.

Carbon Dioxide Equivalent
A measure for comparing CO_2 with other greenhouse gases (GHG). CO_2e is calculated by multiplying the metric tons of a GHG by its associated global warming potential (GWP).

Carbon Monoxide
Carbon monoxide (CO) is a colorless, odorless, gas produced by incomplete combustion of carbon substances, such as gasoline or diesel fuel. While there are no ecological or environmental effects from CO, human exposure to CO at high concentrations can cause fatigue, headaches, confusion, dizziness, and chest pain.

Carbon Sink
Any process or mechanism that removes carbon dioxide from the atmosphere. A forest is an example of a carbon sink because it sequesters carbon dioxide from the atmosphere.

Co-Benefits
Additional benefits that accompany the emissions reductions associated with GHG reduction measures, such as improvement in air quality, employment, climate resiliency, or community quality of life.

Combined Heat and Power
CHP is the generation of both heat and electricity from the same process, such as combustion of fuel, with the purpose of utilizing or selling both simultaneously. In combined heat and power systems, the thermal energy byproducts of a process are captured and used, whereas, in a separate heat and power system, the byproducts would be wasted. Examples of combined heat and power systems include gas turbines, reciprocating engines, and fuel cells. CHP is also known as *cogeneration*.

Community Air Protection Program Community
Community Air Protection Program communities are defined under Assembly Bill 617 (Garcia, 2017). The program's focus is to reduce exposure in communities throughout California that are most impacted by air pollution.

Compact Infill
Project which is located on an existing site within the central city or inner-ring suburb with high-frequency transit service. Examples may be community redevelopment areas, reusing abandoned sites, intensification of land use at established transit stations, or converting underutilized or older industrial buildings.

Construction Vehicle Mix
The user can select the type of vehicle mix for each of the four construction trip types (e.g., worker). The vehicle class descriptors are as follows.

- "LDA, LDT1, LDT2" = 25/50/25 percent mix of light duty autos, light duty truck class 1, and light duty truck class 2.
- "HHDT, MHDT" = 50/50 percent mix of heavy-heavy duty trucks and medium-heavy duty trucks.
- "HHDT" = 100 percent heavy-heavy duty trucks
- "EMFAC Fleet Mix" = total mix of all vehicles for the analysis level provided by EMFAC2021.

Criteria Pollutant
Criteria pollutants are a group of six common air pollutants for which the federal and state governments have set national ambient air quality standards (NAAQS) and California ambient air quality standards (CAAQS), respectively. The standards are set to protect public health and welfare and the environment. The federal criteria pollutants are ozone (O_3), CO, lead (Pb), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and particulate matter (PM), which consists of particulates 10 microns in diameter or less (PM10) and 2.5 microns in diameter or less (PM2.5). Definitions of these pollutants are provided in this appendix (see *Carbon Monoxide*, *Lead*, *Nitrogen Dioxide*, *Ozone*, *Particulate Matter*, and *Sulfur Dioxide*). California has set CAAQS for these six pollutants, in addition to standards for visibility reducing particles, hydrogen sulfide, and vinyl chloride.

Dashboard
The CalEEMod dashboard is an interactive and visually engaging tool that allows users to quickly view key emissions, climate, and health and equity results for their project. There are two dashboards for emissions reporting: one for construction results and one for operations results. There is one dashboard for climate risks and one dashboard for health and equity. The dashboards allow users to customize and filter the presentation of results using a combination of tables, graphs, and icons. The user may also view selected measures, as available.

Density
The amount of persons, jobs, or dwellings per unit area. This is an important metric for determining transportation-related parameters.

Destination Accessibility
A measure of the number of jobs or other attractions reachable within a given travel time. Destination accessibility tends to be highest at central locations and lowest at peripheral ones.

Disadvantaged Community
A disadvantaged community is defined by the State of California as a census tract that is in the top 25 percentile of CalEnviroScreen, an environmental justice screening tool developed by the Office of Environmental Health Hazard Assessment to evaluate communities for their environmental pollution burden as well as vulnerability due to socioeconomic conditions. Disadvantaged community designation is often used by the State of California in funding and other programs (CalEPA 2017).

Efficacy
The capacity to produce a desired effect.

Elasticity
The percentage change of one variable in response to a percentage change in another variable. For example, if the elasticity of vehicle miles traveled (VMT) with respect to density is -0.12, this means a 100 percent increase in density leads to a 12 percent decrease in VMT. Elasticity is represented by the following formula [percent change in variable A] / [percent change in variable B], where the change in B leads to the change in A.

EMFAC
The EMission FACtor model (EMFAC) estimates the official emissions inventories of on-road mobile sources in California. EMFAC is developed and used by CARB to assess emissions from on-road vehicles including cars, trucks, and buses in California, and to support CARB's regulatory and air quality planning efforts to meet the Federal Highway Administration's transportation planning requirements. The U.S. Environmental Protection Agency approves EMFAC for use in State Implementation Plan and transportation conformity analyses.

Emission Factor
A relative value that relates the quantity of a pollutant to an activity associated with the release of that pollutant. Emission factors are typically expressed in terms of pollutant weight divided by an activity rate. For example, metric tons of CO_2 emitted per VMT (annotated as MT CO_2/VMT).

ENERGY STAR
A joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy which sets national standards for energy-efficient consumer products. ENERGY STAR-certified products are guaranteed to meet the efficiency standards specified by the program.

Equity
Equity is the "just and fair inclusion into a society in which all can participate, prosper, and reach their full potential" (Policy Link 2021). Equity means creating the conditions, practices and environment that would enable all communities and individuals to lead healthy, thriving lives, recognizing that communities and individuals have historically faced and continue to face today discrimination and oppression because of their race, gender, sexuality, ability, citizenship status, or other characteristics. Thus, distributional equity includes increasing access to power, redistributing and providing additional resources, and eliminating barriers to opportunity.

Evapotranspiration
The loss of water from the soil both by evaporation and by transpiration from plants growing in the soil (USEPA 2010).

Exposure (to climate hazards)
The effects of climate change that a project will face. Exposure includes change in the severity and location of a climate hazard (i.e., flood intensity associated with a flood zone). Projects can be exposed to both primary effects of climate change (i.e., sea level rise, reduced precipitation) and associated secondary effects (i.e., extreme high tides, reduced snowpack).

Exposure (to air pollution)
The effects of air pollution that a project will face. People are exposed to air pollution in multiple ways, including breathing polluted air, eating foods that have accumulated pollutants, drinking contaminated water, ingesting contaminated soils, and touching contaminated surfaces. The primary human health and ecological impacts from exposure to criteria pollutants are defined in this appendix (see *Carbon Monoxide*, *Lead*, *Nitrogen Dioxide*, *Ozone*, *Particulate Matter*, and *Sulfur Dioxide*). Certain reduction measures, such as installation of diesel particulate filters on ventilation systems, may reduce exposure to air pollution.

Fugitive Dust
Dust particles that are introduced [or resuspended] into the air through certain activities such as soil cultivation, or vehicles operating on open fields or dirt roadways.

General Plan
A set of long-term goals and policies that guide local land use decisions. The 2003 *General Plan Guidelines* developed by the California Office of Planning and Research provides advice on how to write a general plan that expresses a community's long-term vision, fulfills statutory requirements, and contributes to creating a great community.

Global Warming Potential
The ratio of radiative forcing that would result from the emission of one unit of a GHG (e.g., methane, nitrous oxide) to that from the emission of one unit of CO_2 over a fixed period (e.g., 20 years, 100 years) (CCAR 2009). For example, methane (CH_4) has a 100-year GWP of 25, which means 1 metric ton of CH_4 has the same global warming impact as 25 metric tons of CO_2 over 100 years. CalEEMod uses GWPs from various publications depending on the pollutant (IPCC 2007, CARB 2020, WMO 2018) .

Graywater
Water from sinks, showers, tubs, and washing machines that has not contacted biological pathogens. It is non-drinkable water that can be collected and reused on site for irrigation, flushing toilets, and other purposes.

Greenhouse Gas
The principle anthropogenic GHGs contributing to global warming are CO_2, CH_4, nitrous oxide (N_2O), and fluorinated compounds, including sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs). The most common GHGs emitted by land use developments and linear construction projects, which are quantified by CalEEMod, are CO_2, CH_4, N_2O, and HFCs (including refrigerants).

Hazard (Climate Hazard)
A danger to a project or a community caused or exacerbated by climate change, including extreme weather events or gradual changes in climate (i.e., flooding, wildfires, drought, increasing temperatures, reduced snowpack).

Headway
The amount of time, typically measured in minutes, that elapses between two public transit vehicles servicing a given route. Headway for buses and rail are generally shorter during peak periods and longer during off-peak periods. Headway is the inverse of frequency (i.e., headway = 1/frequency), where frequency is the number of arrivals over a given time, such as the number of buses per hour).

Health Equity
Health equity is achieved when all people have full and equal access to opportunities that enable them to lead healthy, thriving lives (California Health and Safety Code Section 131019.5).

Healthy Places Index®
Developed by the Public Health Alliance of Southern California, the HPI evaluates the socioeconomic and community conditions that shape health outcomes at the neighborhood level. The HPI score is calculated from eight weighted Policy Action Areas: Economic, Education, Transportation, Social, Neighborhood, Housing, Clean Environment, and Healthcare Access. The final HPI scores are then ranked as percentiles, with higher percentiles (closer to 100) indicating healthier community conditions, and lower (closer to 0) indicating less healthy conditions.

Impact (of climate change)
The way a project experiences an effect of climate change. A climate hazard's impact is determined by the project's vulnerability to a hazard and its adaptive capacity. Impacts can be direct (sea level rise, changes in precipitation) or secondary, meaning they are related to a specific sector (i.e., public health, water management, natural resources).

Infill Development
A project that is located within or contiguous to the central city. Examples of infill projects are construction on redevelopment areas, abandoned sites, or underutilized older buildings/sites.

Job Center
An area with a high degree and density of employment.

Kilowatt Hour (kWh)
The kWh is a measure of electrical energy that is equal to 3,600 kilojoules. It is commonly used by utilities to measure and bill consumers for their electricity use. The kWh is the basis for most energy-related GHG emissions calculations. Alternatively, megawatt hours (MWh) are also used. There are 1,000 kWh hours in 1 MWh.

Land Use Scale
The land use scale defines the geographic extent of the project and influences the applicability of various measures. CalEEMod includes two land use scales: Project/Site and Plan/Community.

Land Use Scale (Program/Community)
One of two land use scales. Projects that occur at the scale of a neighborhood (e.g., specific plan, general plan, climate action plan), corridor, or entire municipality (e.g., city- or county-level).

Land Use Scale (Project/Site)
One of two land use scales. Projects that occur at the scale of a parcel, business, or individual development smaller than a neighborhood.

Land Use Type
Land use types are broad categories of land uses with similar operating characteristics. Each of these land use types includes several more detailed land use subtypes. CalEEMod has eight land use types: Commercial, Educational, Industrial, Parking, Recreational, Residential, Retail, and Linear. The user-selected land use type is a foundational input to construction and operations modules because it determines many default parameters.

Land Use Subtype
Land use subtypes are distinct land use developments or facility types. CalEEMod has 79 different land use subtypes. These land use subtypes were chosen for inclusion in CalEEMod because each has an established trip rate, which is critical for mobile source calculations. The four land use subtypes for linear land use types were directly incorporated in CalEEMod from the RCEM. The user selected land use subtype is a foundational input to construction and operations modules because it determines many default parameters.

Landscape Area
Water features and all planting and turf areas in a landscape design plan, including any special landscape areas. The landscape area should not include building footprint, sidewalks, driveways, parking lots, decks, patios, or other hardscapes and non-irrigated areas designed for non-development.

Lead (Pb)
Pb is a soft metal that was previously added to gasoline, which, when combusted, generated small Pb particles that could be inhaled and deposited in environment (soil and water). Once absorbed into the body, Pb accumulates in bones and adversely affects multiple organ systems. Children are particularly at risk of lead poisoning. The primary health impacts of Pb exposure are anemia, behavioral disorders, low IQ, reading and learning disabilities, and nerve damage. Ecological effects of Pb include losses in biodiversity, changes in community composition, and decreased growth and reproductive rates in plants and animals. Leaded fuel in the U.S. was banned in all on-road vehicles in 1996. The primary sources of Pb emissions today are metal refineries, smelters, battery manufacturers, iron and steel producers, and racing and aircraft industries.

Lifecycle Emissions
Emissions that are produced from the energy and resources used throughout the lifecycle of a product or material. Lifecycle emissions include the extraction of raw resources, physical distribution, use of the product or material, and disposal at the end of a product's life.

Locational Context
Used to identify emission reduction measures within the transportation sector that are appropriate in certain types of neighborhoods differentiated by transportation characteristics and level of development (e.g., urban, rural, suburban). See *Suburban*, *Urban*, and *Rural*.

Low-Income Community
Low-income communities are census tracts with median household incomes at or below 80 percent of the statewide median income or at or below the state income limit threshold. Assembly Bill 1550 (Gomez, 2016) requires at least 10 percent of the state's cap-and-trade funds go to projects benefiting low-income households or communities.

Lumen
A unit measure of the brilliance of a source of visible light, or the power of light perceived by the human eye. The more lumens, the brighter the light. For example, a 100-watt incandescent bulb produces about 1,600 lumens. A 40-watt energy savings bulb produces about 450 lumens.

Master Planned Community
Large communities developed specifically incorporating housing, office parks, recreational area, and commercial centers within the community. Master planned communities tend to encompass a large land area with the intent of being self-sustaining. Many master planned communities may have lakes, golf courses, and large parks.

Mixed Use
A development project that incorporates more than one type of land use. For example, a mixed-use development may be a building with ground-floor retail and housing on the floors above. A larger mixed-use development may incorporate a variety of land uses within a short proximity of each other. This may include integrating office space, shopping, parks, schools, and residential development. Given the close proximities, mixed-use developments can encourage walking and other non-auto modes of transport from residential to office/commercial/institutional locations (and vice versa).

Nitrogen Dioxide (NO_2)
NO_2 can be directly emitted from combustion sources, such as boilers, gas turbines, and mobile and stationary engines. NO_2 is also naturally formed through photochemical reactions among nitric oxide (NO) and other air pollutants. Human exposure to NO_2 at high concentrations can aggravate lung and heart problems, intensify responses to allergens in asthmatics, decrease lung-function in children, and potentially lead to premature death. NO_2 is a precursor to O_3 formation and acid rain and can contribute to global warming and reduce water quality. High ambient NO_2 concentrations over prolonged periods may also injure crops.

Ordinance
A local law usually found in municipal code. Examples of ordinances include those related to noise control, snow removal, pet restrictions, and zoning.

Outcome Measures
Health and equity measures that focus on enhancing the project features and operational practices that advance equity-supportive outcomes.

Ozone (O_3)
Ground-level O_3, or smog, is not directly emitted into the atmosphere. Rather, it is naturally formed through photochemical reactions between volatile organic compounds (VOC) and nitrogen oxides (NO_X) (both by-products of combustion). Concentrations of ground-level O_3 are typically greatest on sunny days in urban environments, but because O_3 can be transported long distances in the air, rural communities also experience O_3 pollution. Exposure to ground-level O_3 at certain concentrations can make breathing more difficult, cause shortness of breath and coughing, inflame and damage the airways, aggravate lung diseases, increase the frequency of asthma attacks, and cause chronic obstructive pulmonary disease. Within the environment, ground-level

O_3 can cause crop damage, typically in the form of stunted growth, leaf discoloration, cell damage, and premature death.

Particulate Matter
PM pollution consists of very small liquid and solid particles floating in the air, which can include smoke, soot, dust, salts, acids, and metals. NAAQS and CAAQS have been set for two sizes of PM—PM10 (10 microns in diameter or less) and PM2.5 (2.5 microns in diameter or less). PM10 typically deposits on the surfaces of the larger airways of the upper region of the lung and can induce tissue damage and lung inflammation and is linked with asthma and chronic obstructive pulmonary disease. PM2.5 travels into and deposits on the surface of the deeper parts of the lung and can induce tissue damage and lung inflammation and is also linked with hospitalizations from heart and lung causes. Depending on its composition, PM10 and PM2.5 can also affect water quality and acidity, deplete soil nutrients, damage sensitive forests and crops, affect ecosystem diversity, and contribute to acid rain.

Photovoltaic
A system that converts sunlight directly into electricity using cells made of silicon or other conductive materials. When sunlight hits the cells, a chemical reaction occurs, resulting in the generation of electricity (USEPA 2010). There are often many PV cells in a single solar panel.

Process Measures
Health and equity measures that focus on facilitating greater community participation and decision-making in the process of land use planning.

Recycled Water
Non-drinkable water that can be reused for irrigation, flushing toilets, and other purposes. It has been processed through a wastewater treatment plant, unlike greywater, and typically needs to be redistributed from the treatment plant to the site where it will be used.

Renewable Energy
Energy sources that are, within a short time frame relative to the Earth's natural cycles, sustainable, and include non-carbon technologies such as solar energy, hydropower, and wind, as well as carbon-neutral technologies such as biomass (IPCC 2001).

Resilience (to climate change)
The ability of an individual, project, community, or natural system to prepare, cope, and recover from disruptions, shocks, and stresses caused by climate impacts.

Ride Sharing
A form of carpooling or vanpooling where multiple people travel in the same vehicle instead of separately driving in individual vehicles. Ridesharing can be casual and formed independently or as part of an employer program.

Rural
An area characterized by little development. Compared to urban and suburban areas, rural areas have a lower density of residences, higher numbers of single-family residences, and higher numbers of vehicle-dependent land use patterns.

Sensitivity (to climate change)
The project's susceptibility to the effects of climate change. The degree to which different components of a project will be exposed to climate change and their capabilities hindered. Points of sensitivity include the project's functions, structures, and individuals who interact with the project. Sensitivity is an element of *Vulnerability*.

Separate Heat and Power
A typical system for acquiring heat and, separately, acquiring power. Thermal energy and electricity are generated and used separately. For example, heat is generated from a boiler while electricity is acquired from the local utility. Separate heat and power systems can be replaced by more efficient combined heat and power systems.

Sequestration
The process of increasing the carbon content of a carbon reservoir other than the atmosphere. Biological approaches to sequestration include direct removal of carbon dioxide from the atmosphere through afforestation, reforestation, and practices that enhance soil carbon in agriculture. Physical approaches include separation and disposal of carbon dioxide from flue gases or from processing fossil fuels to produce hydrogen- and carbon dioxide-rich fractions and long-term storage in underground depleted oil and gas reservoirs, coal seams, and saline aquifers (IPCC 2001).

Special Landscape Area
The portion of landscape area dedicated solely to edible plants, areas irrigated with recycled water, water features using recycled water, and areas dedicated to active play, such as parks, sports fields, golf courses, and other areas where turf provides a playing surface.

Suburban
An area characterized by dispersed, low-density, single-use, automobile-dependent land use patterns, usually outside of the central city.

Sulfur Dioxide (SO_2)
SO_2 is generated by burning fossil fuels, industrial processes, and natural sources, such as volcanoes. Exposure to SO_2 at certain concentrations can increase incidence of pulmonary symptoms and disease, decrease pulmonary function, and lead to increased risk of mortality, especially among the elderly and people with cardiovascular disease or chronic lung disease. SO_2 deposition in the environment contributes to soil and surface water acidification and acid rain.

Title 24
Title 24, Part 6 regulates building energy efficiency standards in California. Regulated energy uses include space heating and cooling, ventilation, domestic hot water heating, and some hard-wired lighting. Title 24 determines compliance by comparing the modeled energy use of a “proposed home” to that of a minimally Title 24 compliant “standard home” of equal dimensions. Title 24 focuses on building energy efficiency per square foot; it places no limits upon the size of the house, or the actual energy used per dwelling unit. The current Title 24 standards were published in 2019.

Transit-Oriented Development
Transit-oriented development (TOD) refers to projects built in compact, walkable areas that have easy access to public transit, ideally in a location with a mix of uses, including housing, retail offices, and community facilities. TODs are generally described as places within a 10-minute walk (0.5 mile) of a high-frequency rail transit station (either rail or bus with headways of less than 15 minutes).

Transit Ridership
The number of passengers who ride in a public transportation system, such as buses and subways.

Transportation Demand Management
A transportation strategy designed to increase the transportation system efficiency and reduce demand on the system. Common transportation-demand management (TDM) strategies include discouraging single-occupancy vehicle travel; encouraging more efficient travel patterns and alternative modes of transportation (e.g., walking, bicycling, public transit, and ridesharing); and shifting travel patterns from peak to off-peak hours and to closer destinations.

Tree and Grid Network
Describes the layout of streets within and surrounding a project. Streets that are characterized as a tree network actually look like a tree and its branches. Streets are not laid out in any uniform pattern, intersection density is low, and the streets are less connected. In a grid network, streets are laid out in a perpendicular and parallel grid pattern. Streets tend to intersect more frequently, intersection density is higher, and the streets are more connected.

Trip Purpose
CalEEMod divides total residential trips across the following three trip purpose types.

- "Home-Work (H-W)" = represents trips traveling in either direction between home and work locations.
- "Home-Shop (H-S)" = represents trips traveling in either direction between home and shopping destinations (generally retail).
- "Home-Other (H-O)" = represents trips traveling in either direction between home and all other locations that are not work or shopping destinations (e.g., school, park, gym).

CalEEMod divides total non-residential trips across the following three trip purpose types.

- "Home-Work (H-W)" = represents trips traveling in either direction between home and work locations.
- "Work-Other (W-O)" = represents trips made by an employee traveling in either direction between a work location and all other locations that are not home.
- "Other-Other (O-O)" = represents trips made by a person traveling in either direction between land uses that do not involve home or work locations.

Under-Served (or Under-Represented), Under-Resourced, and/or Marginalized Communities
Communities that have been historically neglected by governments at all levels, whether because of policy (e.g., redlining), systemic racism, or a combination of factors. These communities are likely to not only experience greater levels of day-to-day pollution burdens, but also have greater vulnerability to climate disasters, economic disruptions, and other challenges. In addition, community members have often been excluded from decision-making and lack the resources and capacity to participate meaningfully in land use planning and other civic and political processes.

Urban
An area located within the central city with higher density land uses than in the suburbs. Often characterized by multi-family housing, tall office buildings, and dense retail.

Urban Heat Island Effect
A term used to describe when a developed area is warmer than the surrounding rural areas, caused by urban land surfaces that retain heat (e.g., concrete, asphalt, metal, and other materials found in buildings and pavements). These urban surfaces can be darker than natural vegetation found in more rural areas. Darker surfaces absorb more sunlight that lighter surfaces, resulting in more heat (see *Albedo*). Urban environments also tend to have fewer plants and trees compared to rural locations. Plants and trees release water vapor to the air

through transpiration, cooling the ambient temperature. Urban tree planting and measures requiring lighting building surfaces can help reduce the urban heat island effect.

Vehicle Miles Traveled
The number of miles driven by vehicles, an important traffic parameter, and the basis for most traffic-related emissions calculations.

Vehicle Occupancy
The number of persons in a vehicle during a trip, including the driver and passengers.

Vulnerable Population (to climate change)
A group of individuals or a community that faces greater risks and has higher sensitivity to the impacts of climate change. Additionally, these groups may have a lower ability and/or fewer or insufficient resources to manage or recover from climate impacts. Populations may be vulnerable because of their physical environment, socioeconomic demographics, political status, or other drivers. Example factors that can contribute to a population's vulnerable status include race, class, sexual orientation, sexual identification, and income-status.

Vulnerability (to climate change)
The extent to which a project is susceptible to climate change. Vulnerability is the combination of a project's sensitivity, exposure, and adaptive capacity to climate hazards. Vulnerability includes susceptibility to direct climate impacts as well as secondary climate impacts. Vulnerability encompasses not only physical threats to a project's structure or facilities, but also impacts on a project's functions, operations, and users.

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CalEEMod
California Emissions Estimator Model

Appendix B
Acronym List

Prepared for:
California Air Pollution Control Officers Association (CAPCOA)

Prepared by:
ICF
in collaboration with
Sacramento Metropolitan Air Quality Management District, Fehr & Peers, STI, and Ramboll

April 2022
CalEEMod Version 2022.1

List of Acronyms

.csv	comma-separated value file
.pdf	portable document format file
.xls	Excel file
A	Accountability
AB	Assembly Bill
A/C	air conditioning
ACM	alternative calculation method
AF	acre feet
AP-42	compilation of air pollutant emission factors by USEPA
APCD	air pollution control district
APG	Adaptation Planning Guide
API	application programming interface
AWWA	American Water Works Association
BIPOC	Black, Indigenous, and People Of Color
BMP	best management practice
BOD	biochemical oxygen demand
BTU	British thermal unit
C	carbon
CAAQS	California ambient air quality standards
CAFE	corporate average fuel economy
CalEEMod	California Emissions Estimator Model
Cal OES	California Governor's Office of Emergency Services
CalRecycle	California Department of Resources Recycling and Recovery
Caltrans	California Department of Transportation
CAPCOA	California Air Pollution Control Officers Association
CARB	California Air Resources Board
CBO	community-based organization
CCD	Community-Centered Development
C.C.R.	California Code of Regulations
CDC	Centers for Disease Control and Prevention
CE	Construction Equity
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CES	CalEnviroScreen® 4.0
CEUS	California Commercial End-Use Survey
CH_4	methane
CHP	combined heat and power
CNG	compressed natural gas
CPUC	California Public Utilities Commission
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
CoSMos	Costal Storm Modeling System
CSTDM	California Statewide Travel Demand Model
DE	destruction efficiency
DOC	degradable organic carbon
DPF	diesel particulate filter

DU	dwelling unit
DWR	California Department of Water Resources
EDFZ	electricity demand forecast zone
EF	emission factor
EIA	United States Energy Information Administration
EIR	environmental impact report
EMFAC	on-road vehicle emission factors model
Energy Code	Building Energy Efficiency Standards
ET_0	reference evapotranspiration
ETW	equivalent test weight
ETWU	estimated total water use
ft^3	cubic feet
g	gram
G2	2-stroke gasoline
G4	4-stroke gasoline
gal	gallon
GHG	greenhouse gas
GIF	Geospatial Innovation Facility
g/L	grams per liter
GWP	global warming potential
ha	hectare
Handbook	Handbook for Analyzing Greenhouse Gas Emission Reductions, Assessing Climate Vulnerabilities, and Advancing Health and Equity
HFC	hydrofluorocarbons
HHDT	heavy-heavy duty trucks
HHS	U.S. Department of Health and Human Services
HHV	higher heating value
H-O	home-other
hp	horsepower
hp-hr	horsepower hour
HPI	Healthy Places Index
hr	hour
H-S	home-shop
HVAC	heating, ventilating, and air conditioning
H-W	home-work
IC	Inclusive Communities
ICARP	Integrated Climate Adaptation and Resiliency Program
IE	Inclusive Engagement
in	inches
IPCC	Intergovernmental Panel on Climate Change
ITE	Institute of Transportation Engineers
KBTU	thousand British thermal units
kg	kilograms
KSF	thousand square feet
kW	kilowatt
kWh	kilowatt hour
L	liters
LA	landscape area
lb	pounds
LDA	light-duty auto
LDT1	light-duty truck type 1

LDT2	light-duty truck type 2
LGBTQIA+	Lesbian, gay, bisexual, transgender, queer and questioning, intersex, asexual, and other gender identities
LFM	landfill methane
LGOP	Local Government Operation Protocol
m	meter
m^2	square meters
MAWA	maximum applied water allowance
mg	milligrams
MG	million gallons
MHDT	medium-heavy duty trucks
mi	mile
mm	millimeters
MMBTU	million British thermal units
MND	mitigated negative declaration
mpg	miles per gallon
mph	miles per hour
MPO	metropolitan planning organization
MRI	Midwest Research Institute
m/s	meters per second
MSW	mixed solid waste
MT	metric tons; 1,000 kilograms
MTCE	metric tons carbon equivalent
MWELO	Model Water Efficient Landscape Ordinance
MWh	megawatt hour
MY	model year
N_2O	nitrous oxide
NAAQS	national ambient air quality standards
NHTSA	National Highway Traffic and Safety Administration
NO	nitric oxide
NO_2	nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration
NOx	nitrogen oxides
NRDC	Natural Resources Defense Council
NWL	natural and working lands
O_3	ozone
OBUS	other buses
OEHHA	Office of Environmental Health Hazard Assessment
OFFROAD	off-road vehicle emission factors model
O-O	other-other
Pb	lead
PF	plant factor
PFC	perfluorocarbon
PG&E	Pacific Gas and Electric
PM	particulate matter
PM2.5	particulate matter 2.5 microns in diameter or less
PM10	particulate matter 10 microns in diameter or less
ppm	parts per million
R	refrigerants
RASS	Residential Appliance Saturation Survey
RCEM	Road Construction Emissions Model

RCP	Representative Concentration Pathway
R&D	research and development
ROG	reactive organic gases
RTPA	Regional Transportation Planning Agency
SAFE	Safer Affordable Fuel-Efficient Vehicles Rule
SB	Senate Bill
SCAQMD	South Coast Air Quality Management District
scf	standard cubic feet
SF_6	sulfur hexafluoride
SLA	special landscape area
SLOAPCD	San Luis Obispo Air Pollution Control District
SNAP	Significant New Alternatives Policy
sqft	square feet
SO_2	sulfur dioxide
SORE	Small Off-Road Engines Model
SO_x	sulfur oxides
TAZ	traffic analysis zone
TDM	transportation-demand management
TOD	transit-oriented development
TOG	total organic gases
TSP	total suspended particulates
UBUS	urban bus
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
VMT	vehicles miles traveled
VOC	volatile organic compound
W-O	work-other
WRCC	Western Regional Climate Center

CalEEMod

California Emissions Estimator Model

Appendix C
Emission Calculation Details for CalEEMod

Prepared for:
California Air Pollution Control Officers Association (CAPCOA)

Prepared by:
ICF
in collaboration with
Sacramento Metropolitan Air Quality Management District, Fehr & Peers, STI, and Ramboll

April 2022
CalEEMod Version 2022.1

Table of Contents

1 Overview

The California Emissions Estimator Model (CalEEMod) calculates ozone precursors, criteria pollutants, and greenhouse gases (GHG) (collectively referred to as *emissions*) from land use development and linear projects. These emission estimates can be used for quantification and reporting as part of the California Environmental Quality Act (CEQA) environmental documentation. This appendix provides the detailed quantification method, including the underlying equations and supporting documentation for calculating default activity data, emissions, and emission reductions from measures.

Emissions are quantified in three modules within the **Input** component—**Construction**, **Operations**, and **Vegetation**. Each of these modules includes one or more submodules and screens covering a specific emission source (e.g., off-road equipment). This appendix discusses the default data sources and emissions calculations associated with each submodule and screen. Because user inputs in the **Characteristics** and **Land Use** modules inform the emissions calculations, this appendix also addresses these modules. Likewise, this appendix describes the types of emission reduction measures included in the **Measures** module. Figure C-1 illustrates the modules, submodules, and screens that are described in this appendix.

The user is directed to the following additional appendices for further information related to emissions quantification.

- Appendix D, *Technical Source Documentation for Emissions Calculations*: Provides additional technical emissions quantification methods and sources.
- Appendix G, *Default Data Tables*: Provides defaults and emission factors for the estimation of emissions. References to specific data tables within Appendix G are provided throughout this appendix.

The user may also consult the **Construction Calcs** and **Operations Calcs** screens within the **Results** component. These screens present a series of tables with emissions results by source. For example, the **Construction Calcs** screen displays total construction emissions from all sources and then individually by source (i.e., off-road equipment, dust from material movement, demolition, mobile exhaust, on-road fugitive dust, architectural coatings, paving, and electricity consumption). Where applicable, the source tables present emissions by process. For example, emissions from vehicle trips and vehicle miles traveled (VMT) are presented separately within the mobile exhaust table. Users can view the equations and variables underpinning the results by clicking directly on any calculated emissions value in the tables. Users can click the toggles at the top of the screen to display unmitigated or mitigated emissions for the daily or annual condition. Daily emissions can be presented for the winter or summer season. Annual emissions can be presented in pounds, tons, or metric tons (MT). While the emissions displayed in the **Construction Calcs** and **Operations Calcs** screens can also be viewed in the dashboards and **Reports** component, the screens enhance transparency by specifically identifying the equations and variables used by CalEEMod to quantify emissions by source and process.[1]

[1] As noted in the paragraph, users must click an emissions result to see the equations and variables used in the calculation of that result.

Figure C-1. CalEEMod Structural Elements Described in Appendix C

2 Characteristics Module

The **Characteristics** module includes three screens: **Project Detail**, **Utility Information**, and **Pollutants**. These screens have no calculations and are used to provide information on appropriate default values for subsequent screens. Each screen is briefly described in the following sections. See Section 4.3.1, *Characteristics Module*, of the User's Guide for additional information.

2.1 Project Detail Screen

The **Project Detail** screen summarizes administrative information (e.g., county) from the **Map** component that is relevant to emission quantification. Based on the project location, the screen will display the windspeed and precipitation frequency. Windspeed and precipitation frequency influences the intensity of emission factors related to fugitive dust generated during project construction. CalEEMod includes average annual windspeeds based on hourly data from 1996 to 2006 for various monitoring stations throughout California from the Western Regional Climate Center (2021) (refer to Table G-1). Precipitation frequency represents the average annual days with precipitation greater than 0.1 inch based on data from 2016–2019 for various monitoring stations throughout California (NOAA 2021a) (refer to Table G-2). CalEEMod selects the nearest monitoring station to the project to inform the default windspeed and precipitation frequency. The user should review this information to confirm it is accurate before moving forward.

User input is also required or recommended for the following data fields.

- *Automatic Updates to Default Values*: CalEEMod is a complex information model that requires the user to input a certain level of project detail, with some inputs influencing later dependent defaults. Because the user may have different interests in how these dependencies are handled, the model was built with three update options—always, never, and if not overridden. See Section 4.3.1.1, *Project Detail Screen*, in the User's Guide for additional information.

- *Quantification mode*: The user may quantify emissions for only construction, only operations, both, or neither, by making the appropriate selection from the dropdown menu and toggle. If the user deselects either Construction or Operations, the now-irrelevant data fields on the **Project Detail** screen will be locked and grayed out, prohibiting user input. For example, if Construction is deselected, the "Windspeed" data field will be locked, as it only influences emission factors related to fugitive dust generated during construction. If the user turns off the toggle, thereby deselecting both Construction and Operations, CalEEMod will not quantify emissions and the corresponding modules will be hidden from the Side Navigation Bar.

- *Analysis Level for Defaults*: The analysis level defines the degree of aggregation for mobile source emission factors and various data fields with default values (e.g., Windspeed). Four analysis levels are available for user selection—County, Air District, Air Basin, and Statewide. CalEEMod defaults to County, which provides the most locationally-specific emission factors and defaults. If the user changes the analysis level to one of the other options, the "County" data field will be replaced by a data field for the new analysis level (e.g., Air Basin) with the default value prepopulated based on the project location.

- *Start of Construction*: The construction year influences the intensity of several emission factors, including those for vehicles and equipment. The user should identify the day, month, and year for their first phase of construction. This information will be carried forward to the **Construction Phases** screen.

- *Operational Year*: The operational year influences the intensity of several emission factors, including those for vehicles, equipment, and electricity consumption. The operational year is typically the first year following construction when the project is fully operational.

2.2 Utility Information Screen

The **Utility Information** screen summarizes the electric and gas utility companies for the project based on the project location. The user should confirm the utilities before moving forward. The user may select a different California utility from the dropdown menu. If the project utility is not included in the dropdown menu, the user may select User Defined.

CalEEMod includes electricity intensity factors for carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) for many California utilities and will default to those factors when the specific utility is selected. If electricity intensity factors for the selected utility are not available, CalEEMod will default to the statewide grid average intensity.

Electricity emissions can be quantified using emission factors for the latest year with reported data, which is 2019. Alternatively, the user may elect to use forecasted future year carbon intensities by selecting the forecasted factors toggle. Forecasted carbon intensities are only available for utilities that provided data during programming and reflect utility-specific planning considerations, including future integration of renewables. Future year emission factors for these utilities may be available for all programmed operational years (i.e., 2020 through 2050) or only a subset of years (e.g., 2020 through 2030). If a utility provided forecasted emission factors for a subset of years, emission factors for all remaining years are held constant at the values for the last year in which data were provided. For example, the City of Anaheim Public Utilities Department provided forecasted CO_2 factors through 2032. Because 2032 is the last year in which the utility provided data, the 2032 carbon intensity of 267 pounds (lb) of CO_2 per megawatt-hour (MWh) is held constant as the default CO_2 intensity for all years from 2033 through 2050.

As noted above, forecasted electricity emission factors are only available for a subset of utilities (refer to Table G-3). No future year emission factors are available for the statewide default. Where future year data are not available for a utility or year, toggling the "Forecasted Factors" button will not yield any changes to the emission factors shown on the screen. It is also important to note that data provided by utilities is based on their own internal planning projections and may not always yield a reduction in carbon intensity over the prior year.

The selected natural gas utility is provided for informational purposes only and does not influence the carbon intensity of natural gas combustion. Emission factors for natural gas combustion are from the U.S. Environmental Protection Agency (USEPA) (1998a) AP-42 and the California Air Resources Board (CARB) (2020a) (refer to Table G-4).

2.3 Pollutants Screen

CalEEMod quantifies the following pollutants. Definitions of these pollutants are provided in Appendix A, *Glossary*.

- Total organic gases (TOG).
- Reactive organic gases (ROG).[2]

[2] CalEEMod uses the term volatile organic gases (VOC) when referring to emissions from the application of architectural coatings, consistent with local regulations. VOCs are organic compounds that can evaporate into an organic gas. VOC can be either reactive or non-reactive. Over the years, non-reactive VOCs have been exempted

- Nitrogen oxides (NO_X).
- Carbon monoxide (CO).
- Sulfur dioxide (SO_2).
- Particulate matter (PM) that is 10 microns in diameter or less (PM10).
- PM that is 2.5 microns in diameter or less (PM2.5).
- Biogenic CO_2.
- Non-biogenic CO_2.
- CH_4.
- N_2O.
- Refrigerants (R).
- Carbon dioxide equivalent (CO_2e).[3]

The model automatically selects all pollutants for quantification on the **Pollutants** screen. The user should uncheck any pollutants they do not want quantified before moving forward.

3 Land Use Module

3.1 Land Use Screen

The primary project description data that the user needs to enter is all land use types and sizes that make up the project. CalEEMod contains several land use categories that are mainly based on land use classifications from the Institute of Transportation Engineers (ITE). Further division of some land uses (mainly warehouses) has been added. CalEEMod also contains linear land use types, as defined by the Sacramento Metropolitan Air Quality Management District's Roadway Construction Emissions Model (RCEM). The land use subtype determines default values for numerous data fields throughout the model. The user-defined land use (e.g., User Defined Commercial) does not have any default information, and the user is required to enter all necessary information. Land use types and subtypes identified by the user in the **Start a New Project** splash screen are automatically prepopulated in the **Land Use** screen. Additional land uses can be added by clicking "Add Land Use Type."

Once the land use types and subtypes are defined, the user should provide or review available defaults for the following inputs.

- *Unit*: Different units (e.g., 1,000 square feet [sqft], acre) are available by land use subtype. Depending on the unit selected by the user, CalEEMod may internally convert the input to an alternative unit so that the information is cross-compatible with emission factors and other inputs defined by the alternative unit.

from regulation. Both VOC and ROG are precursors to ozone, so they are summed in the CalEEMod output under the header ROG.

[3] Represents all CO_2 emissions plus CH_4, N_2O, and refrigerants as adjusted by their corresponding global warming potential (GWP).

- *Size*: This numeric input corresponds with the “Unit” data field to collectively form the size estimate for the land use subtype (e.g., a 200 “Size” is multiplied with a 1,000 sqft “Unit” to equal a 200,000 sqft land use subtype).

- *Lot Acreage*: The lot acreage is used to calculate housing density (for residential land use types) and dust emissions from earthmoving activities during project construction, and to assign construction default data (e.g., off-road equipment). CalEEMod automatically calculates the lot acreage for all non-linear and linear use types based on user inputs for the “Land Use Subtype,” ”Unit,” and ”Size.” Refer to Table G-5.

  The default lot acreage for the residential land use types is based on data from the 2019 Residential Appliance Saturation Survey (RASS) (CEC 2020). Retirement communities and congregate care facilities are assumed to be similar in size to multi-family units. The default for single-family housing land use subtype is inclusive of parking and landscaped area. The model assumes 480 sqft of paved driveway space per dwelling unit (DU) for single-family housing. The remainder of the difference between the total lot acreage and paved driveway space is conservatively assumed to be landscaped area.

  The default lot acreages for other residential land use subtypes and all non-residential land use types are equal to the building footprint and, therefore, do not include any parking or landscape area. The user should review these default acreages and confirm they accurately reflect the total project lot acreage.

  The user should adjust the default acreages if the project is a mixed use, multi-story building. For these projects, the default acreage value for the residential land use subtype should be retained and the acreage values for all non-residential land use subtypes should be zeroed out. If the mixed use, multi-story building includes only non-residential uses, whichever land use subtype has the highest default acreage value should be retained and the acreage values for all other land use subtypes should be zeroed out.

  For linear land use types, there is no default lot acreage based on the inputs for the “Unit” and “Size” data fields (i.e., project site length in miles). This is because no default project site width is assumed for linear land use types, which is needed to calculate the area.

- *Building Square Feet*: The building square footage is used to calculate several operational source emissions and construction-generated emissions from architectural coatings. CalEEMod generates default inputs for residential building square footage based on the 2019 RASS (CEC 2020). Default inputs for non-residential land use subtypes are also available and are based on Table B1 of the U.S. Energy Information Administration’s Commercial Building Energy Consumption Survey (2016) and land use statistics from the South Coast Air Basin (See Appendix D, *Technical Source Documentation for Emissions Calculations*). No building square footage is assumed for linear land use subtypes, Parking land use subtypes with no structure (e.g., Parking Lot land use subtype), and the city park and golf course land use subtypes. Accordingly, CalEEMod reports a 0 value for building square footage for these land use subtypes; the value is locked at 0 and cannot be overridden.

- *Landscape Area*: Landscape area is a required input to calculate operational outdoor water consumption and associated emissions. The area includes water features and all planting and turf areas in a landscape design plan, *including* any special landscape areas (defined in the below bullet) (i.e., do not subtract special landscaping area from landscaping area). The landscape area should not include building footprint, sidewalks, driveways, parking lots, decks, patios, or other hardscapes and non-irrigated areas designed for non-development.

Defaults for the landscape area are only available for the single-family housing land use subtype. The landscape area for this land use subtype (11,713 sqft per DU) is equal to the difference between the total lot area (14,143 sqft per DU) and the combination of the building area (1,950 sqft per DU) and the paved driveway space (assumed 480 sqft per DU). The user must provide the landscaping area for all other land use subtypes. Leaving the input for landscaping area blank will exclude quantification of operational outdoor water consumption and associated emissions.

- *Special Landscape Area*: If defined, this is used to calculate operational outdoor water consumption and associated emissions. The area includes the portion of landscape dedicated solely to edible plants, areas irrigated with recycled water, water features using recycled water, and area dedicated to active play, such as parks, sports fields, golf courses, and places where turf provides a playing surface.

  Unlike the "Landscape Area" data field, inputs for the "Special Landscape Area" data field are not required to enable the calculation of operational outdoor water consumption and associated emissions. However, defining the special landscape area (if any) is recommended, as it will provide for a more accurate quantification of these sources, as discussed further in Section 5.4.1.2, *Annual Outdoor Water Use*.

  CalEEMod assumes zero special landscape area as a default for all land use subtypes except City Park, Golf Course, Elementary School, High School, Junior College (2 yr), Junior High School, University/College (4 yr). For these uses, the special landscape area is equal to the landscape area (i.e., the model assumes 100 percent of the landscape area is classified as special landscape area).

- *Recreational Building Area*: The recreational building area is used to provide a more refined estimate of several operational source emissions and construction-generated emissions from architectural coatings and consumer products. For City Park, Golf Course, and Recreational Swimming Pool land use subtypes, the user should enter in this data field the square footage of only the buildings associated with these land uses (e.g., restrooms/changing rooms, pro-shop).

- *Population*: Project population is used to calculate operational waste generation and associated emissions for residential land use types. Population defaults for residential land use types are from the California Department of Finance (2020) (refer to Table G-6).

- *Description*: If desired, the user may enter a description of the land use type. For example, "ground floor retail in mixed use building A." This description will be included in the CalEEMod output.

4 Construction Module

The **Construction** module is used to calculate the emissions associated with the construction of a project. Construction can have several different types of sources that contribute to emissions. The sources quantified by CalEEMod are off-road equipment usage, on-road vehicle travel, material movement, demolition, architectural coating, paving, and electricity consumption. Each of these source types is discussed in more detail in the subsequent sections. These emission sources are associated with various types of construction phases. Typical construction phases include demolition, site preparation, grading, trenching, building construction, paving, and architectural coating. The extent to which these phases occur depends on the specific project. For instance, a demolition phase would typically only occur if demolition of existing structures was required. Similarly, trenching only typically occurs if the project requires trenching generally associated with underground utilities. Unique aspects and default assumptions associated with these phases are discussed in the following sections in the context of the different emission source calculations.

4.1 Construction Phases Screen

CalEEMod generates default construction phases and schedule assumptions on the **Construction Phases** screen based on user inputs in the **Land Use** module. Specifically, for non-linear land use types, construction surveys performed by the South Coast Air Quality Management District (South Coast AQMD) are used to define the default phases and durations based on the total project acreage (refer to Table G-7). If the project acreage is in between the acreages in the survey, the next highest acreage tier is used. If the project size defined by the user is between the sizes of two surveyed projects, CalEEMod conservatively uses the phase duration for the larger project. For instance, if the given project is 7 acres, the program will use the phase duration for the 10-acre project rather than that for the 5-acre project. For large acreage sites, the survey was extrapolated by adding additional phase time equivalent to adding phase time from two acreage ranges in the survey. This occurs for sites larger than 34 acres. In these situations, the user should consider the accuracy of the equipment and phase duration estimations or use site-specific construction schedules and equipment lists. For linear land use types, the default phases and durations are based on the total number of workdays and the user selection of the predominant soil/site type on the **Land Use** screen (refer to Table G-8) (Ramboll 2016). These inputs determine the default construction phase durations.

The date range, workdays per week, and total days are dynamically linked to each other and will influence one another if the user changes these values. Note that while trenching is a phase option, it is not included as a default construction phase. If a project includes trenching, the user must enter site-specific inputs related to trenching on all applicable screens.

4.2 Off-Road Equipment Screen

CalEEMod calculates combustion exhaust emissions from operation of off-road equipment powered by diesel, gasoline, and natural gas. The fuel selection dropdown menu also includes “electric” as an option. Electric-powered equipment does not generate combustion exhaust emissions. When electric-powered equipment is selected, CalEEMod calculates electricity consumption and associated indirect GHG emissions under the **Electricity** screen, as discussed in Section 4.10, *Electricity Screen*. There are also measures that can be implemented that will allow for use of alternatively fueled and electric-powered equipment.

CalEEMod generates default equipment lists based on user inputs in the **Land Use** module. The model relies on the South Coast AQMD construction survey to develop the default equipment lists for non-linear land use types (e.g., Residential) based on total project acreage as calculated from the acreage entered in the **Land Use** module (refer to Table G-9). If the project acreage is in between the acreages in the survey, the next highest acreage tier is used. For large acreage sites, the survey was extrapolated by adding additional phase time equivalent to adding phase time from two acreage ranges in the survey. This occurs for sites larger than 34 acres. In these situations, the user should consider the accuracy of the equipment and phase duration estimations or using site-specific construction schedules and equipment lists.

For linear land use types, a survey of 11 road construction projects (Tetra Tech 2013) is used to inform the default number of equipment and type of equipment per phase, which are based on the land use subtype and maximum area disturbed per day (refer to Table G-10). The maximum area disturbed per day is calculated as the lot acreage divided by the number of workdays in the linear grading phase. The default equipment activity per day is 8 hours per day per equipment. Except for signal boards, the default number of equipment is generated assuming the maximum area disturbed per day is less than or equal to 5 acres. An additional piece of equipment is added for every 5 acres greater than the initial 5-acre threshold. For example, if the maximum area disturbed per day is 6 acres, the amount of equipment for each equipment type would be equal to the baseline number of equipment plus one more piece until the next threshold of 10 acres is surpassed, at which point a second piece of equipment would be added to the total default number of equipment. The default number of signal boards is calculated differently than the other equipment types. The number is based on the linear land use type total size, summed based on the user inputs on the **Land Use** screen, assuming one signal board per half mile.

The calculations associated with this screen include the running exhaust emissions from all fossil-fueled equipment, as well as starting and evaporative emissions from gasoline- and natural gas-fueled equipment. Since the majority of off-road equipment used for construction projects are diesel fueled, CalEEMod assumes all equipment in the default equipment list are diesel-powered. However, the user may override this default and modify the fuel selection. CalEEMod calculates the exhaust emissions based on the CARB (2021a) OFFROAD2017 methodology using the following equation.

$$E_p = \sum_i (EF_i \times Pop_i \times hp_i \times Load_i \times Activity_i)$$

Where:

E = total daily off-road equipment emissions (g/day).

EF = emission factor in grams per horsepower-hour (g/hp-hr) (Table G-11).

Pop = population, or the number of pieces of equipment (number/day).

hp = average horsepower for the off-road equipment (unitless) (Table G-12).

Load = load factor of the off-road equipment (unitless) (Table G-12).

Activity = hours of daily operation of the off-road equipment (hr/day/number).

p = pollutant.

i = equipment type.

The program allows the user to enter the number of pieces of equipment, fuel type, engine tier, horsepower, load factor, and daily hours of operation for each selected equipment type. The following sections describe the development methodology for the off-road equipment emission factors, default average horsepower, and load factor.

4.2.1 Average Horsepower

Average equipment horsepower default data are based on the most populous horsepower bin for each equipment and fuel type combination in OFFROAD2017-ORION (refer to Table G-12). Note that these defaults are different than the OFFROAD2017-ORION horsepower assumptions used in emission factors calculations. This is because the equipment emission factor calculations were performed for each horsepower bin (e.g., 1 to 15, 16 to 25) so that bin-specific emission factor rates could be developed. Defaults for the average equipment horsepower were estimated based on the weighted average horsepower across all horsepower bins for each equipment type. Equipment population is the weighting factor used to combine across horsepower bins.

4.2.2 Load Factor

Load factor is the ratio of the actual average power output to maximum power output of a piece of equipment. Load factors do not vary by horsepower range. Load factors for construction, industrial, and light commercial equipment are based on recent estimates published by CARB (2017b) for all available diesel equipment types and from OFFROAD2011 for diesel equipment types that are not included in the latest published CARB estimates. Load factors for gasoline- and natural gas-powered construction, industrial, and light commercial equipment are from the OFFROAD2007.[4] Refer to Table G-12.

4.3 Off-Road Equipment Emission Factors Screen

Calendar year average emission factors for construction (e.g., excavator, crawler tractors, cranes), industrial (e.g., aerial lifts, forklifts, other material handling equipment), and light commercial (e.g., air compressors, generator sets, pumps) equipment are based on OFFROAD2017-ORION v1.0.1 (CARB 2020b). The model was run in exhaust and evaporative modes on a statewide basis for 41 scenario years (2010–2050). Emission factors were developed for diesel-, gasoline- and natural gas-fueled equipment. Emission factors for each equipment type, horsepower range, and fuel type combination were estimated based on daily emissions and fleet-wide annual energy use (i.e., total horsepower-hours, or hp-hr) reported in model output files. Total energy use was estimated as the product of OFFROAD2017-ORION annual activity, average horsepower and population as shown in following equation.

$$EU_i = Activity_i \times hp_i \times Pop_i$$

Where:

EU = fleetwide annual off-road equipment energy use (hp-hr/year).

Activity = total annual equipment usage (hr/year).

hp = average horsepower for the off-road equipment (unitless).

Pop = total annual population of an off-road equipment (unitless).

i = equipment type.

Emission factors for each piece of equipment and horsepower range were estimated according to the following formula.

$$EF_p = \frac{E_p \times UC_1 \times UC_2}{EU \times LF}$$

Where:

EF = emission factor (g/hp-hr).

E = total exhaust or evaporative emissions (short tons/day).

UC_1 = unit conversion from daily emissions to annual emissions (365 days/year).

UC_2 = unit conversion from short tons to grams (90,7184.740760757 g/short ton).

EU = fleetwide annual off-road equipment energy use (hp-hr/year).

[4] Load factors are not readily available in the OFFROAD2017-ORION model. Per April 2021 CARB staff input, load factors for gasoline- and natural gas-fueled equipment were obtained from the OFFROAD2007 model.

LF = load factor of the off-road equipment (unitless).

p = pollutant.

Daily exhaust emissions, daily evaporative emissions, and total energy use are outputs from OFFROAD2017-ORION. Load factors were obtained from the latest CARB diesel equipment load factor estimates and OFFROAD2007.

OFFROAD2017-ORION does not estimate CH_4 or N_2O emissions. For each equipment type and fuel type combination, emission factors for CH_4 and N_2O were estimated by multiplying CO_2 emission factors by the mass ratio of CH_4 and N_2O to CO_2 emissions in California's 2000–2018 GHG emission inventory for off-road equipment by fuel type (CARB 2021b).

Note that calendar-year average default emission factors are only available for horsepower ranges reported in OFFROAD2017-ORION. If the user manually inputs an equipment piece with a horsepower that falls outside the OFFROAD2017-ORION horsepower range for that equipment type, a red warning message will appear on the **Off-Road Equipment EF** screen. The user must supply the associated emission factors to enable the quantification of emissions for that equipment type.

Tier specific emission factors for diesel equipment were obtained from CARB's (2017a) Carl Moyer Program Guidelines. Refer to Table G-11 for the calendar year average emission factors and Table G-13 for the tier specific emission factors.

4.4 Dust from Material Movement Screen

Fugitive dust is generated by the various activities during construction, contributing to PM10 and PM2.5 emissions. CalEEMod calculates fugitive dust associated with the site preparation and grading phases from three major activities: grading, bulldozing, and truck loading.[5] Fugitive dust emissions from these activities are calculated using the methodology in USEPA AP-42, as described in the following sections.

4.4.1 Grading Equipment Passes

Fugitive dust emissions from grading equipment passes are estimated using the methodology described in Section 11.9 of USEPA's AP-42 (USEPA 1998b). Section 11.9 provides guidance to estimate the emission factor of PM10 by applying a scaling factor to PM15. Similarly, the emission factor of PM2.5 is scaled from that of total suspended particulates (TSP). The following presents the equations used to calculate the emission factors for PM15 and TSP and the scaling factors for PM10 and PM2.5.

$$EF_{PM15} = 0.051 \times (S)^{2.0}, \text{ and } EF_{PM10} = EF_{PM15} \times F_{PM10}$$

$$EF_{TSP} = 0.04 \times (S)^{2.5}, \text{ and } EF_{PM2.5} = EF_{TSP} \times F_{PM2.5}$$

Where:

EF = emission factor (lb/VMT).

[5] While defaults are only available the site preparation and grading phases, the user can model dust emissions from material movement under any phase in the construction schedule by clicking "Add Phase." The user must define the total acres graded for all non-default phases.

S = mean vehicle speed (mph). The AP-42 default value is 7.1 mph.

$F_{PM2.5}$ = PM2.5 scaling factor. The AP-42 default value is 0.031.

F_{PM10} = PM10 scaling factor. The AP-42 default value is 0.6.

Grading dust emissions are calculated by multiplying the emission factors with the total VMT for the grading equipment (i.e., grader). VMT is estimated based on the dimensions of the grading area and the blade width of the grading equipment.

$$E_p = EF_p \times VMT, \text{ and}$$

$$VMT = As/Wb \times UC_1 \div UC_2$$

Where:

E = emissions (lb/day).

EF = emission factor (lb/VMT).

VMT = vehicle miles traveled (mile).

As = the acreage of the grading site (acre/day).

Wb = Blade width of the grading equipment. The program uses a default blade width of 12 feet based on Caterpillar's 140 Motor Grader (Caterpillar 2021).

UC_1 = unit conversion from acre to square feet (43,560 sqft/acre).

UC_2 = unit conversion from feet to miles (5,280 feet/mile).

p = pollutant (PM10 or PM2.5).

The dimensions (e.g., length and width) of the grading site have no impact on the calculation, only the total area to be graded. Multiple passes with equipment may be required to properly grade a piece of land. The acres value is based on the equipment list and the number of days specified for the grading or site preparation phase according to the anticipated maximum number of acres a given piece of equipment can pass over in an 8-hour workday, as determined by South Coast AQMD in consultation with building estimator references (refer to Table G-14).

4.4.2 Bulldozing

Similar to the grading equipment passes emission estimation, the bulldozing emission factors for fugitive dust are scaled from the emission factors for PM15 and TSP. Based on AP-42 Section 11.9, the dust emission factors for bulldozing are calculated using the following equations (USEPA 1998b).

$$EF_{TSP} = \frac{C_{TSP} \times s^{1.2}}{M^{1.3}}, \text{ and } EF_{PM2.5} = EF_{TSP} \times F_{PM2.5}$$

$$EF_{PM15} = \frac{C_{PM15} \times s^{1.5}}{M^{1.4}}, \text{ and } EF_{PM10} = EF_{PM15} \times F_{PM10}$$

Where:

EF = emission factor (lb/hr).

C = arbitrary coefficient used by AP-42.

M = material moisture content (%).

s = material silt content (%).

F = scaling factor.

C, M, s, and F vary depending on the bulldozed material. Table C-1 summarizes the constants for overburden presented in AP-42 (USEPA 1998b:Tables 11.9-1 and 11.9-3).[6]

Table C-1. Bulldozing Fugitive Emission Factors

Constant	Overburden
C_{TSP}	5.7
C_{PM15}	1.0
M	7.9%
s	6.9%
F_{PM10}	0.75
$F_{PM2.5}$	0.105

The program uses the constants associated with overburden as defaults for the calculation of bulldozing dust emissions since overburden more closely models the bulldozed materials during land development construction. The dust emissions are calculated by multiplying the emission factor with the hours of operation for the dozers listed in the equipment list using the following formula.

$$E_p = EF_p \times Hr$$

Where:

E = emissions (lb/day).

EF = emission factor (lb/hr).

Hr = hours of operation (hr/day).

p = pollutant (PM10 or PM2.5).

4.4.3 Truck Loading

Processes such as a truck dumping earthen materials on a pile or loading soil from a pile to a truck with a front-end loader cause fugitive dust emissions. CalEEMod calculates these emissions using the methodology described in Section 13.2.4 of USEPA AP-42 (USEPA 2006a). The emission factor is based on the material moisture content and mean wind speed and is calculated using the following equation.

[6] *Overburden* is the layer of earth located between the topsoil and the coal seam.

$$EF_p = k \times (0.0032) \times \frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

Where:

EF = emission factor (lb/short ton).

K = particle size multiplier. The AP-42 default value for PM10 is 0.35 and that for PM2.5 is 0.053.

U = mean wind speed. The program selects wind speed based on the value listed on the **Project Detail** screen. It has been converted internally to miles per hour.

M = material moisture content (percent). The moisture contents of different materials are listed in AP-42 (USEPA 2006a:Table 13.2.4-1). The program uses the moisture content of cover (12%) as default.

p = pollutant (PM10 or PM2.5).

Fugitive dust emissions are calculated by multiplying the emission factor with the throughput of loaded and unloaded material that is entered by the user (i.e., material imported and exported).

$$E_p = EF_p \times TP$$

Where:

E = emissions (lb/day).

EF = emission factor (lb/short ton).

TP = throughput of loaded and unloaded materials (short ton/day). Refer to Appendix D, *Technical Source Documentation for Emissions Calculations,* for suggested material movement quantities by project land use type and size.

p = pollutant (PM10 or PM2.5).

CalEEMod assumes 1.2641662 short tons per cubic yard based on a bulk density of 1.5 grams per cubic centimeter. Typical soil densities range from about 1.25 to about 1.6, and 1.5 is the approximate density of a silty loam soil, which is relatively common in most other parts of the state. The density reported above does not account for watering to suppress dust, it only accounts for natural moisture. See Section 4.4.4, *Emissions Control*, for instructions on including dust control in the emissions analysis.

4.4.4 Emissions Control

If applicable, the user may select the “Water Exposed Area” toggle to account for dust control as part of the project design. Default reduction efficacies are available for watering exposed surfaces at frequencies of 2 or 3 times per 8-hour workday, based on published literature (Countess Environmental 2006:Table 3-7). The twice daily efficacy assumes watering every 3.2 hours and achieves a 61 percent reduction in fugitive dust emissions from grading equipment passes, bulldozing, and truck loading. The three times daily efficacy assumes watering every 2.1 hours and achieves a 74 percent reduction in fugitive dust emissions from these sources. The user may also define their own watering frequency and reduction factors by selecting “Other” from the dropdown menu.[7] If the "Water Exposed Area" toggle is selected, the reduction efficacies will be applied to the calculation of unmitigated fugitive dust.

4.5 Demolition Screen

The program calculates demolition dust emissions using the methodology described in the report prepared for USEPA by the Midwest Research Institute (MRI) (1988). The three primary operations that generate dust emission during the demolition phase are (1) mechanical or explosive dismemberment, (2) debris loading, and (3) truck travel over paved and unpaved roads. Emissions from on-road truck travel are included in the **Trips and VMT** screen (see Section 4.6, *Trips and VMT Screen*). This section describes the quantification method for mechanical or explosive dismemberment and debris loading. CalEEMod adds the emissions from these sources to calculate total fugitive dust emissions from demolition activities.[8]

4.5.1 Mechanical or Explosive Dismemberment

Based on the MRI report, there are no AP-42 emission factor data available for mechanical or explosive dismemberment. Thus, the emission factor for dismemberment and collapse of a structure is calculated using the following AP-42 equation for batch drop operations (USEPA 2006a).

$$EF_D = k \times (0.0032) \times \frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

Where:

> EF_D = dismemberment emission factor (lb/short ton of debris).
>
> k = particle size multiplier. The AP-42 default value for PM_{10} is 0.35 and that for $PM_{2.5}$ is 0.053.
>
> U = mean wind speed. The program selects the default mean wind speed based on the wind speed (m/s) provided on the **Project Detail** screen.
>
> M = material moisture content. The program uses 2% as the default based on the MRI report.
>
> p = pollutant (PM10 or PM2.5).

The dust emissions are calculated by multiplying the above emission factors with the total weight of building waste using the following equation.

$$E_{D\cdot p} = EF_{D\cdot p} \times W$$

[7] Local air districts may have suggestions for reduction efficacies in their CEQA guidelines.

[8] The user can model dust emissions from demolition under any phase in the construction schedule by clicking "Add Phase." They user must define the square footage of demolished area or short tons of building debris.

Where:

E_D = dismemberment emissions (lb/day).

EF_D = dismemberment emission factor (lb/short ton of debris).

W = building waste (short ton of debris/day).

p = pollutant (PM10 or PM2.5).

If the total building waste weight is not known, the program will estimate the tonnage using the *building waste tonnage – structural floor space* relationship determined from a 1976 analysis by Murphy and Chatterjee of the demolition of 12 commercial brick, concrete, and steel buildings. The following data are cited directly from the MRI report:

1 sqft floor space = 10 cubic feet original building volume,
1 cubic foot building volume = 0.25 cubic foot waste volume,
1 cubic yard building waste = 0.5 short ton weight; therefore,
1 sqft represents 0.046 short ton of waste material.

The total building waste is then calculated using the following equation:

$$E_{D \cdot p} = EF_{D \cdot p} \times SF \times UC_1$$

Where:

E_D = dismemberment emissions (lb/day).

EF_D = dismemberment emission factor (lb/short ton of debris).

SF = building square footage (sqft/day).

UC_1 = unit conversion from square feet to short ton (0.046 short ton/sqft).

p = pollutant (PM10 or PM2.5).

4.5.2 Debris Loading

Debris loading emission factors for fugitive dust are scaled from the emission factor for TSP according to the following equation.

$$EF_{L \cdot p} = k \times EF_{L\text{-}TSP}$$

Where:

EF_L = loading dust emission factor (lb/short ton).

k = particle size multiplier. The AP-42 default values are 0.35 for PM10 and 0.053 for PM2.5.

$EF_{L\text{-}TSP}$ = loading TSP emission factor (lb/short ton). The default value is 0.058 lb/short ton, the average of TSP factors (i.e., 0.053 and 0.063 lb/short ton) measured from two tests of the filling of trucks with crushed limestone using a front-end loader (Midwest Research Institute 1988:28).

p = pollutant (PM10 or PM2.5).

PM10 and PM2.5 dust emissions from debris loading are then calculated following the same methodology as used for mechanical or explosive dismemberment.

$$E_{L \cdot p} = EF_{L \cdot p} \times SF \times UC_1$$

Where:

E_L = loading emissions (lb/day).

EF_L = loading emission factor (lb/short ton).

SF = building square footage (sqft/day).

UC_1 = unit conversion from square feet to short ton (0.046 short ton/sqft).

p = pollutant (PM10 or PM2.5).

4.5.3 Emissions Control

If applicable, the user may select the “Water Demolished Area” toggle to account for dust control as part of the project design. Default reduction efficacies are available for watering during demolition at a frequency of 2 times per 8-hour workday, based on published literature (Countess Environmental 2006:Table 3-7). The twice daily efficacy assumes watering every 4 hours and achieves a 36 percent reduction in fugitive dust emissions from demolition. The user may also define their own watering frequency and reduction factors by selecting “Other” from the dropdown menu.[9] If the “Water Demolished Area” toggle is selected, the reduction efficacies will be applied to the calculation of unmitigated fugitive dust.

4.6 Trips and VMT Screen

The number of workers, vendor, hauling, and onsite truck trips and associated VMT are used to determine both the exhaust and mechanical (i.e., tirewear and brakewear) emissions associated with on-road vehicle use, as well as fugitive dust emissions from travel over paved and unpaved roads. CalEEMod defines these trip types as follows:

- *Worker*: Trips made by employees commuting from an offsite origin to the construction site. Defaults for worker trip numbers and lengths are automatically generated for all construction phases and land use types based on prior user inputs.
- *Vendor*: Trips made by water or cement trucks traveling from an offsite origin to the project site. Defaults for vendor trip numbers and lengths are automatically generated for all construction phases identified for linear land use projects. Defaults for vendor trip numbers and lengths for land use development projects are only available for the building construction phase.
- *Hauling*: Trips made by heavy trucks traveling from an offsite origin to the project site. Defaults for hauling trip numbers are automatically generated for all construction phases in which the user has defined a material quantity in the **Demolition** or **Dust from Material Movement** screens. The hauling trip length default is set at 20 miles per one-way trip.
- *Onsite Truck*: Trips made by heavy trucks traveling within the construction property boundary. There are no trip rate or length defaults for onsite trucks.

[9] Local air districts may have suggestions for reduction efficacies in their CEQA guidelines.

This section provides the sources consulted to develop default values for vehicle trip rates and lengths and provides the quantification methodology for the estimation of vehicle emissions (exhaust and mechanical). See Section 4.7, *On-Road Fugitive Dust Screen*, for the road dust quantification method.

4.6.1 Default Values for Vehicle Trip Rate

Worker trips for all construction phases except building construction and architectural coating is based on 1.25 workers per equipment in that phase resulting in one roundtrip per worker. For building construction workers, the trip number is estimated using the trip generation rate from a survey conducted by the Sacramento Metropolitan Air Quality Management District. This has been reanalyzed and results in slightly different numbers than used by other programs and that was previously reported in some agency documents. The analysis and data supporting these values can be found in Appendix D, *Technical Source Documentation for Emissions Calculations*. The land types selected for the project are grouped into four categories presented in Table C-2, which also presents the associated Sacramento Metropolitan Air Quality Management District trip generation rates.

Table C-2. Building Construction Worker and Vendor Trip Rates

Land Use Subtype	Rate Metric	Worker Trip Rate	Vendor Trip Rate
Single-Family	Daily trips per DU	0.36	0.1069
Multi-Family	Daily trips per DU	0.72	0.1069
Commercial/Retail	Daily trips per 1000 square feet	0.32	0.1639
Office/Industrial	Daily trips per 1000 square feet	0.42	0.1639

Source: South Coast AQMD's analysis of the Sacramento Metropolitan Air Quality Management District's Building Construction Worker and Vendor trip rates found in Appendix D, *Technical Source Documentation for Emissions Calculations*.
DU = dwelling unit

Architectural coating worker trips are 20 percent of building construction phase trips. Defaults for vendor trips for land use development projects are only available for building construction and are based on the land uses and trip rate indicated in Table C-2. The user must provide vendor trips rates for all other phases for land use development projects requiring this type of vehicle trip. Appendix D, *Technical Source Documentation for Emissions Calculations,* includes suggested vendor trip rates for construction phases where defaults are not currently programmed. For linear land use types, defaults for the number of one-way vendor trips per day are available for all construction phases. The vendor trip rate accounts for water trucks but no other types of vendors (e.g., cement trucks). If the linear land use construction requires other types of vendor trips, the user will need to add those trips to the defaults quantified for water trucks. The derivation of the default total water truck trips per linear phase is a three-step process.

1. The number of one-way trips per water truck is estimated to be 10 per day, based on average trip data output from EMFAC2017 for T7 single construction trucks (Ramboll 2018).
2. The number of trucks per day for the "Linear, Grubbing & Land Clearing" and "Linear, Grading & Excavation" phases are based on the maximum area disturbed per day, divided by 5. For the "Linear, Drainage, Utilities, & Sub-Grade" and "Linear, Paving" phases, the maximum area disturbed per day is divided by 10.

3. The number of one-way trips per water truck is multiplied by the number of trucks per day to calculate the total water truck trips per day per phase.

Hauling trips are based on the amount of material that is demolished (as defined in the **Demolition** screen) or imported or exported (as defined in the **Dust from Material Movement** screen) assuming a truck can handle 16 cubic yards of material. For phased trips, the truck is assumed to be full both ways. For non-phased trips, the truck is assumed to be empty one direction and thus results in more haul trips calculated. The user must provide hauling trips rates for all activities not associated with demolition or material movement, as applicable.

There are no trip rate defaults for onsite trucks. The user must enter site-specific assumptions when a project includes onsite truck trips. Refer to Appendix D, *Technical Source Documentation for Emissions Calculations,* for suggested onsite trip rates and lengths.

4.6.2 Default Values for Vehicle Trip Lengths

As described further in Section 5.1.1.1, *Default Vehicle Trips and VMT*, CalEEMod includes default trip length estimates from the 2015 California Statewide Travel Demand Model (CSTDM) and regional travel demand models from local metropolitan planning organizations (MPO) or Regional Transportation Planning Agencies (RTPA), where available. If MPO/RTPA data are available for the project location, the user may select either data source by clicking the appropriate toggle.

Both the CSTDM and MPO/RTPA databases include trip length information for home-work (H-W) and work-other (W-O) trips. A H-W trip represents trips traveling in either direction between home and work locations and is used to define construction worker trips. A W-O trip is made by an employee traveling in either direction between a work location and all other locations that are not home and is used to define construction vendor trips.

If the CSTDM is selected, the default trip lengths for workers and vendors are based on the statewide data for H-W and W-O trips, respectively, aggregated to the user-selected analysis level defined on the **Project Detail** screen (refer to Table G-15). If MPO/RTPA is selected, the trip length for workers and vendors are based on the local data for H-W and W-O trips, respectively, aggregated to the MPO/RTPA jurisdictional boundary (refer to Table G-16).

The hauling trip length default is set at 20 miles. There are no trip length defaults for onsite trucks.

4.6.3 Emissions Quantification

On-road vehicles generate combustion exhaust emissions (running and evaporative) and dust emissions from tirewear and brakewear (i.e., mechanical) (dust emissions from vehicle travel over paved and unpaved roads are discussed in Section 4.7, *On-Road Fugitive Dust Screen*). These emissions are based on the vehicle trips rates and lengths along with emission factors from EMFAC2021 (California Air Resources Board 2021c). The detailed methodology for converting EMFAC2021 emission rates into CalEEMod vehicle emission factors is provided in Section 5.1.3.1, *Vehicle Emission Factors from EMFAC2021*. This section provides the quantification methodology for the estimation of combustion exhaust and mechanically generated dust emissions from construction vehicle trips. Because the vehicle fleet mix influences the intensity of emissions, defaults for defining the vehicle mix are also described.

4.6.4 Vehicle Fleet Mix

The user can select the type of vehicle mix for each of the four construction trip types (e.g., worker). CalEEMod assumes that construction worker trips are made by a fleet consisting of 25 percent light-duty auto (or passenger car), 50 percent light-duty truck type 1 (LDT1), and 25 percent light-duty truck type 2 (LDT2). This is an assumed fleet mix based on field observations. The user may override this default to use the EMFAC fleet mix, which is the total mix of all vehicles for the analysis level provided by EMFAC2021.

CalEEMod assumes vendor trips are made by a fleet consisting of 50 percent medium trucks (MHDT) and 50 percent heavy trucks (HHDT). CalEEMod assumes hauling and onsite truck trips are made by a fleet consisting of 100 percent HHDT. The user may override these defaults to use the EMFAC fleet mix, MHDT/HHDT mix, all MHDT, or all HHDT.

The equivalent test weight (ETW) from EMFAC2021 for each type of vehicle is presented in Table C-3 (CARB 2021d).

Table C-3. Gross Vehicle Weights

Vehicle Type	ETW (lb)
LDA	All
LDT1	<= 3,750
LDT2	3,751 – 5,750
MHDT	14,001 – 33,000
HHDT	33,000 – 60,000

4.6.5 Exhaust Emissions (Running and Evaporative)

EMFAC2021 emission factors for each construction vehicle fleet mix are based on aggregated model year and vehicle speeds for the user-selected analysis level defined on the **Project Detail** screen. The emission factor database includes emission factors for all calendar years (2010–2050) and seasons (summer, winter). CalEEMod identifies the appropriate calendar year and seasonal emission factors based on the start and end dates of the construction phases. Running exhaust emission factors are presented in units of grams per mile (g/mile) and evaporative emission factors are presented in units of grams per trip (g/trip). While combustion results in running exhaust emissions of all criteria pollutants and GHGs, evaporative emissions are only emitted as TOG and ROG. See Section 5.1.3.1, *Vehicle Emission Factors from EMFAC2021*, for additional information on the sources and methods used to develop the running and evaporative emission factors.

Emissions from construction vehicle trips are calculated using the following equation.

$$E_p = ((EEF_{m,s} \times Trips) + ((REF_{m,s} \times Trips \times Length))$$

Where:

E = combustion emissions (g/day).

EEF = evaporative emission factor (g/trip) (ROG and TOG only).

REF = running exhaust emission factor (g/mile).

Trips = vehicle trips (trips/day).

Length = vehicle trip length (miles/trip).

m = vehicle fleet mix.

s = season. CalEEMod applies winter emission factors to vehicle trips made during phases that occur between October through March, and summer emission factors to vehicle trips made during phases that occur between April through September.

p = pollutant (PM10 or PM2.5).

4.6.6 Mechanical Emissions (Tirewear and Brakewear)

As vehicles are driven, PM10 and PM2.5 are generated from degradation of brakes and tires. These emissions are calculated using the following equation. Note that seasonality (winter, summer) does not influence the intensity of brakewear or tirewear emissions.

$$E_p = (BWEF + TWEF)_m \times (Trips \times Length)$$

Where:

E = dust emissions (g/day).

BWEF = brakewear emission factor (g/mile).

TWEF = tirewear emission factor (g/mile).

Trips = vehicle trips (trips/day).

Length = vehicle trip length (miles/trip).

m = vehicle fleet mix.

p = pollutant (PM10 or PM2.5).

4.7 On-Road Fugitive Dust Screen

CalEEMod calculates fugitive dust from travel of construction vehicles on paved and unpaved roads consistent with the method discussed in Section 5.1.4, *Road Dust Screen*. All worker, vendor, and hauling trips are assumed to occur on public roadways (i.e., not within the project construction boundary). The percentage of vehicle miles travel on paved roadways is based on the user-selected analysis level defined on the **Project Detail** screen. The local air districts were surveyed to request that they provide percentages for their corresponding location types (i.e., air basin, air district, and county). The statewide default assumption of 100 percent was applied to the smaller location types unless the local air district specified alternative percentages. All onsite trucks trips are assumed to occur within the project construction boundary and therefore exclusively on unpaved roads. Defaults for roadway characteristics (e.g., road silt loading content) and vehicle characteristics (e.g., average vehicle weight) are the same as described in Section 5.1.4, *Road Dust Screen*.

4.7.1 Emissions Control

If applicable, the user may select the “Control Strategy” toggle to account for dust control as part of the project design. The following four control strategies are available.

- Water unpaved roads twice daily.
- Apply dust suppressants to unpaved roads.

- Limit vehicle speeds on unpaved roads to 25 mph.
- Sweep paved roads once per month.

The first three strategies influence the intensity of dust generation from vehicle travel on unpaved roads within the project construction boundary. Watering and application of dust suppressants are mutually exclusive—that is, the user may select watering or dust suppressants, but not both. The last strategy influences the intensity of dust generation from vehicle travel on paved roads within the project construction boundary. This strategy is only applicable if the percentage of paved onsite truck travel is greater than 0.

Default reduction efficacies for the four strategies are based on published literature (Countess Environmental 2006:Tables 3-7, 6-6, and 5-5). If the "Control Strategy" toggle is selected, the reduction efficacies will be applied to the calculation of unmitigated fugitive dust.

4.8 Architectural Coatings Screen

VOC off-gassing emissions result from evaporation of solvents contained in surface coatings. The program calculates the VOC evaporative emissions from application of residential and non-residential surface coatings. The architectural coating emission factor is based on the VOC content of the surface coatings and is calculated estimated using the following equation.

$$EF = C_{VOC} \times UC_1 \times UC_2 \div S$$

Where:

> EF = architectural coating emission factor (lb VOC/sqft).
>
> C_{VOC} = VOC content (g/L). This varies by location and year based on VOC content data provided by California air districts. If data were not available from a local air district, CalEEMod assumes CARB's statewide limits (Table G-17).
>
> UC_1 = unit conversion from grams to lb (0.00220462262 lb/g).
>
> UC_2 = unit conversion from gallons (gal) to liters (L) (3.78541 L/gal).
>
> S = sqft coated per gal (180 sqft/gal).

Architectural coating emissions are calculated using the following equation.

$$E = EF \times F \times A_{paint}$$

Where:

> E = architectural coating emissions (lb VOC/day).
>
> EF = architectural coating emission factor (lb VOC/sqft).
>
> F = fraction of surface area. For all land use types except Parking, the default values based on South Coast AQMD methods used in their coating rules are 75% for the interior surfaces and 25% for the exterior shell. The fractions for the Parking land use type are 90% for interior surfaces and 10% for the exterior shell.
>
> A_{paint} = building surface area painted (sqft).

The program assumes the total surface for painting as follows.

- 2.7 times the building square footage for residential land uses.
- 2.0 times the building square footage for non-residential land uses, with the following exceptions.
    - 2.0 times the recreational building square footage for City Park, Golf Course, and Recreational Swimming Pool land use subtypes.[10]
    - 0.05 times the lot acreage (converted to square feet) for the Parking land use type.

All land use information provided by a metric other than square footage (e.g., gasoline station pumps) will be converted to square footage using the default conversions or user defined equivalence.

CalEEMod also calculates VOC emissions from the painting of stripes, handicap symbols, directional arrows and car space descriptions for the Parking land use type. See Appendix D, *Technical Source Documentation for Emissions Calculations*, for the studies conducted to determine a default percent of parking lot square footage that is painted. The equation for striping emission is the same as that for E_{AC} above, but A_{paint} is as follows.

$$A_{paint} = A_{PL} \times P$$

Where:

A_{PL} = parking lot area (sqft).

P = percent of parking lot area that is painted (6%).

The VOC content limit for parking lot area is either provided by local air districts or based on the exterior coating VOC limit of the region where the project is located.

4.9 Paved Area Screen

CalEEMod estimates VOC off-gassing emissions associated with paving of asphalt surfaces using the following equation.

$$E = EF \times A \times P$$

Where:

E = paving emissions (lb VOC/day).

EF = paving emission factor (lb VOC/acre). The default emission factor is 2.62 lb/acre (Sacramento Metropolitan Air Quality Management District 1994).

A = area paved (acre).

CalEEMod provides default inputs for area paved for the single-family housing land use subtype and all linear and parking land use subtypes. Defaults for single-family housing

[10] The factors 2.7 and 2 are based on page A9-124 of South Coast AQMD's 1993 *CEQA Air Quality Handbook*.

are generated based on the unit amount defined in the **Land Use** module, assuming 480 sqft of paved driveway space per DU. The area paved for linear and parking land use subtypes is equal to the lot acreage defined in the **Land Use** module. CalEEMod assumes 0 paved area for all other land use types. The user may override this value if their project includes additional paving.

P = percent of area that is paved with asphalt (%).

Evaporative VOC emissions are only generated by asphalt paving. CalEEMod defaults to 100 percent asphalt paving for all parking lot (except for “other non-asphalt surfaces”) and linear land use subtypes. Paving for all other land use types is assumed non-asphalt (e.g., concrete) and the default percent is set to 0.

4.10 Electricity Screen

CalEEMod calculates GHG emissions from the consumption of electricity during construction according to the following equation.

$$E_p = EF_p \times EC \times UC_1$$

Where:

E = electricity emissions (lb/yr).

EF = utility emission factor (lb/MWh) (Table G-3).

EC = annual construction electricity consumption (kilowatt-hours per year [kWh/yr]).

UC_1 = unit conversion from kWh to MWh (0.001 MWh/kWh).

p = pollutant (CO_2, CH_4, and N_2O).

CalEEMod displays the construction years for the project based on the construction schedule defined in the **Construction Phases** screen. CalEEMod only calculates electricity consumption if the user identifies electric-powered construction equipment in the **Off-Road Equipment** screen. Electricity consumption for off-road equipment is estimated according to the following equation.

$$EC = Activity_i \times Pop_i \times (hp_i \times UC) \times Load_i \times D$$

Where:

EC = annual electricity consumption (kWh/yr).

Activity = hours of daily operation of the off-road equipment (hr/day/number).

Pop = population, or the number of pieces of equipment (number/day).

hp = average horsepower for the off-road equipment (unitless) (Table G-12).

UC = unit conversion from horsepower to kW (0.745701 kW/hp).

Load = load factor of the off-road equipment (unitless) (Table G-12).

D = days per year of equipment operation, as defined by the phase duration (day/yr).

i = off-road equipment type.

CalEEMod does not estimate electricity consumption for any source other than user-defined electric-powered equipment (e.g., mobile offices, electric haul trucks). The user must enter site-specific assumptions when a project includes non-equipment sources of electricity consumption. Note that if a phase requires electricity for both equipment and non-equipment sources, the user would need to add their non-equipment electricity estimate to the CalEEMod generated default for equipment electricity consumption.

As discussed in Section 2.2, *Utility Information Screen*, CalEEMod includes carbon intensities for several electric utilities throughout California, as well as the carbon intensity for the statewide grid average. Electricity emissions can be quantified using the latest year with reported data, which is 2019. Alternatively, the user may elect to use forecasted future year carbon intensities that reflect implementation of SB 100. If the forecasted factors toggle is selected, CalEEMod will use the forecasted carbon intensities applicable to each construction year.

4.11 Maximum Daily and Annual Construction Emissions

Since construction phases may or may not overlap in time, the maximum daily construction emissions will not necessarily be the sum of all possible daily emissions. CalEEMod calculates daily emissions for each construction phase. The program will then add together the daily emissions for each construction phase that overlaps in time. The model also accounts for seasonality and calculates the highest daily emissions that would occur during the winter (October through March) and summer (April through September) seasons. For example, consider a project with the phases and schedule shown in Table C-4.

Table C-4. Example Schedule

Phase	Start Date	End Date	Days	Days/Week
Demolition	1/1/2022	1/30/2022	20	5
Site Preparation	2/1/2022	3/15/2022	31	5
Grading	3/1/2022	3/31/2022	23	5
Building Construction	4/1/2022	10/30/2023	412	5
Architectural Coatings	9/1/2023	10/30/2023	42	5
Paving	10/15/2023	10/30/2023	11	5

As shown in Table C-4, the site preparation and grading phases would occur concurrently between 3/1/2022 and 3/15/2022. Likewise, the building construction and architectural coatings phases would occur concurrently between 9/1/2023 and 10/30/2023. The paving phase would overlap with both building construction and architectural coatings between 10/15/2023 and 10/30/2023. During these periods of overlapping construction activity, CalEEMod adds daily emissions among the phases to calculate combined daily emissions. The program will then select the highest emissions among the individual phases and combined overlapping periods to report as the daily summer and winter maximums.

Table C-5 illustrates the calculation of maximum daily NO_x emissions for the example project. As shown in the table, NO_x emissions for the overlapping winter period in 2022 are 37 lb per day. This amount is greater than the emissions that would be independently generated by either the site preparation (20 lb) or grading (17 lb) phases and would therefore be reported for the maximum daily winter output in 2022. There would be no phase overlap in the construction schedule between 4/1/2022 and 9/1/2023. Emissions from the building construction phase (36 lb) would be reported as the maximum daily summer output in 2022. For the overlapping summer period in

2023, the highest NO_x emissions are 38 lb, which occurs between 9/1/2023 and 9/30/2023. This value exceeds the emissions estimate for the building construction phase that would occur independently earlier in the 2023 summer season. Accordingly, 38 lb per day would be reported in the CalEEMod output as the maximum daily summer NO_x emissions in 2023. For the overlapping winter period in 2023, the highest NO_x emissions are 42 lb. These emissions would be reported as the daily winter maximum for 2023. The consideration of seasonality in the presentation of summer and winter outputs is new to version 2022.1 and can result in considerable differences in maximum daily summer and winter results.

Table C-5. Example Maximum Daily Nitrogen Oxides Calculation

Phase	Daily Nitrogen Oxides Emissions (lb)	Overlapping Periods		
		3/1/2022 to 3/15/2022	9/1/2023 to 10/30/2023	10/15/2023 to 10/30/2023
	Year and Season	*2022 Winter*	*2023 Summer* *2023 Winter*	*2023 Winter*
Demolition	10	-	-	-
Site Preparation	20	20	-	-
Grading	17	17	-	-
Building Construction	36	-	36	36
Architectural Coatings	2	-	2	2
Paving	4	-	-	4
Total Emissions	-	37	38	42
Max Daily Emissions (lb) for CalEEMod Output				
2022 Winter [a]	37			
2022 Summer [b]	36			
2023 Winter [c]	42			
2023 Summer [d]	38			

Notes:
[a] The 2022 winter seasons are from 1/1/2022 to 3/30/2022 and 10/1/2022 to 12/31/2022. The highest emissions that occur during these dates are from concurrent site preparation and grading (3/1/2022 to 3/15/2022). The combined emissions (37 lb) from these phases exceed the emissions that would be independently generated by any other phase during the winter 2022 season.
[b] The 2022 summer season is from 4/1/2022 to 9/30/2022. Only the building construction phase would occur during this time, and therefore would be reported as the summer 2022 maximum.
[c] The 2023 winter seasons are from 1/1/2023 to 3/30/2023 and 10/1/2023 to 12/31/2023. The highest emissions that occur during these dates are from concurrent building construction, architectural coatings, and paving (10/15/2023 to 10/30/2023). The combined emissions (42 lb) from these phases exceed the emissions that would be independently generated by any other phase (or other overlapping phase combinations) during the winter 2023 season.
[d] The 2023 summer season is from 4/1/2023 to 9/30/2023. The highest emissions that occur during these dates are from concurrent building construction and architectural coatings (9/1/2023 to 9/30/2023). The combined emissions (38 lb) from these phases exceed the emissions that would be independently generated by any other phase during the summer 2023 season.

Annual construction emissions are calculated based on the daily emissions for each construction phase and the construction schedule defined in the **Construction Phases** screen. CalEEMod assigns all emissions for a phase to a single year if the start and end dates both occur in that year. For phases that span multiple years, CalEEMod calculates the number of days in each year the phase would occur based on the phase start and end dates and working days per week. CalEEMod then multiplies the daily phase emissions by the number of days the phase would occur in each year. Table C-6 illustrates the calculation of annual emissions for the example project.

Table C-6. Example Annual Nitrogen Oxides Calculation

Phase	Daily Nitrogen Oxides Emissions (lb)	2022			2023		
		lb/day	day/year	lb/year	lb/day	day/year	lb/year
Demolition	10	10	20	200	0	0	0
Site Preparation	20	20	31	620	0	0	0
Grading	17	17	23	391	0	0	0
Building Construction	36	36	196	7,056	36	216	7,776
Architectural Coatings	2	0	0	0	2	42	84
Paving	4	0	0	0	4	11	44
Total Emissions (lb)	**-**	**-**	**-**	**8,267**	**-**	**-**	**7,904**
Total Emissions (short tons) for CalEEMod Output	**-**	**-**	**-**	**4.13**	**-**	**-**	**3.95**

5 Operations Module

The **Operations** module is used to calculate the emissions associated with operation of a land use development (i.e., non-linear) project. The operational phase of a project can have several different types of sources that contribute to emissions. The sources quantified by CalEEMod are mobile, area, energy, water and wastewater, solid waste, refrigerants, off-road equipment, and stationary. Each of these source types is discussed in more detail in the subsequent sections.

5.1 Mobile Sources Submodule

On-road operational mobile source emissions are generated by resident, worker, customer, and delivery vehicles visiting the land use subtypes of a project. The emission processes associated with on-road mobile sources includes running, starting, idling, evaporative, and mechanical (i.e., brakewear, tirewear, and road dust). Running and mechanical emissions depend on VMT. All other emissions depend on the number of vehicle trips. Emissions from these processes are quantified based on user inputs and defaults in the **Vehicle Data**, **Fleet Mix**, **Vehicle EF**, and **Road Dust** screens.

The methods and assumptions used by the program to quantify mobile source emissions are described in the following sections. Section 5.1.1.1, *Default Vehicle Trips and VMT*, explains how CalEEMod generates default vehicle trip and VMT forecasts for use if project-specific data are not available. Section 5.1.3, *Vehicle Emission Factors Screen*, describes the methodology for converting EMFAC2021 emissions rates to CalEEMod mobile source emission factors. This section also provides the equations and variables used to develop emission factors for HFC. Section 5.1.4, *Road Dust Screen,* provides the equations and variables used to develop emission factors for road dust. Section 5.1.5, *Mobile Source Emissions Quantification,* provides the final equations for quantifying mobile source emissions.

5.1.1 Vehicle Data Screen

CalEEMod can generate default assumptions for vehicle trips and VMT based on user inputs in the **Project Details** and **Land Use** screens. Alternatively, the user may provide project-specific trip and VMT inputs from a traffic study or other source by clicking "Enter Trips and VMT Manually" in the **Vehicle Data** screen. The following sections define the methodology used by CalEEMod to generate default vehicle trips and VMT.

5.1.1.1 Default Vehicle Trips and VMT

5.1.1.1.1 General Methodology

The specific type of trip and VMT forecast by CalEEMod is referred to as "project generated trips and VMT" and it is inclusive of all vehicle types (i.e., passenger and commercial vehicles) and trip purposes for either an "average day" or "peak day." The day type is dependent on the selected emissions report (i.e., annual or daily). The simplified VMT calculation multiplies the vehicle trips generated from the project's land use subtypes by vehicle trip lengths, as shown in the following equation.

$$\text{VMT} = \text{Vehicle Trips} \times \text{Vehicle Trip Lengths}$$

This equation calculates the total VMT generated from the project's land use subtypes but does not capture the "project's effect on VMT." Land use projects have the potential to influence existing VMT generated by neighboring land uses and from vehicle trips already traveling on the network under baseline conditions.[11] A more complete analysis of VMT would provide forecasts of both project-generated VMT and the project's effect on VMT. Travel demand models can produce both metric forms, while CalEEMod is limited to project-generated forecasts.

5.1.1.1.2 Data Fields and Sources

CalEEMod is populated with the following data fields used to estimate vehicle trips and VMT.

- *Trip rate:* Weekday, Saturday, and Sunday vehicle trip rates primarily from *Trip Generation Manual, 10th Edition* (ITE 2017a). A few rates are from the 9th Edition (ITE 2012).
- *Trip link type:* Weekday (and some Saturday) primary, diverted, and pass-by vehicle trip percentages by land use type from *Trip Generation Handbook, 3rd Edition* (ITE 2017b).
- *Trip type (residential):* Residential weekday vehicle trip purpose percentages are available from the 2015 CSTDM by traffic analysis zone (TAZ) (refer to Table G-18). The year 2015 is the most current base year for the CSTDM. Weekday percentages are used for Saturday and Sunday inputs. The user should disclose this limitation in VMT forecasts unless the default

[11] *Baseline* in this document refers to the definition contained in section 15125 of the CEQA Guidelines.

values are replaced with new documented trip purpose percentages. CalEEMod includes a secondary database of residential trip purpose splits from regional travel demand models from local MPO/RTPAs (refer to Table G-19). These data were supplied by the following local MPO/RTPAs.

- Butte County Association of Governments
- Fresno Council of Governments
- Kern Council of Governments
- Kings County Council of Governments
- Madera County Council of Governments
- Metropolitan Transportation Commission
- Sacramento Area Council of Governments
- Southern California Association of Governments
- San Luis Obispo Council of Governments
- Tulare County Association of Governments
- Tahoe Regional Planning Agency

Coverage of the MPO/RTPA database may not spatially extend throughout the entire MPO/RTPA jurisdictional boundary. For example, data from the San Luis Obispo Council of Governments may not be available for every TAZ in their justification. The MPO/RTPA toggle will only activate on the **Vehicle Data** screen if the project is in a TAZ for which there is MPO/RTPA data. Because CalEEMod applies trip characteristics (e.g., vehicle trip purpose splits) at the TAZ spatial scale for the analysis of operational mobile source emissions, MPO/RTPA data may be precluded in the **Operations** module but available for the analysis of construction mobile source emissions, which aggregates defaults for trip lengths to the MPO/RTPA jurisdictional boundary (refer to Section 4.6.2, *Default Values for Vehicle Trip Lengths*).

- *Trip type (non-residential):* Non-residential weekday vehicle trip purpose percentages from the 2015 CSTDM by TAZ or from regional travel demand models from local MPO/RTPAs, where available (refer to Tables G-18 and G-19). Weekday percentages are used for Saturday and Sunday inputs. The user should disclose this limitation in VMT forecasts unless the default values are replaced with new documented trip purpose percentages.

- *Trip length (residential):* Residential weekday vehicle trip lengths from the 2015 CSTDM by TAZ or from regional travel demand models from local MPOs, where available (refer to Tables G-18 and G-19). Weekday data are used for Saturday and Sunday inputs. The user should disclose this limitation in VMT forecasts unless the default values are replaced with new documented trip lengths.

- *Trip length (non-residential):* Non-residential weekday vehicle trip lengths from the 2015 base year of the CSTDM by TAZ or from regional travel demand models from local MPOs, where available (refer to Tables G-18 and G-19). Weekday data are used for Saturday and Sunday inputs.

5.1.1.1.3 Limitations

In addition to select limitations noted above regarding the capture of the 'project's effect on VMT,' other limitations that the user should consider in their CalEEMod applications are listed below.

- *Trip rate:* The ITE vehicle trip rates are not calibrated and validated to California or local project area conditions, nor do they separate passenger and commercial vehicles. The lack of calibration and validation means that ITE rates do not necessarily represent conditions in California, where important variables influencing trip generation, such as income and auto ownership, are higher than other states represented in the data. The user is encouraged to replace these rates with project-specific vehicle trip rates whenever possible. When conducting analysis of projects that will not be operational for many years, the user should also consider current trends in vehicle trip rates and consider whether adjustments are necessary to better reflect expected conditions for the project's opening or operational year.

- *Trip link type:* The ITE data for primary, diverted, and pass-by rates are limited to a few land use types and does not include complete estimates for all analysis days used in CalEEMod. See Section 5.1.1.2, *Trip and VMT Calculations*, for more details on CalEEMod analysis days.

- *Trip types:* The CSTDM data represents estimated 2015 conditions. The MPO/RTPA data represents the latest year for which data were available from the traffic demand model, which differs among those MPO/RTPAs that provided information. The age of the CSTDM data combined with the recent travel behavior changes caused by COVID-19 responses raises questions about the applicability of the data for baseline and future forecast conditions. In addition, the CSTDM data is limited to TAZ-level values. Vehicle trip purpose splits for individual land uses may vary and may be influenced by the local context of individual project study areas.

- *Trip length (residential):* The CSTDM data represents estimated 2015 conditions. The MPO/RTPA data represents the latest year for which data were available from the traffic demand model, which differs among those MPO/RTPAs that provided information. The age of the CSTDM data raises questions about baseline and future forecast applicability. Further, vehicle trip lengths from CSTDM TAZs may not be sufficiently sensitive to the project land uses and local land use context. Regional travel demand models or mobile device data vendors are alternative sources of vehicle trip length estimates that capture the local context of individual project study areas.

- *MPO/RTPA data:* Trip type percentages and trip lengths provided by MPO/RTPAs truncate data at their demonstrative borders. Also, not all trip purposes (e.g., work-other) may currently occur in a specific MPO TAZ, resulting in a zero value for the default trip distance and purpose split. The user electing to use MPO/RTPA data (if available) should carefully review the TAZ data for reasonableness and applicability to their project.

- *Scale of application:* CalEEMod is designed for individual project site analysis typically involving a single parcel or small group of parcels. Estimates of VMT by CalEEMod at larger scales such as for a specific plan or general plan would result in overestimates of total VMT because the model is not capable of capturing the trip interactions between land uses. CalEEMod only produces gross estimates of total vehicle trips by land use and no process exists to distribute those trips between land uses, which would occur at larger scales.

- *VMT Estimation for SB 743:* In general, CalEEMod is not applicable for SB 743 VMT analysis because most lead agencies elect to follow the Governor's Office of Planning methodology and threshold recommendations, which require citywide or regionwide VMT estimates. The use of citywide or regionwide VMT efficiency metrics requires use of travel demand models to establish the threshold value and then to perform the project analysis for consistency with the threshold. CalEEMod cannot produce citywide or regionwide VMT estimates and relies on ITE vehicle trip rates instead of the travel demand model trip rates. The user should also note that SB 743 analysis will tend to focus on automobile only VMT whereas CalEEMod VMT estimates are for total VMT, inclusive of automobile and commercial vehicles, which is required for air quality and GHG analyses under CEQA.

5.1.1.2 Trip and VMT Calculations

This section describes the CalEEMod calculations used to forecast default vehicle trips and VMT to be used when project-specific data are not available.

5.1.1.2.1 Project Location

CalEEMod first identifies in which CSTDM or MPO/RTPA TAZ the project is located. The TAZ selection determines key default inputs related to VMT, specifically the vehicle trip purpose percentages and vehicle trip lengths. CalEEMod automatically identifies the project CSTDM TAZ based on the user defined project location in the **Administrative Map** screen. If MPO/RTPA data are available for the project location and the user elects to use the MPO/RTPA data through the toggle, the model will automatically identify the appropriate MPO/RTPA TAZ.

5.1.1.2.2 Trip Rate

Vehicle trip rate describes the number of trips generated by each land use for the specific analysis day. Multiplying the vehicle trip rate per unit size of land use size (e.g., per DU, per 1,000 sqft) yields total vehicle trips generated by each land use. The ITE trip generation rates are used as defaults in CalEEMod. ITE has guidance about how their trip rates should be used (ITE 2017a). Further, the ITE (2017b) *Trip Generation Handbook* contains procedures for collecting project-specific vehicle trip rates that may more accurately represent the local study area context. The user is encouraged to consult with transportation professionals to develop the best available vehicle trip rates. If more accurate trip rate information is available, the user can override the default trip rate. The user will be required to provide justification from alternative sources of data (e.g., project-specific traffic study) to demonstrate that a different trip rate is appropriate for their project. MPO/RTPAs may be another source of trip generation rates specific for the given region.

Project-generated vehicle trips are used to calculate VMT for either an “average day” or a “peak day.” The average day rates are used when calculating annual emissions from a project, and peak day rates are used when calculating peak daily summer or winter emissions. Since CalEEMod has different trip rates for different days of the week, the peak day is determined based on the highest total of either weekday, Saturday, or Sunday trip emissions. The user should note that this highest day estimate is dependent on the availability of ITE vehicle trip rates, which may not exist for Saturdays or Sundays or have a much smaller sample size for these days. When Saturday or Sunday rates are not available, CalEEMod defaults to weekday rates.

An important limitation of the ITE data for peak day conditions is that it neither includes information about the highest daily vehicle trip generation for a land use subtype, nor details about how vehicle trip generation changes seasonally. These limitations weaken the ability of CalEEMod to represent specific peak daily summer and winter conditions. If peak day summer or winter VMT estimates are essential to the project emissions analysis, then the user should collect vehicle trip generation data for the land use subtypes under analysis during those seasons.

For peak day VMT, CalEEMod chooses the highest vehicle trip rate amongst weekday, Saturday, and Sunday data, and multiplies the rate by the size metric to get total peak day vehicle trips. This product is then multiplied by weekday vehicle trip purpose splits and vehicle trip lengths. If the user has Saturday or Sunday specific input data, those should be substituted accordingly.

5.1.1.2.3 Trip Purpose

Once the total number of vehicle trips for a land use subtype is determined, the next step is to determine the trip purpose percentage breakdown. The trip purpose breakdown represents the proportion of total vehicle trips dedicated to different types of activities such as going to work or shopping. This breakdown is important because activities such as working tend to have longer vehicle trip lengths than activities such as shopping that are often done closer to the home. Multiplying the total trips for a land use subtype by trip purpose breakdown percentage yields vehicle trips of a given trip purpose. Two sets of trip type breakdown are used in CalEEMod: residential and non-residential. Note that these breakdowns do not include separate values for passenger and commercial vehicles.

- *Residential trip purposes*: These include home-work (H-W), home-shop (H-S), and home-other (H-O). A H-W trip represents trips traveling in either direction between home and work locations. A H-S trip represents trips traveling in either direction between home and shopping destinations (generally retail). A H-O trip represents trips traveling in either direction between home and all other locations that are not work or shopping destinations (e.g., school, park, gym). The default residential trip purpose breakdown is from the CSTDM TAZ estimates (refer to Table G-18). CalEEMod includes a secondary database of residential trip purpose splits from regional travel demand models (refer to Table G-19). The user may elect to use the MPO/RTPAs data over the CSTDM data, where available. The user can also prepare more location-specific estimates from traffic study models or mobile device data. The trip purpose breakdown can be overwritten if the user can provide sufficient justification for alternative sources of data (e.g., project-specific traffic study) that demonstrate a different breakdown.
- *Non-residential trip purposes*: Non-residential trip purposes are more complex because of the wide variety of non-residential land use types. For example, a Commercial land use will have a very high percentage of trips associated with H-W, while a Retail land use will have a very low percentage of H-W trips. Most trips to and from a Commercial land use are by employees, while most of the trips to and from a Retail land use are by shoppers. The default non-residential trip purpose breakdown is from the CSTDM TAZ estimates (refer to Table G-18). Non-residential trip purpose splits are also available from many local MPO/RTPAs (refer to Table G-19). The user may elect to use the MPO/RTPA data over the CSTDM data for projects located in these areas. The trip purpose breakdowns represent aggregate proportions of vehicle trip purposes including H-W, work-other (W-O), and other-other (O-O). A H-W trip is the same as defined above for residential. A W-O trip is made by an employee traveling in either direction between a work location and all other locations that are not home. An O-O trip is made by a person traveling in either direction between land uses that do not involve home or work locations.

An important limitation of the non-residential trip purpose estimates is that they are aggregate and may not accurately represent specific land use types. The estimates are derived from TAZs that contain a mix of non-residential land uses. If the non-residential land uses for a project are similar to those within the CSTDM or MPO/RTPA TAZ, then the trip purpose proportions may be reasonable. When land uses differ, then the user should consider whether to adjust the default percentages. The most common adjustments would be to increase the H-W percentage for land uses where most vehicle trips are generated by employees and thus decreasing the other trip purposes. Likewise, shopping related land uses may need to have lower H-W and W-O percentages and higher O-O percentages. For example, trip purpose splits shown in Table C-7 were developed by the Transportation Research Board (2021). The comparison demonstrates the general differences between retail and service land uses.

Table C-7. Vehicle Trip Purpose Split Comparison for Retail versus Service Land Uses

Trip Purpose	Retail [a]	Service (e.g., Commercial) [b]
H-W	15%	26%
W-O	54%	53%
O-O	32%	21%

H-W = home-work; O-O = other-other; W-O = work-other
[a] Retail includes North American Industry Classification System (NAICS) codes 44-45.
[b] Service includes NAICS codes 52-92.

The user should note that differences can be much larger than shown in Table C-7. As evidence, consider TAZ 1064 from the CSTDM. This TAZ has a H-W trip purpose split of 71 percent. This high value is due to the large amount (over 5,000) and concentration of office employees in the TAZ compared to other non-residential uses. If a project involved adding more office space to this TAZ, the current split may be reasonable, whereas, adding a retail land use could increase the proportion of W-O and O-O. As with other default inputs, trip purpose breakdown can be overwritten by the user.

5.1.1.2.4 Trip Length

5.1.1.2.4.1 Primary Trip Length

Each trip type has a primary trip length associated with it, which is the full distance from the trip origin to the trip destination with no intermediate stops. These trip lengths are based on the CSTDM or MPO/RTPA TAZ in which the project is located (refer to Tables G-18 and G-19). For residential projects, average primary vehicle trip lengths of all trip types are determined with the following equation. Non-residential land use types use a similar equation based on their trip types.

$$PTL_i = H\text{-}W_{miles} \times H\text{-}W_{trip\%} + H\text{-}S_{miles} \times H\text{-}S_{trip\%} + H\text{-}O_{miles} \times H\text{-}O_{trip\%}$$

Where:

PTL = average primary trip length.

$H\text{-}W_{miles}$ = H-W trip length.

$H\text{-}W_{trip\%}$ = % of the total primary trips that are H-W trips.

$H\text{-}S_{miles}$ = H-S trip length.

$H\text{-}S_{trip\%}$ = % of the total primary trips that are H-O trips.

$H\text{-}O_{miles}$ = H-O trip length.

$H\text{-}O_{trip\%}$ = % of the total primary trips that are H-O trips.

i = land use subtype.

5.1.1.2.4.2 Adjustment for Trip Link Type

Trip link types describe the characteristics of the vehicle trip attracted to each land use subtype, whether it is a primary trip, a diverted link trip, or a pass-by trip. Primary trips contain no intermediate stops. For example, a trip from home to work without any stops along the way would be 100 percent primary. In contrast, a commercial customer stopping for coffee on their way to work would represent a pass-by trip for the coffee shop, presuming the coffee shop was already on the same travel route to work. Hence, pass-by trips generate virtually no additional running emissions but could generate additional resting and startup emissions. Diverted trips involve a short diversion from the original travel route, which generates a small amount of running emissions while also generating additional resting and startup emissions. The VMT associated with a trip is adjusted by modifying the primary trip length to account for reductions from pass-by and diverted trips. The vehicle trip lengths mentioned above obtained from the CSTDM or MPO/RTPA database are for primary trip links. For pass-by trip links the vehicle trip length is 0.1 mile. For diverted trip links, the vehicle trip length is 2 miles. This value represents the typical diversion from a freeway to adjacent highway commercial uses for urban/suburban areas. Diverted trips from arterials may be shorter or longer depending on the type of project and the study area roadway configuration. Note that only the primary trip lengths have data fields presented on the **Vehicle Data** screen. The diverted link trip length (2 miles), and pass-by trip length (0.1 mile) are constants stored in the backend of the model.

The trip link percentages in CalEEMod are from the *3rd Edition Trip Generation Handbook* (ITE Handbook) (ITE 2017b) (refer to Table G-20). Not all land use subtypes or analysis days (e.g., weekday, Saturday, and Sunday) are included in the ITE Handbook so the user should carefully review the information. The trip link percentages can be overwritten if the user can provide justification for alternative sources of data (e.g., project-specific traffic study) that demonstrate different breakdowns. The ITE Handbook does not contain trip link percentages for 83 of the non-linear land use subtypes used in CalEEMod. In most cases, these land use subtypes were coded as having 100 percent primary trips. This default minimizes the potential for underestimation of VMT but could contribute to overestimation. If land use subtypes are similar—i.e., Movie Theater (No Matinee) may have similar trip patterns as Quality Restaurant—then the user can consider replacing the land use subtype with missing diverted or pass-by percentages with the percentages of the similar land use subtype. Likewise, if diverted or pass-by trips are not desired for those land use subtypes where defaults are given, the user can change the default percentages to 0 and have primary equal 100 percent. Since ITE did not include any diverted or pass-by percentages for Sundays, the Saturday values were substituted to minimize the potential for substantially overestimating Sunday VMT.

5.1.1.3 Example VMT and Trips Calculation

The following example shows each step of how CalEEMod calculates the annual average day and peak day VMT and trips for a Regional Shopping Center land use subtype.[12] Both of these outputs are needed to calculate mobile running, mechanical, and evaporative emissions. Figure C-2 illustrates these steps.

1. The user enters project location on the **Home** screen and the land use subtype and unit amount on the **Land Use** screen.

   Location = Sacramento (CSTDM TAZ 660)

[12] Results in each equation are the product of calculations performed within CalEEMod and may not match manual computations using rounded values.

Land Use Subtype = Regional Shopping Center (ITE Land Use Code 820)

Unit = 1000 sqft (KSF)

Size = 75 (i.e., 75,000 sqft)

2. CalEEMod will return the following defaults on the **Vehicle Data** screen based on the inputs from step 1 above.

   - Weekday, Saturday, and Sunday average vehicle trip rates

     37.75 trips per weekday per unit (KSF)

     46.12 trips per Saturday per unit (KSF)

     21.10 trips per Sunday per unit (KSF)

   - Weekday vehicle primary trip lengths. As noted above, diverted and pass-by trip lengths are constants stored in the backend of the model. Also, residential trip lengths are zeroed out because the project's land use type is non-residential.

     10.06 miles per Non-Res H-W trip

     7.69 miles per Non-Res W-O trip

     6.44 miles per Non-Res O-O trip

     0.00 miles per Res H-W trip

     0.00 miles per Res H-S trip

     0.00 miles per Res H-O trip

   - Weekday and Saturday primary, diverted, and pass-by percentages. Saturday values are also used for Sunday estimates.

     37.9% for primary weekday trips

     28.1% for diverted weekday trips

     34.0% for pass-by weekday trips

     42.5% for primary Saturday trips

     31.5% for diverted Saturday trips

     26.0% for pass-by Saturday trips

   - Vehicle trip purpose percentages. Residential trip lengths are zeroed because the project's land use type is non-residential.

     17.4% for Non-Res H-W primary weekday trips

     9.0% for Non-Res W-O primary weekday trips

     73.5% for Non-Res O-O primary weekday trips

     0.0% for Res H-W primary weekday trips

     0.0% for Res W-O primary weekday trips

     0.0% for Res O-O primary weekday trips

3. CalEEMod calculates the number of primary, diverted, and pass-by vehicle trips for each analysis day using the following equations.

$$\text{Weekday}_{\text{primary}} = 75 \text{ KSF} \times 37.75 \text{ trips/KSF} \times 37.9\% = 1{,}074 \text{ trips/day}$$

$$\text{Saturday}_{\text{primary}} = 75 \text{ KSF} \times 46.12 \text{ trips/KSF} \times 42.5\% = 1{,}470 \text{ trips/day}$$

$$\text{Sunday}_{\text{primary}} = 75 \text{ KSF} \times 21.10 \text{ trips/KSF} \times 42.5\% = 673 \text{ trips/day}$$

$$\text{Weekday}_{\text{diverted}} = 75 \text{ KSF} \times 37.75 \text{ trips/KSF} \times 28.1\% = 795 \text{ trips/day}$$

$$\text{Saturday}_{\text{diverted}} = 75 \text{ KSF} \times 46.12 \text{ trips/KSF} \times 31.5\% = 1{,}089 \text{ trips/day}$$

$$\text{Sunday}_{\text{diverted}} = 75 \text{ KSF} \times 21.10 \text{ trips/KSF} \times 31.5\% = 498 \text{ trips/day}$$

$$\text{Weekday}_{\text{pass-by}} = 75 \text{ KSF} \times 37.75 \text{ trips/KSF} \times 34.0\% = 963 \text{ trips/day}$$

$$\text{Saturday}_{\text{pass-by}} = 75 \text{ KSF} \times 46.12 \text{ trips/KSF} \times 26.0\% = 899 \text{ trips/day}$$

$$\text{Sunday}_{\text{pass-by}} = 75 \text{ KSF} \times 21.10 \text{ trips/KSF} \times 26.0\% = 411 \text{ trips/day}$$

4. CalEEMod determines the total trips per day for Weekday, Saturday, and Sunday by summing the outputs from step 3 above. CalEEMod selects the peak day trip from these totals to quantify daily mobile source evaporative emissions.

$$\text{Weekday}_{\text{total}} = 1{,}074 + 795 + 963 = 2{,}831 \text{ trips/day}$$

$$\text{Saturday}_{\text{total}} = 1{,}470 + 1{,}089 + 899 = 3{,}459 \text{ trips/day}$$

$$\text{Sunday}_{\text{total}} = 673 + 498 + 411 = 1{,}582 \text{ trips/day}$$

$$\text{Peak day Trips} = \text{Saturday}_{\text{total}} = 3{,}459 \text{ trips/day}$$

5. CalEEMod calculates annual trips from step 4 above using the following equations. The annual trips total is used to quantify annual mobile source evaporative emissions.

$$\text{Annual Trips}_{\text{weekday}} = 2{,}831 \text{ trips/day} \times 5 \text{ days/week} \times 52.1429 \text{ weeks/year} = 738{,}148 \text{ trips/year}$$

$$\text{Annual Trips}_{\text{Saturday}} = 3{,}459 \text{ trips/day} \times 1 \text{ day/week} \times 52.1429 \text{ weeks/year} = 180{,}362 \text{ trips/year}$$

$$\text{Annual Trips}_{\text{Sunday}} = 1{,}582 \text{ trips/day} \times 1 \text{ day/week} \times 52.1429 \text{ weeks/year} = 82{,}516 \text{ trips/year}$$

$$\text{Annual Trips}_{\text{total}} = 738{,}148 + 180{,}362 + 82{,}516 = 1{,}001{,}026 \text{ trips/year}$$

6. CalEEMod multiplies the primary vehicle trip rates from step 3 above by the vehicle trip purpose percentages to (i.e., $\text{Weekday}_{\text{primary}}$ above is the sum of the below Weekday $\text{H-W}_{\text{primary}}$, Weekday $\text{W-O}_{\text{primary}}$, and Weekday $\text{O-O}_{\text{primary}}$) using the following equations.

$$\text{Weekday H-W}_{\text{primary}} = 1{,}074 \text{ trips/day} \times 17.4\% = 187 \text{ trips/day}$$

$$\text{Weekday W-O}_{\text{primary}} = 1{,}074 \text{ trips/day} \times 9.0\% = 97 \text{ trips/day}$$

$$\text{Weekday O-O}_{\text{primary}} = 1{,}074 \text{ trips/day} \times 73.5\% = 790 \text{ trips/day}$$

$$\text{Saturday H-W}_{\text{primary}} = 1{,}470 \text{ trips/day} \times 17.4\% = 256 \text{ trips/day}$$

$$\text{Saturday W-O}_{\text{primary}} = 1{,}470 \text{ trips/day} \times 9.0\% = 133 \text{ trips/day}$$

$$\text{Saturday O-O}_{\text{primary}} = 1{,}470 \text{ trips/day} \times 73.5\% = 1{,}081 \text{ trips/day}$$

$$\text{Sunday H-W}_{\text{primary}} = 673 \text{ trips/day} \times 17.4\% = 117 \text{ trips/day}$$

$$\text{Sunday W-O}_{\text{primary}} = 673 \text{ trips/day} \times 9.0\% = 61 \text{ trips/day}$$

$$\text{Sunday O-O}_{\text{primary}} = 673 \text{ trips/day} \times 73.5\% = 495 \text{ trips/day}$$

7. CalEEMod multiplies the vehicle trips from step 6 above by vehicle trip lengths using the following equations.

$$\text{Weekday H-W VMT}_{\text{primary}} = 187 \text{ trips/day} \times 10.06 \text{ miles/trip} = 1{,}883 \text{ miles/day}$$

$$\text{Weekday W-O VMT}_{\text{primary}} = 97 \text{ trips/day} \times 7.69 \text{ miles/trip} = 745 \text{ miles/day}$$

$$\text{Weekday O-O VMT}_{\text{primary}} = 790 \text{ trips/day} \times 6.44 \text{ miles/trip} = 5{,}083 \text{ miles/day}$$

$$\text{Weekday VMT}_{\text{diverted}} = 795 \text{ trips/day} \times 2.0 \text{ miles/trip} = 1{,}590 \text{ miles/day}$$

$$\text{Weekday VMT}_{\text{pass-by}} = 963 \text{ trips/per day} \times 0.1 \text{ mile/trip} = 96 \text{ miles/day}$$

$$\text{Weekday VMT}_{\text{total}} = 1{,}883 + 745 + 5{,}083 + 1{,}590 + 96 = 9{,}397 \text{ miles/day}$$

$$\text{Saturday H-W VMT}_{\text{primary}} = 256 \text{ trips/day} \times 10.06 \text{ miles/trip} = 2{,}579 \text{ miles/day}$$

$$\text{Saturday W-O VMT}_{\text{primary}} = 133 \text{ trips/day} \times 7.69 \text{ miles/trip} = 1{,}020 \text{ miles/day}$$

$$\text{Saturday O-O VMT}_{\text{primary}} = 1{,}081 \text{ trips/day} \times 6.44 \text{ miles/trip} = 6{,}961 \text{ miles/day}$$

$$\text{Saturday VMT}_{\text{diverted}} = 1{,}089 \text{ trips/day} \times 2.0 \text{ miles/trip} = 2{,}178 \text{ miles/day}$$

$$\text{Saturday VMT}_{\text{pass-by}} = 899 \text{ trips/day} \times 0.1 \text{ mile/trip} = 90 \text{ miles/day}$$

$$\text{Saturday VMT}_{\text{total}} = 2{,}579 + 1{,}020 + 6{,}961 + 2{,}178 + 90 = 12{,}829 \text{ miles/day}$$

$$\text{Sunday H-W VMT}_{\text{primary}} = 117 \text{ trips/day} \times 10.06 \text{ miles/trip} = 1{,}180 \text{ miles/day}$$

$$\text{Sunday W-O VMT}_{\text{primary}} = 61 \text{ trips/day} \times 7.69 \text{ miles/trip} = 467 \text{ miles/day}$$

$$\text{Sunday O-O VMT}_{\text{primary}} = 495 \text{ trips/day} \times 6.44 \text{ miles/trip} = 3{,}185 \text{ miles/day}$$

$$\text{Sunday VMT}_{\text{diverted}} = 498 \text{ trips/day} \times 2.0 \text{ miles/trip} = 997 \text{ miles/day}$$

$$\text{Sunday VMT}_{\text{pass-by}} = 411 \text{ trips/day} \times 0.1 \text{ mile/trip} = 41 \text{ miles/day}$$

$$\text{Sunday VMT}_{\text{total}} = 1{,}180 + 467 + 3{,}185 + 997 + 41 = 5{,}869 \text{ miles/day}$$

8. CalEEMod selects the peak day trip from step 7 above to quantify daily mobile source running and mechanical emissions.

$$\text{Peak day VMT} = \text{Saturday VMT}_{\text{total}} = 12{,}829 \text{ miles/day}$$

9. CalEEMod calculates annual VMT from step 7 above using the following equations. The annual VMT total is used to quantify annual mobile source running and mechanical emissions.

$$\text{Annual VMT}_{weekday} = 9{,}397 \text{ miles/day} \times 5 \text{ days/week} \times 52.1429 \text{ weeks/year} = 2{,}449{,}948 \text{ miles/year}$$

$$\text{Annual VMT}_{Saturday} = 12{,}829 \text{ miles/day} \times 1 \text{ day/week} \times 52.1429 \text{ weeks/year} = 668{,}947 \text{ miles/year}$$

$$\text{Annual VMT}_{Sunday} = 5{,}869 \text{ miles/day} \times 1 \text{ day/week} \times 52.1429 \text{ weeks/year} = 306{,}045 \text{ miles/year}$$

$$\text{Annual VMT}_{total} = 2{,}449{,}948 + 668{,}947 + 306{,}045 = 3{,}424{,}938 \text{ miles/year}$$

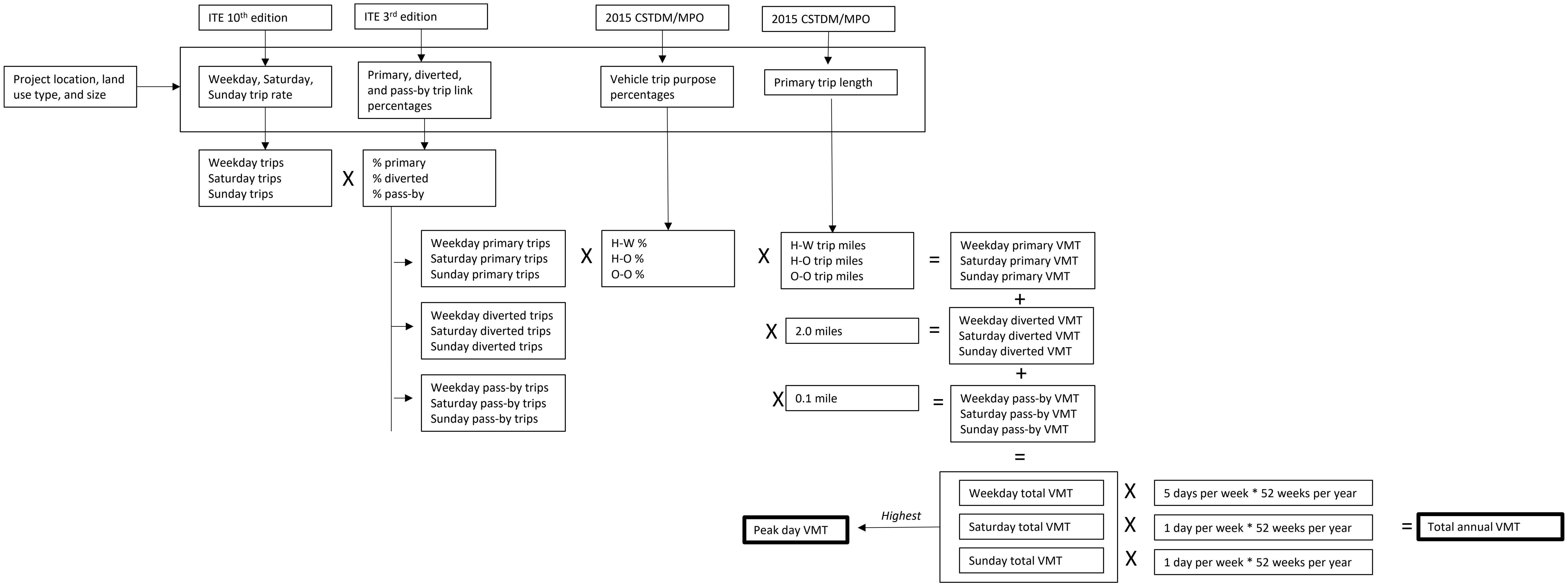

Figure C-2. Vehicle Miles Traveled Calculation Method

5.1.2 Fleet Mix Screen

This screen displays for the operational analysis year the default vehicle fleet mix by land use type and season (Annual, Summer, and Winter). The default fleet mix is based on data from EMFAC2021 for the user-selected analysis level (e.g., county) and operational year (e.g., 2030).

5.1.3 Vehicle Emission Factors Screen

All vehicle emission factors, except those for HFCs, are based on EMFAC2021 v1.0.1 (CARB 2021d). EMFAC2021 emission rate data for each vehicle class includes multiple emission types that are presented with varying units. Running and mechanical emissions are presented in units of grams per mile (g/mile), while starting and evaporative emissions are presented in units of grams per trip (g/trip), and idling emissions are presented in units of grams per vehicle per day (g/vehicle/day). The emission rate data in EMFAC2021 is not readily available in a format that is compatible with CalEEMod vehicle emission factor formats. In addition, EMFAC2021 emission rate data is presented for vehicle class and fuel type combinations while CalEEMod vehicle emission factors are aggregated over all fuel types for each vehicle class. Thus, emission rates output by EMFAC2021 are not directly used. Rather, post-processed EMFAC2021 emission inventory and activity data are the basis for CalEEMod vehicle emission factors. Emission type and fuel type data are aggregated for each vehicle class to develop emission factors by vehicle class for use in CalEEMod.

The following sections describe the methodology by which EMFAC2021 emissions inventory and activity data were processed to develop vehicles emission rates for CalEEMod. Following this, the equations and variables used to develop emission factors for HFC and road dust are provided.

5.1.3.1 Vehicle Emission Factors from EMFAC2021

5.1.3.2 EMFAC2021 Emissions Inventory Data

For each desired calendar year (2010–2050), vehicle model year, vehicle type and season (Annual, Summer, and Winter), detailed daily EMFAC2021 inventory outputs were provided by CARB in MySQL database format for the following geographies: counties, air basins, air districts and statewide for all fuel types (e.g., gasoline, diesel, and electric). The EMFAC2021 MySQL emissions data were provided for the aggregated speed option. The EMFAC2021 MySQL emissions data is the basis of CalEEMod emission factors.

5.1.3.3 EMFAC2021 Emissions Inventory Units versus CalEEMod Emission Factor Units

In CalEEMod, running emission factors for all pollutants and PM emissions from tire and brake wear are in units of grams per vehicle miles traveled (g/VMT). For all other emission types, emission factors are in units of g/trip (derived as total emissions divided by the total number of trips). Table C-8 summarizes the acronyms, descriptions, and units of each vehicle emission type and activity in EMFAC2021 and the corresponding emission factor units as presented in CalEEMod.

Table C-8. EMFAC2021 Emission Types and Activity

EMFAC2021 Acronyms for Each Vehicle Emission Type	EMFAC2021 Description of Each Vehicle Emission Type	EMFAC2021 Emission Rate Unit	CalEEMod Emission Factor Unit
RUNEX	Running exhaust	short tons/day	g/mile
PMBW	PM brakewear	short tons/day	g/mile
PMTW	PM tirewear	short tons/day	g/mile
STREX	Start exhaust	short tons/day	g/trip
HTSK	Hot Soak evaporative	short tons/day	g/trip
RUNLS	Running Loss evaporative	short tons/day	g/trip
IDLEX	Idle exhaust	short tons/day	g/trip
RESTL	Resting Loss evaporative	short tons/day	g/trip
DIURN	Diurnal Loss evaporative	short tons/day	g/trip
VMT	Vehicle miles traveled	miles/day	miles (per day, per season, or per year)
Trip	Total trips per day of a vehicle class	trips/day	trips (per day, per season, or per year)
Population	Vehicle population	vehicle	vehicle

5.1.3.4 Conversion from EMFAC2021 Emissions Inventory to CalEEMod Emission Factors

EMFAC2021 emissions are disaggregated by fuel types while CalEEMod vehicle emission factors are aggregated across fuel types. Therefore, CalEEMod emission factors were estimated based on average EMFAC2021 emission rates for each vehicle type, weighted according to annual VMT, annual trips, or vehicle population.

CalEEMod emission factors for each emission mode by vehicle class were calculated based on EMFAC2021 emissions inventory output according to the following equations. Emission factors were combined across fuel types for each emission mode by weighting according to the same activity types (i.e., VMT or trips) as applied in the following equations.

CalEEMod emission factors of all vehicle classes are calculated according to the following equations.

$$RUNEX_{CalEEMod} = \sum_{i,j}\left[\left(\frac{RUNEX_{DailyEmissions}}{VMT} \times UC\right)_{i,j} \times \frac{VMT_{i,j}}{\sum VMT}\right]$$

$$PMBW_{CalEEMod} = \sum_{i,j}\left[\left(\frac{PMBW_{DailyEmissions}}{VMT} \times UC\right)_{i,j} \times \frac{VMT_{i,j}}{\sum VMT}\right]$$

$$PMTW_{CalEEMod} = \sum_{i,j}\left[\left(\frac{PMTW_{DailyEmissions}}{VMT} \times UC\right)_{i,j} \times \frac{VMT_{i,j}}{\sum VMT}\right]$$

$$STREX_{CalEEMod} = \sum_{i,j}\left[\left(\frac{STREX_{DailyEmissions}}{Trips} \times UC\right)_{i,j} \times \frac{Trips_{i,j}}{\sum Trips}\right]$$

$$HTSK_{CalEEMod} = \sum_{i,j}\left[\left(\frac{HTSK_{DailyEmissions}}{Trips} \times UC\right)_{i,j} \times \frac{Trips_{i,j}}{\sum Trips}\right]$$

$$DIURN_{CalEEMod} = \sum_{i,j}\left[\left(\frac{DIURN_{DailyEmissions}}{Trips} \times UC\right)_{i,j} \times \frac{Trips_{i,j}}{\sum Trips}\right]$$

$$RESTL_{CalEEMod} = \sum_{i,j}\left[\left(\frac{REST_{DailyEmissions}}{Trips} \times UC\right)_{i,j} \times \frac{Trips_{i,j}}{\sum Trips}\right]$$

$$RUNLS_{CalEEMod} = \sum_{i,j}\left[\left(\frac{RUNLS_{DailyEmissions}}{Trips} \times UC\right)_{i,j} \times \frac{VMT_{i,j}}{\sum VMT}\right]$$

$$IDLEX_{CalEEMod} = \sum_{i,j}\left[\left(\frac{IDLEX_{DailyEmissions}}{Trips} \times UC\right)_{i,j} \times \frac{Pop_{i,j}}{\sum Pop}\right]$$

Where:

$RUNEX_{CalEEMod}$, $PMBW_{CalEEMod}$, $PMTW_{CalEEMod}$, $STREX_{CalEEMod}$, $HTSK_{CalEEMod}$, $RUNLS_{CalEEMod}$, $IDLEX_{CalEEMod}$, $DIURN_{CalEEMod}$, $RESTL_{CalEEMod}$ = CalEEMod vehicle emission factors by vehicle class or vehicle class grouping (g/mi or g/trip).

Daily Emissions = total pollutant emissions (short tons/day) output from EMFAC2021 by vehicle class.

VMT = total VMT (miles/day) output from EMFAC2021 by vehicle class.

Trips = total number of trips (trips/day) output from EMFAC2021 by vehicle class.

Pop = total number of vehicles (number) with non-zero idling emissions per day output from EMFAC2021 by vehicle class.

UC = conversion factor from short tons to grams (90,7184.740760757 g/short ton).

i = fuel type.

j = model year.

5.1.3.5 HFC Emission Factors

HFCs are organic compounds that contain fluorine and hydrogen atoms and are mainly used as refrigerants in air conditioning (A/C) systems. HFCs are a type of GHG with global warming potentials (GWP) up to thousands of times larger than CO_2. HFC emissions (assumed to be HFC-134a) from on-road mobile sources are primarily from refrigerant leakage, which increases when A/C units are in operation.

HFC emission factors are based on information provided by CARB (2017c) and are calculated using a top-down approach (i.e., the factors are derived from total emission inventory estimates and activity data). CARB estimated that the annual HFC-134a emissions were 49 grams per year from each light-duty vehicle (LDV), and 257 grams per year from each heavy-duty vehicle (HHDV) (CARB 2007; CARB 2017c). These estimates reflect three assumptions.

1. Vehicle A/C operates during 5 summer (or relatively warm) months per year.
2. The winter (or relatively cold) month emission rate is 18 percent of the summer month emission rate.
3. The in-use A/C operates on average for 1 hour in LDVs per weekday and for 8 hours in HHDVs on all days of the week.

CARB then estimated the average (statewide) leakage rates, as shown in Table C-9. HFC emission factors are calculated as a running loss rate (g/hr) and can be converted to a g/mile rate by assuming a fleet-average vehicle speed.

Table C-9. Statewide Hydrofluorocarbon (HCF) Leak Rates for Light- and Heavy-Duty Vehicles

Air Conditioning Operation	Light-Duty Vehicles (g HFC-134a/hour)	Heavy-Duty Vehicles (g HFC-134a/hour)
On	0.0616	0.1512
Off	0.0089	0.0218
Weighted average	0.031	0.076

Under USEPA's Significant New Alternatives Policy (SNAP), HFC-134a must be replaced by refrigerants with much lower GWPs. The use of HFC-134a is forbidden in new light-duty vehicles starting in 2021 and forbidden in all new vehicles starting in 2026. The SNAP requirement does not apply to existing vehicles. As a result, HFC emissions from on-road vehicles will decrease over time as new vehicles with alternative refrigerants are introduced into the vehicle fleet, and as older vehicles with HFC refrigerants are retired from the fleet.

The following steps were taken to develop HFC emission factors by vehicle category (VC) for each geographic area (A), calendar year (Y), and season (S) ($EF(HFC, A, Y, S)^{VC}_{RUNLOSS}$) for CalEEMod.

1. The weighted-average HFC leakage rate for LDV (0.031 g/h) was used for the Non-Truck category, and the weighted average HFC leakage rate for HHDV (0.076 g/hr) was used for both Truck 1 and Truck 2 categories. Truck/Non-Truck emission factors were mapped to their corresponding EMFAC 2021 vehicle classes, and the associated VMT data, which was obtained from EMFAC2021.
2. HFC emission factors were set to 0 for 2021 and later model year (MY) LDV and for 2026 and later MYs HHDV, per USEPA's SNAP regulation.
3. For each vehicle category, geographic area, calendar year, and season, the emission factor (g/mi) was calculated as a weighted average emission rate based on VMT.

$$EF(HFC,A,Y,S)^{VC} = \frac{\sum_v ER_{On}^{VC(MY)} \times VMT(A,Y,S)^{v(\Sigma,MY)}}{\sum_v VMT(A,Y,S)^{v(\Sigma,MY)} \times \bar{v}(A,Y,S)^{v(\Sigma,MY)}}$$

Where:

EF = HFC emission factor (g/mile).

ER = HFC leakage (emission) rate (g/hr).

VC = vehicle category factor (g/mile).

VMT = vehicle miles traveled (miles).

$\bar{v}$ = mean vehicle category speed (mph).

A = geographic area.

Y = calendar year.

S = season.

MY = model year.

The mean vehicle speed is used to convert the emission factor from a running loss factor (g/hr) to g/mile and was calculated for each area and year from the default VMT speed distributions in EMFAC2021. Emission factors calculated for EMFAC 2021 vehicle classes were traced to their analogous EMFAC2007 vehicle classes.

1. HFC emission factors for each geographic area were mapped to their corresponding air district and air basin, and aggregated, resulting in emission factors for each district and basin, for each vehicle category, calendar year, and season. In addition, statewide emission factors for each vehicle category, calendar year, and season were calculated by aggregating emission factors from every geographic area.
2. HFC emission factors by season were then derived assuming that:

- On average, A/C is on for 5 "hot" months and off for 7 "cold" months during the year. This results in seasonal weighting factors of $^5/_{12} = 0.41667$ for A/C-On and $^7/_{12} = 0.58333$ for A/C-Off.
- The emission factors for "hot" months are used for summer emission factors, and the emission factors for "cold" months are used for winter emission factors.
- The seasonal weighting factors are used to generate annual emission factors. This approach is consistent with the methods used by CARB to develop the annual emissions inventory.

3. For areas where Urban Bus (UBUS) VMT data was unavailable in EMFAC2021, the “Other Buses” (OBUS) HFC emission factors for the corresponding area and year were substituted as replacement values for years before 2020.

5.1.4 Road Dust Screen

Vehicles that drive on both paved and unpaved roads generate fugitive dust by dispersing the silt from the roads. Fugitive dust emission factors for travel on paved roads are calculated using the methodology described in Section 13.2.1 of USEPA’s AP-42, as shown below (USEPA 2011).

$$EF_{paved} = (k \times (sL)^{0.91} \times (W)^{1.02}) \times (1 - P/4N)$$

Where:

EF_{paved} = paved road dust emission factor (g/mile).

k = particle size multiplier for particle size range. The AP-42 default values are 0.25 g/VMT for PM2.5 and 1.00 g/VMT for PM10.

sL = road surface silt loading (g/m^2). The AP-42 default value is 0.1 g/m^2, which corresponds to vehicle travel on roads with at least 5,000 vehicle per day under normal conditions.

W = average weight (short tons) of *all the vehicles* traveling the road. The statewide default is 2.4 short tons (CARB 2021e).

P = number of “wet” days with at least 0.254 mm (0.01 in) of precipitation during the averaging period. The precipitation frequency is based on the project location and is listed on the **Project Detail** screen.

N = number of days in the averaging period (e.g., 365 for annual, 91 for quarterly). The model does not include a precipitation adjustment in the daily calculation.

Fugitive dust emission factors for travel on *unpaved* roads are calculated using the methodology described in Section 13.2.2 of USEPA’s AP-42, as shown below (USEPA 2006b).

$$EF_{unpaved} = \left(\frac{k(s/12)^1 (S/30)^{0.5}}{(M/0.5)^{0.2}} - C\right) \times \left(1 - \frac{P}{365}\right)$$

Where:

$EF_{unpaved}$ = unpaved road dust emission factor (g/mile).

k = particle size multiplier for particle size range. The AP-42 default values are 816.47 g/VMT for PM2.5 and 81.65 g/VMT for PM10.

s = surface material silt content (%). The model assumes the AP-42 default of 8.5 for scraper routes unless the project is in the San Luis Obispo Air Pollution Control District (SLOAPCD). For projects located in the SLOAPCD, the model defaults to 9.3 per air district guidance.

M = surface material moisture content (%). The model assumes a default average moisture content of 0.5 unless the project is in the SLOAPCD. For projects located in the SLOAPCD, the model defaults to 0.1 per air district guidance.

S = mean vehicle speed (mph). The model assumes a default average speed of 40 mph unless the project is in the SLOAPCD. For projects located in the SLOAPCD, the model defaults to 32.4 mph per air district guidance.

C = emission factor for vehicle fleet exhaust, brakewear, and tirewear.

P = number of days in a year with at least 0.254 mm (0.01 in) of precipitation. The precipitation frequency is based on the project location and is listed on the **Project Detail** screen.

By default, CalEEMod assigns project VMT to unpaved and paved roads based on the percentage of paved and unpaved roads at the user-selected analysis scale (refer to Table G-21). The user may modify the percentage of unpaved roads if project-specific information is available. Likewise, the user may elect to use emission factors from CARB's statewide emission inventory, which are 2.0 lb PM10/VMT and 0.2 lb PM2.5/VMT.

5.1.5 Mobile Source Emissions Quantification

CalEEMod emissions from mobile sources are calculated using the emission factors described in the previous sections and the forecasted vehicle trips and VMT for the project (either input directly by the user or generated according to the method described in Section 5.1.1.1, *Default Vehicle Trips and VMT*).

Running, mechanical (i.e., tirewear and brakewear), and road dust emissions are calculated according to the following equation.

$$E_p = EF_p \times VMT$$

Where:

E = running and mechanical emissions (g/day or g/yr).

EF = emission factor (g/VMT).

VMT = vehicle miles traveled (miles/day or miles/yr).

p = pollutant.

Starting, evaporative, and idling emissions are calculated according to the following equation.

$$E_p = EF_p \times Trip$$

Where:

E = starting, evaporative, and idling emissions (g/day or g/yr).

EF = emission factor (g/trip).

Trip = trips (trips/day or trips/yr).

p = pollutant.

5.2 Area Sources Submodule

The **Area Sources** submodule calculates operational emissions from hearths, consumer products, architectural coatings, and landscape equipment. Emissions associated with natural gas usage in space heating, water heating, and stoves are calculated in the **Energy Use** screen (see Section 5.3.1, *Energy Use Screen*).

5.2.1 Hearths Screen

CalEEMod calculates the emissions from wood stoves and fireplaces. Available wood stove fuel types are conventional, catalytic, non-catalytic, and pellet. The fireplace fuel types are wood, gas, propane, and electric. All fuel types are considered non-biogenic except for wood. CO_2 emissions from the combustion of wood (or biomass) are considered biogenic. Some protocols do not consider these emissions to be a part of the emission inventory. Therefore, CalEEMod reports these CO_2 emissions separate from anthropogenic GHG emissions.

Default values related to hearth activity are available for Residential land use types. The defaults vary by Residential land use type (e.g., Single Family Housing) and air district, though there are also statewide defaults. The default values for the number of wood stoves or hearths (i.e., number of devices installed in all DUs), the amount of wood burned by different hearth types, and the daily and annual duration of activity are based on CARB (2011) and air district supplied values (refer to Table G-22).

Hearth emission factors are based on various sources (USEPA 1996a; USEPA 1996b; USEPA 2015; USEPA 2020) (refer to Table G-23). The following sections provide further detail on the quantification of these emissions by hearth type.

5.2.1.1 Wood Stoves and Wood Fireplaces

The equation to calculate the annual biogenic GHG emissions associated with all wood stove types and wood fireplaces is shown below.

$$E_{SWF} = EF_{SWF} \times UC_1 \times W \times UC_2 \times SWF$$

Where:

> E_{SWF} = wood stove or wood fireplace biogenic GHG emissions (MT/yr).
>
> EF_{SWF} = wood stove or wood fireplace emissions factor (lb/short ton wood) (USEPA 1996a; USEPA 1996b; CARB 2011) (Table G-23).
>
> UC_1 = unit conversion from lb to MT (0.00045359290943564 MT/lb).
>
> W = wood burned (lb/unit/yr).
>
> UC_2 = unit conversion from lb to short ton (0.0005 short ton/lb).
>
> SWF = number of this type of wood stove or wood fireplace in the project.

The emission factors for criteria pollutants are derived from the same sources as the GHG emission factors (USEPA 1996a; USEPA 1996b). The only difference in the equation for criteria pollutant emissions is the unit conversion, as GHG emissions are presented in MT per year and criteria pollutant emissions are presented in short tons per year.

5.2.1.2 Natural Gas and Propane Fireplaces

The equation to calculate the annual non-biogenic GHG emissions associated with natural gas and propane fireplaces is shown below.

$$E_{GPF} = EF_{GPF} \times H \times D \times R \times UC \times GPF$$

Where:

E_{GPF} = natural gas or propane fireplace non-biogenic GHG emissions (MT/yr).

EF_{GPF} = natural gas or propane fireplace non-biogenic GHG emissions factor (lb/MMbtu) (USEPA 2020) (Table G-23).

H = daily duration of fireplace activity (hr/day).

D = annual duration of fireplace activity (days/yr).

R = heating rate (0.06 MMBtu/hr) (South Coast AQMD 2008).

UC = unit conversion from lb to MT (0.00045359290943564 MT/lb).

GPF = number of natural gas or propane fireplaces in the project.

The two differences between the equation for non-biogenic GHG emissions and criteria pollutant emissions are the emission factor source (USEPA 1998a) and the unit conversion, as GHG emissions are presented in MT per year and criteria pollutant emissions are presented in short tons per year. The criteria pollutant emission factors are derived by assuming natural gas has 1,020 BTU per standard cubic foot.

5.2.1.3 Electric Fireplaces

The equation to calculate the annual non-biogenic GHG emissions associated with electric fireplaces is shown below.

$$E_{EF} = U_{EF} \times E \times UC_1 \times UC_2 \times GPF$$

Where:

E_{EF} = electric fireplace non-biogenic GHG emissions (MT/yr).

U_{EF} = carbon intensity of electric utility (lb pollutant/MWh) (Table G-3).

E = electricity consumption of an electric fireplace (270.84 kWh/fireplace/yr) (Sacramento Metropolitan Air Quality Management District 2021).

UC_1 = unit conversion from kWh to MWh (0.001 MWh/kWh).

UC_2 = unit conversion from lb to MT (0.00045359290943564 MT/lb).

GPF = number of electric fireplaces in the project.

The average electricity consumption of an electric fireplace was derived assuming that 56 percent of electric fireplaces are for aesthetics and consume 235 kWh per year while the remaining 44 percent of electric fireplaces are for heating and consume 299 kWh per year (Sac Metro AQMD 2021). There are no direct criteria pollutant emissions associated with electric fireplaces.

5.2.2 Consumer Products Screen

Consumer products are chemically formulated products used by household and institutional consumers, including degreasers; fertilizers/pesticides; detergents; cleaning compounds; polishes; floor finishes; cosmetics; personal care products; home, lawn, and garden products; disinfectants; sanitizers; aerosol paints; and automotive specialty products. Consumer products do not include other paint products, furniture coatings, or architectural coatings.

CalEEMod calculates the fugitive VOC emissions from three types of consumer products: general category, pesticides/fertilizers, and parking degreasers. The emission calculation variables for each consumer product type differs slightly based on the land use subtypes.

The generic equation for fugitive VOC emissions from consumer products is as follows.

$$E = EF \times A$$

Where:

E = consumer products emissions (lb VOC/day).

EF = consumer products emission factor (lb VOC/sqft/day).

A = consumer product use area (sqft).

For general category consumer products, the emission factor is 2.14×10^{-5} lb/sqft/day for projects located outside of the South Coast AQMD boundary and is 1.98×10^{-5} lb/sqft/day for projects located within the South Coast AQMD boundary. For pesticides/fertilizers the emission factor is 7.86×10^{-8} lb/sqft/day, and for parking degreasers it is 5.68×10^{-7} lb/sqft/day. See Appendix D, *Technical Source Documentation for Emissions Calculations*, for derivation of all consumer product type emission factors.

The general category emission calculation does not apply to Parking land use types. For all land use subtypes other than City Park, Golf Course, and Recreational Swimming Pool, the consumer product use area for the general category emission calculation is the building square footage value from the **Land Use** screen. If the land use subtype is either City Park, Golf Course, or Recreational Swimming Pool, the consumer product area is the recreational building square footage value.

The pesticide/fertilizer emission calculation only applies if the land use subtype is City Park or Golf Course. The consumer product use area is equal to the landscape area.

The parking degreaser emission calculation only applies if the land use type is Parking. The consumer product use area is equal to the lot acreage (converted to square feet).

5.2.3 Architectural Coatings Screen

VOC off-gassing emissions result from evaporation of solvents contained in surface coatings such as in paints and primers. The program calculates the VOC evaporative emissions from application of residential and non-residential surface coatings using the following equation, which is slightly different than the VOC evaporative emissions from coatings applied during construction (Section 4.8¸ *Architectural Coatings Screen*).

$$E_{AC} = EF_{AC} \times F \times A \times R$$

Where:

E_{AC} = architectural coating emissions (lb VOC/day).

EF_{AC} = architectural coating emission factor (lb VOC/sqft).

F = fraction of surface area coated (%). For all land use types except Parking, the default values are 25% for the exterior surface and 75% for the interior, which are based on an analysis conducted by South Coast AQMD. The fractions for the Parking land use type are 90% for interior surfaces and 10% for the exterior shell.

A = building surface area (sqft). The program assumes the total surface area for painting equals 2.7 times the building square footage for the residential land uses;2.0 times the building square footage for non-residential land use; 2.0 times the recreational building square footage for City Park, Golf Course, and Recreational Swimming Pool land use subtypes; and 0.05 times the lot acreage (converted to square feet) for the Parking land use type (South Coast AQMD 1993:Table A9-13-C). All land use information provided by a metric other than square footage (e.g., gasoline station pumps) will be converted to square footage using the default conversions or user-defined equivalence.

R = rate at which surfaces are repainted (%). All buildings are assumed to be repainted at a rate of 10% of area per year based on the assumptions used by South Coast AQMD.

The emission factor is based on the VOC content of the surface coatings and is calculated by using the following equation.

$$EF_{AC} = C_{VOC} \times UC_1 \times UC_2 \div C$$

Where:

EF_{AC} = architectural coating emission factor (lb VOC/sqft).

C_{VOC} = VOC content (g/L). This typically varies by air district and year (Table G-17).

UC_1 = unit conversion from lb to grams (0.00220462262 lb/g).

UC_2= unit conversion from L to gal (3.78541 L/gal).

C = coverage of one gal of surface coatings (180 sqft/gal).

CalEEMod also calculates the VOC emissions from the painting of stripes, handicap symbols, directional arrows, and car space descriptions in parking lots. See Appendix D, *Technical Source Documentation for Emissions Calculations*, for the studies conducted to determine a default percent of parking lot square footage that is painted. The equation for estimating striping emissions is the same as the equation for E_{AC} above, except that A is calculated using the following equation.

$$A = A_{PL} \times P$$

Where:

A_{PL} = parking lot area (sqft).

P = percent of parking lot area that is painted (6%).

The VOC content limit for parking area coatings is either provided by local air districts or based on the exterior coating VOC limit of the area where the project is located.

5.2.4 Landscape Equipment Screen

Landscape maintenance includes fuel combustion emissions from equipment such as lawn mowers, shredders/grinders, and leaf blowers. Projects located in colder climates may also generate landscape-related emissions during the winter months from snow removal equipment. CalEEMod can generate landscaping emissions based on statewide average equipment emission intensities for the number of snow and summer days for the project location. Alternatively, the user may input operating assumptions for individual landscaping equipment that will be required for the project.

5.2.4.1 Emissions from Statewide Defaults

Default statewide emission rates from landscaping equipment were developed using CARB's Small Off-Road Engines Model v1.1 (SORE2020) (CARB 2020b) (refer to Table G-24). The model was used along with the total building square footage and DUs in California to determine two emission factors (CEC 2020; California Department of Finance 2020). The emissions factor for commercial landscape equipment is in g/sqft of non-residential building space per day. The emissions factor for residential landscape equipment is in grams per DU per day. CalEEMod multiplies these emission factors by the number of summer days or winter days for the project location, which are assumed to represent the number of equipment operational days (refer to Table G-25). For some regions that do not have snow during winter, the number of actual days for the purpose of calculating landscaping emissions is typical of summer weather, at either 330 or 365 days per year (e.g., South Coast, Sacramento, San Joaquin Valley) unless specified by the local air district. However, regardless of the location, CalEEMod applies a default of 250 days per year for non-residential (e.g., commercial land uses) landscaping equipment because they would likely only operate during weekdays.

5.2.4.2 Emissions from User-Defined Equipment Inputs

A user who has a project-specific landscaping equipment inventory may estimate emissions by manually inputting equipment operating assumptions. CalEEMod calculates the exhaust emissions (running, starting, and evaporative) based on CARB's OFFROAD2017 methodology using the equation presented in Section 4.2, *Off-Road Equipment Screen*. The user must enter the number of pieces of equipment, fuel type, and hours of operation for each selected equipment type. Defaults are available for equipment horsepower and load factor. The following sections describe the development methodology for the equipment emission factors, default average horsepower, and load factor.

5.2.4.2.1 Emission Factor

Landscaping equipment (e.g., chainsaws, leaf blowers/vacuums, trimmers/edgers/brush cutters) emission factors are estimated using the Small Off-Road Engines Model v1.1 (SORE2020) (CARB 2020c) (refer to Table G-26). SORE2020 was run for an annual time period for all California counties for 41 scenario years (2010–2050). Emission factors for each equipment type and horsepower range combination were estimated based on daily exhaust and evaporative emissions and activity according to the following formula.

$$EF_p = \frac{E_p \times UC_1 \times UC_2}{Pop \times hp \times Activity \times LF}$$

Where:

EF = emission factor (g/bhp-hr) (Table G-26).

E = total exhaust or evaporative emissions (short tons/day).

UC_1 = unit conversion from daily emissions to annual emissions (365 days/year).

UC_2 = unit conversion from short tons to grams (90,7184.740760757 g/short ton).

Pop = total annual equipment population (number).

hp = average off-road equipment horsepower (unitless) (Table G-27).

Activity = total annual usage of the off-road equipment (hrs/yr).

LF = load factor of the off-road equipment (unitless) (Table G-27).

p = pollutant.

Total daily exhaust emissions, total daily evaporative emissions, and population are outputs from SORE2020. The average horsepower, load factor, and annual operating hours estimates were obtained from SORE2020 model input files. SORE2020 emissions output includes sector-level detail, i.e., Commercial, Residential, Vendor, and Unknown. The "Commercial" sector includes all businesses that operate lawn and garden equipment except for licensed and unlicensed landscaping businesses which are included in the "Vendor" sector (CARB 2020a). Emission factors for commercial lawn and garden equipment are based on combined data for "Commercial" and "Vendor" sectors. Additionally, for gasoline powered equipment, SORE2020 output includes emissions for two engine types, (1) carburetor engines, and (2) fuel injection engines. Emission factors were aggregated over the engine type (i.e., carburetor and fuel injection) to develop 2-stroke gasoline (G2) and 4-stroke gasoline (G4) data for each equipment type and horsepower range. Similar to OFFROAD2017, the SORE2020 does not output emissions for CH_4 or N_2O. Emission factors for these pollutants were estimated based on the mass emission ratio method described above in Section 4.3, *Off-Road Equipment Emission Factors Screen*.

5.2.4.2.2 Average Horsepower and Load Factor

Average equipment horsepower default data are based on the most populous horsepower bin for each equipment and fuel type combination in SORE2020. Note that these defaults are different than the SORE2020 horsepower assumptions used in emission factors calculations. Default load factor data are also from SORE2020. Load factor is the ratio of the actual average power output to maximum power output of a piece of equipment. Load factors do not vary by horsepower range. Refer to Table G-27.

5.3 Energy Use Submodule

5.3.1 Energy Use Screen

Criteria pollutants and GHGs are emitted as a result of activities in buildings that consume energy in the form of natural gas and electricity.

Combustion of any type of fuel, including natural gas, emits criteria pollutants and GHGs directly into the atmosphere. When this occurs within buildings, it is considered a direct emission source associated with that building, and the program will calculate emissions of all criteria pollutants and GHGs accordingly. Fuel oil, kerosene, and liquefied petroleum gas can also be used as fuel in buildings but are not widely used in California compared to natural gas. As such, CalEEMod does not calculate emissions from combustion of these fuels within buildings. Emissions from wood combustion in wood burning stoves and fireplaces are calculated in the **Area Sources Submodule** (see Section 5.2.1, *Hearths Screen*).

Criteria pollutants and GHGs are also emitted during the generation of electricity at fossil fuel power plants. When electricity is used in buildings, the electricity generation typically takes place offsite at power plants, the majority of which burn fossil fuels. Because power plants are existing stationary sources permitted by air districts and/or the USEPA, criteria pollutant emissions are generally associated with the power plants themselves, and not individual buildings or electricity users. Additionally, criteria pollutant emissions from power plants are subject to local, state, and federal control measures, which can be considered the maximum feasible level of mitigation for stack emissions.

In contrast, GHG emissions from power plants are not subject to stationary source permitting requirements to the same degree as criteria pollutants. Likewise, it is difficult to mitigate GHG emissions emitted at power plants using exhaust after treatment control technologies. The most effective way to control GHGs from power plants is to reduce electricity demand. As such, GHGs emitted by power plants may be indirectly attributed to individual buildings and electricity users, who have the greatest ability to decrease usage by applying mitigation measures to individual electricity “end uses.” The program therefore calculates GHG emissions (but not criteria pollutant emissions) from regional power plants associated with building electricity use.

CalEEMod generates default electricity and natural gas consumption based on the Electricity Demand Forecast Zone (EDFZ) input in the **Project Detail** screen and the land use subtypes and building sqft input in the **Land Use** module. From these inputs, the default electricity and natural gas consumption is then provided to the user based on 2019 consumption estimates from the CEC’s (2020, 2021) 2018–2030 Uncalibrated Commercial Sector Forecast (Commercial Forecast) and the RASS (refer to Table G-28).

Within Title 24 of the California Code of Regulations (Building Standards Code) is Part 6, the Building Energy Efficiency Standards (Energy Code). CEC implements Title 24, Part 6 in order to increase the energy efficiency of newly constructed and altered residential and nonresidential buildings. The CEC adopted the Energy Code in 1978 and has since updated it numerous times over the years, increasing the energy efficiency of new buildings with each subsequent update. The latest Energy Code is for 2019. CEC adopted the 2022 Energy Code in August 2021, and it will take effect January 1, 2023 (CEC 2022).

The following sections summarize the data and assumptions made by CalEEMod to quantify default energy use and associated emissions.

5.3.1.1 Non-Residential Building Energy Use

CalEEMod uses the CEC’s Commercial Forecast database to develop energy intensity values (electricity and natural gas usage per sqft/yr) for non-residential buildings (CEC 2021). The database lists energy use intensity by building type, end use category, and EDFZ. Appendix D, *Technical Source Documentation for Emissions Calculations,* describes in detail the method used to analyze the Commercial Forecast data.

5.3.1.2 Residential Building Energy Use

CalEEMod uses data collected during the RASS to develop energy intensity values (electricity and natural gas usage per DU per year) for residential buildings. Similar to the Commercial

Forecast, the RASS dataset lists energy use intensity by building type, end use category, and EDFZ. Appendix D, *Technical Source Documentation for Emissions Calculations,* describes in detail the method used to analyze the RASS data.

5.3.1.3 Parking Lot Energy Use

For parking lots, several studies have been published regarding the energy use from lighting, ventilation and elevators in parking lots and structures. This data has been incorporated into CalEEMod to calculate electricity use, based on parking lot land use subtype. Appendix D, *Technical Source Documentation for Emissions Calculations,* contains further information regarding the assessment of the electricity usage by parking lots and structures, as well as guidance for overriding the default values (e.g., if the number of elevators is known).

5.3.1.4 Energy Use from Other Land Uses

There are a few CalEEMod land use categories that are not included in the Commercial Forecast or RASS data. These include Golf Courses, Parks, and Recreational Pools. These currently do not have associated default energy use values within the program; however, the user may enter non-default values estimated outside of the program.

5.3.1.5 Calculation of Emissions from Energy Use

CalEEMod calculates emissions associated with buildings by multiplying the natural gas use by appropriate natural gas emission factors and by multiplying electricity use by the GHG intensity factors of the electric utility selected on the **Utility Information** screen (refer to Table G-3). As previously discussed, natural gas use will contribute to both criteria and GHG emissions. See Table G-4 for natural gas emission factors used by CalEEMod. Electricity use will contribute to GHG emissions only.

Emissions from natural gas and electricity use are calculated by the program for each land use using the following equations.

$$\text{Natural Gas Emissions}_i = \Sigma_j(\text{EF}_i \times \text{Energy Intensity} \times \text{Size})$$

Where:

Natural Gas Emissions = natural gas emissions (lb/yr).

EF = emission factor (lb/KBTU) (Table G-4).

Energy Intensity = natural gas energy intensity for a land use (KBTU/sqft/yr or KBTU/DU/yr).

Size = size metric (sqft or DU).

i = each criteria and GHG pollutant.

j = land use type.

$$\text{Electricity Emissions}_i = \Sigma_i(EF_i \times \text{Energy Intensity} \times \text{Size} \times UC)$$

Where:

Electricity Emissions = electricity emissions (lb/yr).

EF = utility emission factor (lb CO_2e/MWh) (Table G-3).

Energy Intensity = electricity energy intensity for a land use (kWh/sqft/yr or kWh/DU/yr).

Size = size metric (sqft or DU).

UC = unit conversion from kWh to MWh (0.001 MWh/kWh).

i = each GHG pollutant.

i = land use type.

5.4 Water and Wastewater Submodule

5.4.1 Water and Wastewater Screen

5.4.1.1 Inputs and Defaults

Water used and wastewater generated by land use development projects results in indirect GHG emissions from the energy used to supply, distribute, and treat the water and wastewater. The wastewater treatment process can also directly emit both CH_4 and N_2O, as discussed in Section 5.4.1.55, *Wastewater Volume by Treatment Method*. The **Water and Wastewater** screen displays the following key data fields for the quantification of emissions.

- Annual outdoor and indoor water use for the project.
- Water energy-intensity factors for the supply, distribution, and treatment of water and wastewater.
- Percentage of wastewater by treatment method (e.g., septic).

Data, assumptions, and equations used to generate defaults for each of these variables are further described in the following sections.

5.4.1.2 Annual Outdoor Water Use

CalEEMod calculates outdoor water consumption using the Maximum Applied Water Allowance (MAWA) method established under the California Department of Water Resources' (DWR) 2015 Model Water Efficient Landscape Ordinance (MWELO) (California Code of Regulations [C.C.R.], Title 23, Division 2, Chapter 2.7). The MAWA is the upper limit of the annual allowed water use for a landscaped area. The calculation is based on the size of the landscape area and expected evapotranspiration. The MAWA equation is as follows.

$$MAWA = [(ET_O - E_{ppt}) \times UC_1] \times [(AF_{ETo} \times LA) + (1 - AF_{ETo}) \times SLA]$$

Where:

> *MAWA* = annual outdoor water use for the land use subtype (gal/yr).
>
> ET_O = evapotranspiration rate (in/year). CalEEMod determines the evapotranspiration rate based on the project location and Appendix A of the MWELO (23 C.C.R. Appendix A) (refer to Table G-29).
>
> E_{ppt} = effective precipitation, which is 25% of total annual precipitation (inches/year). CalEEMod determines total annual precipitation based on the project location, user selected analysis scale (e.g., county, air basin), and data from NOAA (2021a) (refer to Table G-29). The user may elect to exclude precipitation from the calculation of outdoor water use by selecting "No" in the "Include Precipitation?" column. Excluding the precipitation adjustment will increase the calculated annual water consumption rate for the project.
>
> UC_1 = unit conversion from acre-inches/acre to gal/sqft (0.62 gal per sqft per acre-inch per acre).
>
> AF_{ETo} = Evapotranspiration adjustment factor for maximum allowable water use, pursuant to Senate Bill X7-7. The factor is 0.55 for residential development constructed after 2015 and 0.45 for non-residential development. The factors are fixed regardless of the operational year. Further strengthening of regulation may lower maximum allowable water use. Accordingly, projected outdoor water use for projects operating in future years is likely conservative.
>
> *LA* = landscape area of the land use subtype (sqft). The landscape area is either auto-calculated by CalEEMod or input by the user in the **Land Use** module. As discussed in Section 3.1, *Land Use Screen*, landscape area includes water features and all planting and turf areas in a landscape design plan, including special landscape area.
>
> *SLA* = special landscape area of the land use subtype (sqft). The special landscape area must be provided by the user in the **Land Use** module, as discussed in Chapter 3, *Land Use Module*.

Note that landscape area is a required input to the outdoor water consumption equation. As discussed in Chapter 3, *Land Use Module*, defaults for the landscape area are only available for the single-family housing land use subtype. The user must provide the landscaping area for all other land use subtypes. Failure to define the landscaping area in the **Land Use** module will result in 0 outdoor water consumption unless the user specifies a non-zero value for the special landscape area. If your project includes outdoor water consumption and the default value shown in the "Outdoor Water Use" column is 0, return to the **Land Use** module and confirm the landscape area has been defined for all land use subtypes, as applicable.

Some land use types may include special landscape area. This area includes the portion of landscape dedicated solely to edible plants, areas irrigated with recycled water, water features using recycled water, and area dedicated to active play, such as parks, sports fields, golf courses, and where turf provides a playing surface. As discussed in Chapter 3, *Land Use Module*, CalEEMod assumes 0 special landscape area as a default for all land use subtypes except city park, golf course, elementary school, high school, junior college (2 yr), junior high school, university/college (4 yr). For these uses, the default special landscape area is equal to the landscape area (i.e., the model assumes 100 percent of the landscape area is classified as special landscape area).

5.4.1.3 Annual Indoor Water Use

CalEEMod calculates indoor residential water consumption based on per capita daily water use rates from the *Residential End Uses of Water* published by the Water Research Foundation (WRF) (2016) (refer to Table G-30). The equation follows.

$$Indoor_{residential} = GCPD \times Pop \times UC_1 \times DU$$

Where:

$Indoor_{residential}$ = annual indoor water use for residential land use types (gal/yr).

GCPD = indoor residential water consumption rate (34.5 gal per person per day). The water use rate is from the WRF (2016). The value is fixed regardless of the operational year. Water use rates may decline in the future due to technological improvements, more stringent regulation, and/or increasing awareness of resource conservation. Accordingly, projected residential indoor water use for projects operating after 2018 is likely overestimated.

Pop = persons per dwelling unit (person/unit) (California Department of Finance 2020).

UC_1 = unit conversion from daily to annual (365 days/yr).

DU = dwelling units of residential land use subtype input by the user in the **Land Use** module.

CalEEMod calculates indoor water consumption for most non-residential subtypes using data from the year 2000 from the Pacific Institute's *Waste Not Want Not* (Gleick et al. 2003). Total gal (indoor and outdoor) of water used per day per metric are reported in Appendices E and F of the Pacific Institute report, where the metric is employee, student, room, acre, or sqft, depending on the land use. For example, water use at office and retail land uses is reported in a metric of gal per employee per day, while water use at hotels and motels is reported in a metric of gal per room per day. For industrial land use categories, the default indoor water use rate was calculated by dividing the annual water use in California industry by the industrial work area in California (see Appendix D8, *Default Water Use for Industrial Land Uses*). CalEEMod converts the daily water use to annual water use based on the number of days of operation for that land use. CalEEMod assumes that schools operate for 180 days per year while all other non-residential land uses operate for 225 days per year (excluding weekends and holidays). The figures in Appendices E and F of the Pacific Institute report shows the percent of outdoor water use; this percent was removed from total water use to obtain indoor water consumption (gal per year).[13]

For a few land uses (library, place of worship, movie theater, arena, and civic center), the Pacific Institute report does not provide sufficient data to develop indoor water consumption defaults. For these land use subtypes, CalEEMod uses data from the American Water Works Association (AWWA) Research Foundation's *Commercial and Institutional End Uses of Water* (Dziegielewski et al. 2000). The report includes total gal of water used per employee per day, based on surveys of Southern California businesses.

[13] As discussed above, CalEEMod calculates default outdoor water consumption for non-residential land use types using the MWELO method. However, calculated default outdoor water consumption is not used in this calculation of indoor water consumption. This is because the total water consumption data from the Pacific Institute are based on data for the year 2000, which predates the 2015 MWELO. Subtracting outdoor water use that was calculated per the 2015 MWELO from a total water consumption estimate based on year 2000 data is likely to overestimate the fraction of indoor water consumption.

Defaults generated for non-residential indoor water consumption are limited and conservative for the following reasons. The user should replace these defaults with project-specific data whenever possible (refer to Table G-31).

- The consumption defaults are based on historical data for the year 2000, as reported by the Pacific Institute (Gleick et al. 2003) and AWWA's Research Foundation (Dziegielewski et al. 2000). The default values are fixed regardless of the operational year. Indoor water use rates have declined since 2000 and may continue to decline in the future due to technological improvements, more stringent regulation, and/or increasing awareness of resource conservation. Accordingly, the default values likely overestimate actual non-residential indoor water use for development constructed between 2010 and 2050 (the available operational analyses years in CalEEMod).
- The consumption defaults for all non-residential land use subtypes except library, place of worship, movie theater, arena, and civic center are based on statewide average data and do not consider geographical differences in water use patterns.
- The consumption defaults for the library, place of worship, movie theater, arena, and civic center land use subtypes are based on surveys of Southern California businesses. The defaults are applied to all projects with these land use subtypes, regardless of project location.

5.4.1.4 Water Energy-Intensity Factors

The default water energy-intensity factors are based on a study published by the Pacific Institute (Sziniai et al. 2021) (refer to Table G-32). The factors are reported in units of kWh per million gallons (MG) of water used, and represent the amount of electricity needed to: (1) supply and convey the water from the source, (2) treat the water to usable standards, and (3) distribute the water to individual the user. The sum of these factors gives the total electricity required to supply, treat, and distribute water for outdoor uses. For indoor uses, the electricity needed to process the resulting wastewater is also included.

The default water energy-intensity factors are mapped to DWR's (2021) 10 hydrologic regions. CalEEMod selects the appropriate regional factors based on the project location (refer to Table G-33).

5.4.1.5 Wastewater Volume by Treatment Method

When a development project generates wastewater, the water is typically either treated onsite in septic tanks or sent to a centralized wastewater treatment plant to be treated by one of several possible methods. Anaerobic decomposition in septic tanks produces fugitive emissions of CH_4.

Treatment methods at centralized wastewater treatment plants may be composed of aerobic processes or facultative lagoons. The solids from these treatment methods can be digested anaerobically to produce digester gas. In some cases, the combusted digester gas may be part of a cogeneration system that recovers the heat generated from combustion and generates electricity, which can be used for on-site processes.

Anaerobic decomposition in septic tanks and facultative lagoons can produce fugitive emissions of methane. The following figure provides an example of the process flow for a centralized wastewater treatment facility that treats the sewage aerobically, produces digester gas in anaerobic digesters, and combusts the gas. Figure C-3 shows where the GHG emissions are occurring in the process for aerobic systems.

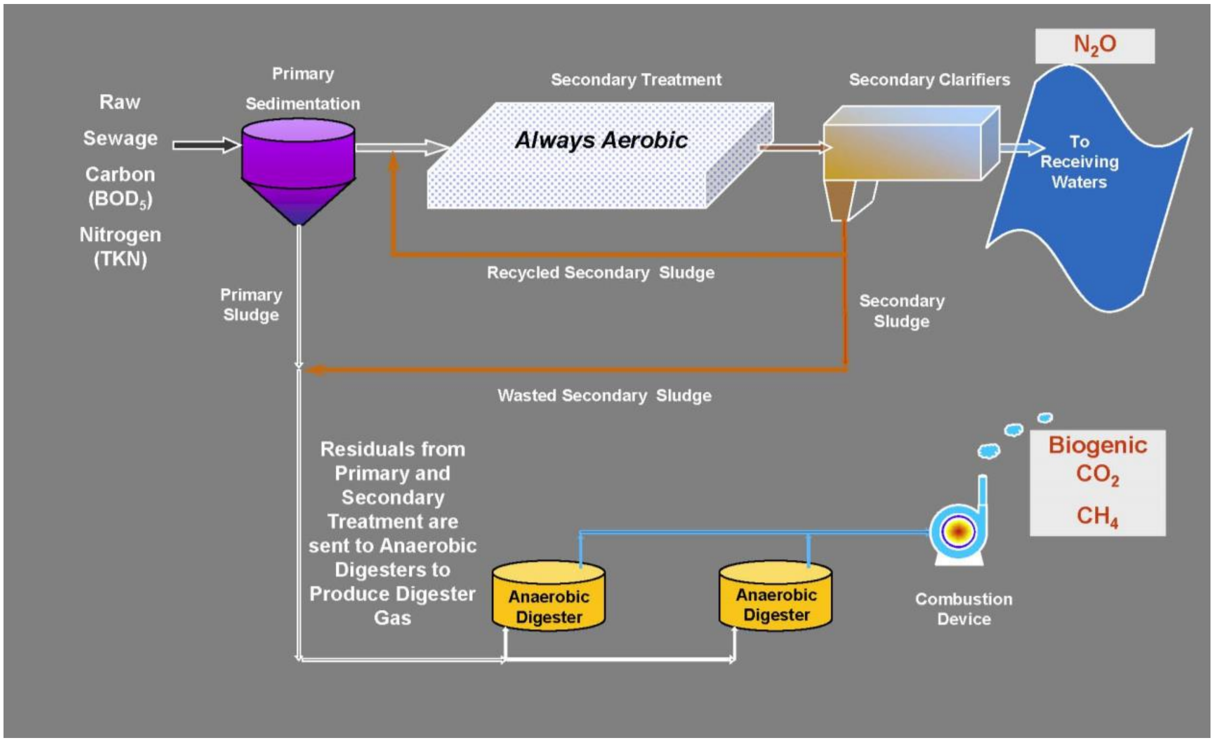

Figure C-3. Centralized Treatment Flow Schematic for Aerobic Systems

As shown in the figure above, N_2O is produced when treated wastewater is released as effluent into aquatic environments such as rivers and estuaries. Although the nitrification/denitrification processes within the wastewater treatment plant may also produce N_2O, the USEPA (2008:8-7) estimated that this contributed to less than 3 percent of national N_2O emissions associated with wastewater in 2005. Therefore, the program assumes that all N_2O emissions are generated from effluent discharged into aquatic environments.

CO_2 emissions are generated from both aerobic and anaerobic processes, as well as from the combustion of digester gas, but CalEEMod currently only calculates combustion emissions. When digester gas is combusted to generate electricity, fossil fuel emissions are offset by this renewable power generation. By default, CalEEMod assumes no cogeneration; however, the user can input an estimate of the percentage of the digester gas combusted. For aerobic and facultative lagoon wastewater treatment, digestion (listed in the last two columns on the **Water and Wastewater** screen) should equal 100 percent. For septic systems, the digestion could be 0 percent or 100 percent. CalEEMod will debit the biogenic combustion CO_2 with the CO_2 that would otherwise have been sourced from fossil fuel combustion.

Centralized wastewater treatment facilities may also treat wastewater using facultative lagoons. The following figure is an example of the treatment process if facultative lagoons provide the secondary treatment assuming process solids are sent to anaerobic digesters and the digester gas is combusted. Figure C-4 shows where the GHG emissions are occurring in the process for facultative lagoons.

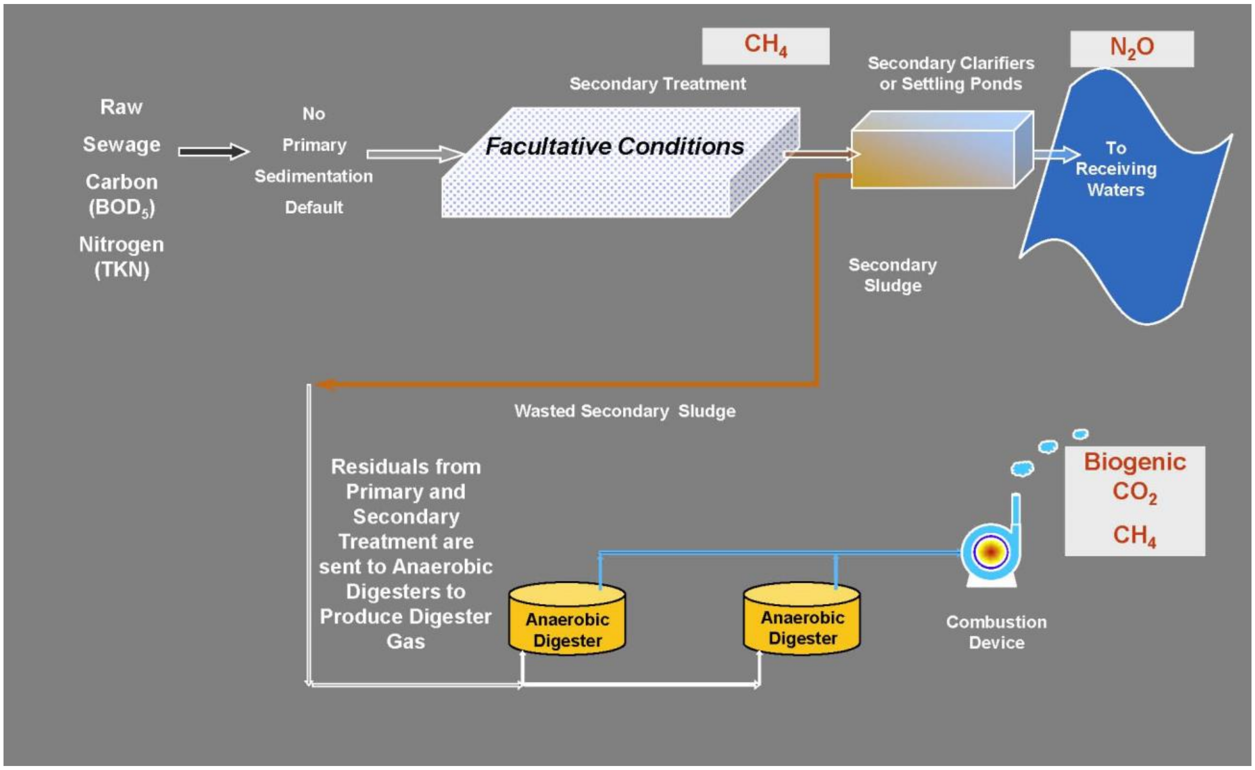

Figure C-4. Centralized Treatment Flow Schematic for Facultative Lagoons

CalEEMod calculates the volume of project-generated wastewater treated by method based on the region-specific distribution of wastewater treatment methods (expressed as the percentage of wastewater treatment by method) (refer to Table G-34). Where region-specific data are not available, the model applies statewide default percentages shown in Table C-10 based on CARB's GHG emission inventory. The user can replace the treatment defaults with project-specific percentages, but the total percentage must equal 100 percent.

Table C-10. Statewide Default Treatment Distribution

Septic (%)	Aerobic (%)	Facultative Lagoons (%)
10.33	87.46	2.21

5.4.1.6 Calculation of GHG Emissions from Water Use

CalEEMod calculates CO_2, CH_4, and N_2O emissions from indoor water use according to the following equation.

$$E_p = V_{indoor} \times E_{indoor} \times EF_P \times UC_1$$

Where:

E = emissions from indoor water use (MT/yr).

V_{indoor} = volume of indoor water use (MG/yr). See Section 5.4.1.23, *Annual Indoor Water Use*.

E_{indoor} = electricity required to supply, treat, and distribute water and the resulting wastewater (kWh/MG) (Table G-32). See Section 5.4.1.44, *Water Energy-Intensity Factors*.

EF = carbon intensity of electricity provider (lb/MWh) (Table G-3). CalEEMod determines the electric utility company for the project based on the project location. The default electricity provider and carbon intensities are shown in the **Utility Information** screen, as discussed in Section 2.2, *Utility Information Screen*.

UC_1 = unit conversion from kWh to MWh (0.001 MWh/kWh).

p = pollutant (CO_2, CH_4, or N_2O).

CalEEMod calculates CO_2, CH_4, and N_2O emissions from outdoor water use according to the following equation.

$$E_p = V_{outdoor} \times E_{outdoor} \times EF_P \times UC_1$$

Where:

E = emissions from outdoor water use (MT/yr).

$V_{outdoor}$ = volume of outdoor water use (MG/yr). See Section 5.4.1.2, *Annual Outdoor Water Use*.

$E_{outdoor}$ = electricity required to supply, treat, and distribute water (kWh/MG) (Table G-32). See Section 5.4.1.44, *Water Energy-Intensity Factors*.

EF = carbon intensity of electricity provider (lb/MWh) (Table G-3). CalEEMod determines the electric utility company for the project based on the project location. The default electricity provider and carbon intensities are shown on the **Utility Information** screen, as discussed in Section 2.2, *Utility Information Screen*.

UC_1 = unit conversion from kWh to MWh (0.001 MWh/kWh).

p = pollutant (CO_2, CH_4, or N_2O).

The sum of emissions from indoor and outdoor water uses for each land use type gives the total GHG emissions from project water consumption.

5.4.1.7 Calculation of GHG Emissions from Wastewater Treatment

GHG emissions generated by wastewater treatment are calculated according to the following equation.

$$E_p = \sum_t V \times UC \times EF_P$$

Where:

E = emission from wastewater treatment (MT/yr).

V = volume of wastewater by treatment method (gal/yr). See Section 5.4.1.55, *Wastewater Volume by Treatment Method*.

UC = unit conversion from short tons to MT (0.907185 MT/short ton).

EF = emission factor for treatment process (short ton/gal/yr) (Table G-35) (see below).

p = pollutant (CO_2, CH_4, or N_2O).

t = treatment process.

The emission factors for each type of wastewater treatment are calculated using CARB's (2010) *Local Government Operations Protocol* (LGOP), which is consistent with USEPA methodologies for the national GHG inventory. The assumptions and equations used to calculate the emission factors are summarized below.

5.4.1.7.1 Methane Emission Factor for Septic Systems

Septic systems utilize microbes to decompose wastewater anaerobically. A by-product of this anaerobic decomposition is CH_4, which is quantified using Equation 10.5 from the LGOP, as follows.

$$EF_{septic} = V \times BOD_5 \times UC_1 \times BO \times MCF_{septic} \times UC_2 \times UC_3$$

Where:

EF_{septic} = fugitive CH_4 emission factor for septic systems (short ton CH_4/gal/yr) (Table G-35).

V = volume of wastewater (L/yr).

BOD_5 = amount of BOD_5 produced per day (200 mg/L). BOD is the "biological oxygen demand," which measures the degradable organic component of the wastewater that could deplete dissolved oxygen in receiving waters if left untreated. BOD_5 is the measurement of dissolved oxygen depletion from a liquid sample held for a 5-day test. The 200 mg per L of wastewater default is typical for residential and commercial wastewater. A higher value is typically associated with certain types of industrial wastewater.

UC_1 = unit conversion from mg to kg (10^{-6} kg/mg).

BO = maximum CH_4-producing capacity for domestic wastewater (0.6 kg CH_4/kg BOD_5 removed).

MCF_{septic} = CH_4 correction factor for septic systems (0.5).

UC_2 = unit conversion from kg to short tons (1.10^{-3} short ton/kg).

UC_3 = unit conversion from L to gal (3.78541 L/gal).

5.4.1.7.2 Methane Emission Factor for Facultative Lagoons

The CH_4 emissions factor for wastewater treatment through facultative lagoons is calculated using Equation 10.3 from LGOP, as follows.

$$EF_{lagoon} = V \times BOD_5 \times UC_1 \times (1 - F_P) \times BO \times MCF_{anaerobic} \times F_{removed} \times UC_2 \times UC_3$$

Where:

EF_{lagoon} = fugitive CH_4 emission factor for facultative lagoons (short ton CH_4/gal/yr) (Table G-35).

V = volume of wastewater (L/yr).

BOD_5 = amount of BOD_5 produced per day (200 mg/L).

UC_1 = unit conversion from mg to kg (10^{-6} kg/mg).

F_P = fraction of BOD_5 removed in primary treatment (0). CalEEMod assumes no primary treatment.

BO = maximum CH_4-producing capacity for domestic wastewater (0.6 kg CH_4 / kg BOD_5 removed).

$MCF_{anaerobic}$ = CH_4 correction factor for anaerobic systems (0.8).

$F_{removed}$ = fraction of overall lagoon BOD_5 removal performance (1).

UC_2 = unit conversion from kg to short tons (1.10^{-3} short ton/kg).

UC_3 = unit conversion from L to gal (3.78541 L/gal).

5.4.1.7.3 Methane Emission Factor for Combustion of Digestion Gas

Anaerobic digesters produce CH_4-rich biogas, which is typically combusted on site. In some cases, the biogas is combusted simply for the purpose of converting CH_4 to CO_2. In other cases, a cogeneration system is used to harvest the heat from combustion and use it to generate electricity for on-site energy needs (discussed further below). In either case, inherent inefficiencies in the system result in incomplete combustion of the biogas, which results in remaining CH_4 emissions. The CH_4 emissions factor from incomplete combustion of digester gas is quantified using Equation 10.1 from LGOP, as follows.

$$EF_{digester} = V \times DG \times F_{CH4} \times P_{CH4} \times (1 - DE) \times UC_1 \times UC_2 \times UC_3$$

Where:

$EF_{digester}$ = CH_4 emission factor for incomplete combustion (short ton CH_4/gal/yr) (Table G-35).

V = volume of wastewater (gal/yr).

DG = volume of biogas generated per volume of wastewater treated (0.01 ft^3 biogas/gal). USEPA (2008:8-9) estimates 1.0 ft^3 of digester gas per person per day and 100 gal of wastewater per person per day.

F_{CH4} = fraction of CH_4 in biogas (0.65) (USEPA 2008:8-9).

P_{CH4} = density of CH_4 at standard conditions (662 g/m^3).

DE = CH_4 destruction efficiency (0.99).

$MCF_{anaerobic}$ = CH_4 correction factor for anaerobic systems (0.8).

UC_1 = unit conversion from ft^3 to m^3 (0.0283 m^3/ft^3).

UC_2 = unit conversion from kg to short tons (1.10^{-3} short ton/kg).

UC_3 = unit conversion from grams to kg (10^{-3} kg/g).

5.4.1.7.4 Biogenic CO_2 Emission Factor Combustion of Digestion Gas

The biogenic CO_2 emission factor for the combustion of biogas is calculated using the following equation.

$$EF_{biogenic} = V \times DG \times F_{CH4} \times EF \div UC_1$$

Where:

$EF_{biogenic}$ = CO_2 emission factor for biogas combustion (short ton CO_2/gal/yr) (Table G-35).

V = volume of wastewater (gal/yr).

DG = volume of biogas generated per volume of wastewater treated (0.01 ft^3 biogas/gal) (USEPA 2008:8-9).

F_{CH4} = fraction of CH_4 in biogas (0.65) (USEPA 2008:8-9).

EF = emission factor for CH_4 combustion (0.120 lb CO_2 / ft^3 CH_4) (United States Department of Energy 2005).

UC_1 = unit conversion from lb to short ton (0.0005 short ton/lb).

5.4.1.7.5 Electricity Factor for Cogeneration

The following equation derived from USEPA's (2006c) *Solid Waste Management and Greenhouse Gases* is used to calculate the amount of electricity generated from the combusted biogas.

$$E_{cogeneration} = V \times DG \times F_{CH4} \times HHV_{CH4} \times ECF \times EFF \times UC_1$$

Where:

$E_{cogeneration}$ = electricity generation factor for biogas combustion (MWh/gal/yr).

V = volume of wastewater (gal/yr).

DG = volume of biogas generated per volume of wastewater treated (0.01 ft^3 biogas/gal) (USEPA 2008:8-9).

F_{CH4} = fraction of CH_4 in biogas (0.65) (USEPA 2008:8-9).

HHV_{CH4} = heating value of methane (1,012 BTU / ft^3 CH_4).

ECF = energy conversion factor (0.00009 kWh/BTU).

EFF = efficiency Factor (0.85). USEPA (2006c) assumes a 15% system efficiency loss, to account for system down-time. USEPA assumes that methane is flared during down-time.

UC_1 = unit conversion from kWh to MWh (0.001 MWh/-kWh).

Since this amount of electricity is generated onsite and no longer needs to be supplied by the local electricity utility, the indirect CO_2e emissions associated with that utility electricity generation are also avoided. The avoided CO_2e emissions are calculated by multiplying the amount of electricity generated (in MWh) by the local utility carbon-intensity factor (Table G-3).

5.4.1.7.6 Nitrous Oxide Emission Factor

N_2O is produced when treated wastewater is discharged to aquatic environments such as rivers or estuaries. The remaining nitrogen in treated wastewater effluent is converted to N_2Oin a multi-step process accomplished by bacteria that are present in soil and aquatic environments. The N_2O emission factor is quantified using Equation 10.9 from the LGOP, as follows.

$$EF_{discharge} = V \times UC_1 \times N_{load} \times R \times EF \times UC_2 \times UC_3$$

Where:

$EF_{discharge}$ = N_2O emission factor for effluent discharge (short ton N_2O/gal/yr) (Table G-35).

V = volume of wastewater (L/yr).

UC_1 = unit conversion from mg to kg (10^{-6} kg/mg).

N_{load} = mass of nitrogen discharged per L of wastewater (26 mg N_2/L) (USEPA 2013). This value is appropriate for residential and commercial wastewater. A higher value may be more appropriate for certain types of industrial wastewater.

R = ratio of molecular weights for N_2O and N_2 (44 g N_2O/28 g N_2) (USEPA 2008).

EF = N_2O effluent emission factor (0.005 kg N_2O/kg N).

UC_2 = unit conversion from kg to short tons (1.10^{-3} short ton/kg).

UC_3 = unit conversion from L to gal (3.78541 L/gal).

5.5 Solid Waste Submodule

5.5.1 Solid Waste Screen

Municipal solid waste (MSW) is the amount of material that is disposed of by land filling, recycling, or composting. CalEEMod calculates the indirect GHG emissions associated with waste that is disposed of at a landfill. The program uses annual waste disposal rates from the California Department of Resources Recycling and Recovery (CalRecycle) data for individual land use types (CalRecycle n.d.) (refer to Table G-36). If waste disposal information was not available, waste generation data was used. CalEEMod uses the overall California MSW composition to generate the necessary types of different waste disposed into landfills. The program quantifies the GHG emissions associated with the decomposition of the waste, which generates CO_2 and CH_4 based on the total amount of degradable organic carbon (DOC).[14]

The amount of carbon generated per short ton of waste is calculated according to the following equation.

$$G = \sum_{MSW} DOC \times DANF \times C \times A$$

[14] Landfill gas generation is dependent upon the amount, type, age and moisture content of the disposed waste. USEPA has developed emission factors for landfill gas as specified in Section 2.4 of AP-42, which are incorporated in the LANDGEM model. This model uses a first order decay equation that will vary with time. However, there is no need to use a time-varying emissions model, as we are interested in total emissions of gases that could be emitted from a short ton of waste. Therefore, instead of using the LANDGEM model, the volume of landfill gas from solid waste will be based on the total amount of degradable organic carbon.

Where:

G = generation mass of carbon (short ton carbon per short ton of waste) (Table G-37).

DOC = degradable organic carbon fraction (%) (CARB 2010:Table 9.6).

DANF = degradable anaerobic fraction (%) (CARB 2010:Table 9.7).

C = waste stream composition (%) (California Integrated Waste Management Board 2020:Table 4).

A = anaerobic carbon fraction (0.5).

MSW = waste category (e.g., newspaper).

The amount of CH_4 and CO_2 emitted is calculated by assuming collection and destruction efficiencies. Regional defaults are available for the percent of project waste that is expected to be sent to landfills with a gas collection system. The default collection efficiency for these systems is 75 percent and the destruction efficiency is 98 percent. Oxidation of CH_4 and CO_2 is calculated according to the following equations.

$$E_{CH4} = T \times G \times [C \times (1 - D) + (1 - C) \times (1 - Ox)] \times R \times UC$$

$$E_{CO2} = T \times G \times [C \times D + (1 - C) \times Ox + 1] \times R \times UC$$

Where:

E_{CH4} = CH_4 emissions (MT CH_4/yr).

E_{CO2} = CO_2 (biogenic) emissions (MT CO_2/yr).

T = short tons of waste generated by the project (short ton/yr).

G = generation mass of carbon (short ton carbon per short ton of waste) (Table G-37).

C = collection efficiency of landfill gas (75%).

D = destruction efficiency of landfill gas (98%).

Ox = oxidation efficiency (10%).

R = ratio of molecular weights for CO_2 and carbon (44 g CO_2 / 12 g carbon) and CH_4 to carbon (16 g CH_4 / 12 g carbon).

UC = unit conversion from short tons to MT (0.907185 MT/short ton).

CalEEMod will also calculate the electricity from any combusted biogas that is used for cogeneration. If applicable, the user should specify the percent of landfill gas energy recovery in the Capture Gas Energy Recovery data field (CalEEMod defaults to 0 percent). Since this amount of electricity is generated on-site and no longer needs to be supplied by the local electricity utility, the indirect GHG emissions associated with that utility electricity generation are avoided. The avoided GHG emissions are calculated by multiplying the amount of electricity generated (in MWh) by the local utility carbon-intensity factor, according to the following equation. Please note that, depending on the amount of electricity generated and the carbon intensity of the electric utility, calculated emissions for the waste sector (or certain pollutants within the waste sector) may be negative. In this case, negative values indicate that displaced grid energy from cogeneration will offset emissions associated with landfill treatment of project-generated waste.

$$E_{cogeneration} = T \times L_r \times (C \times U) \times UC$$

Where:

$E_{cogeneration}$ = avoided GHG emissions from electricity generated from cogeneration (MT pollutant/year).

T = short tons of waste generated by the project (short ton/yr).

L_r = percent of project-generated waste that is sent to a landfill with cogeneration (%) (user input in the **Solid Waste** screen).

C = energy recovery of landfill gas (0.45 MWh/short ton waste) (USEPA 2016a:1-2; USEPA 2021:1).

U = carbon intensity of electric utility (lb CO_2e/MWh).

UC = unit conversion from lb to MT (0.00045359290943564 MT/lb).

5.6 Refrigerants Submodule

5.6.1 Refrigerants Screen

Refrigerants are substances used in equipment for air conditioning (A/C) and refrigeration. Most of the refrigerants used today are HFCs or blends thereof, which can have high GWP values. All equipment that uses refrigerants has a charge size (i.e., quantity of refrigerant the equipment contains), and an operational refrigerant leak rate, and each refrigerant has a GWP that is specific to that refrigerant. CalEEMod quantifies refrigerant emissions from leaks during regular operation and routine servicing over the equipment lifetime, and then derives average annual emissions from the lifetime estimate according to the following equation.

$$E = \sum_{I} (((CS \times OLR) + (CS \times SLR \times (TS \div L))) \times GWP)_r \times KSF \times UC_1$$

Where:

E = average annual refrigerant emissions (MT CO_2e/yr).

CS = equipment charge size (kg refrigerant/KSF). The equipment charge size is the total quantity of refrigerant installed in the refrigeration or A/C equipment. Default equipment charge sizes are based on industry data published by USEPA (2016b) (Table G-38).

OLR = annual operational leak rate (%) (USEPA 2016b) (Table G-38).

SLR = service leak rate (%) (USEPA 2016b) (Table G-38).

TS = times serviced (number of times serviced over equipment lifetime) (USEPA 2016b) (Table G-38).

L = average equipment operational lifetime (years) (USEPA 2016b) (Table G-38).

GWP = global warming potential (unitless) (IPCC 2007; CARB 2020d; World Meteorological Organization 2018) (Table G-39).

KSF = land use size (1,000 sqft). Emissions are quantified by land use subtype, with the input for the land use size based on information in the **Land Use** module.

UC_1 = unit conversion from kg to MT (0.001 MT/kg).

r = refrigerant.

l = equipment type.

Different types of refrigeration equipment are used by different types of land uses. For example, an office may use various types of A/C equipment, while a supermarket may use both A/C equipment and refrigeration equipment. Default refrigeration and A/C equipment types by land use subtype, as well as the default refrigerant used in each equipment type, are based on USEPA (2016b).

5.7 Off-Road Equipment Submodule

5.7.1 Off-Road Equipment Screen

The **Off-Road Equipment** screen calculates emissions from off-road equipment (e.g., forklifts, cranes, loaders, generator sets) used during project operation. The program allows the user to enter the number of pieces of equipment, fuel type, engine tier, daily hours of operation, annual days of operation, horsepower, and load factor. Defaults are available for horsepower and load factor, as described in Sections 4.2.1, *Average Horsepower*, and 4.2.2, *Load Factor* (refer to Table G-12). For each equipment type, the model automatically defaults to diesel fuel, average engine tier, 8 hours of daily operation, and 260 days of annual operation. The user can replace the defaults with project-specific data.

5.7.2 Off-Road Equipment Emission Factors Screen

Emissions are quantified according to the equation shown in Section 4.2, *Off-Road Equipment Screen*.

5.8 Stationary Sources Submodule

The **Stationary Source** submodule calculates emissions from emergency generators and fire pumps and process boilers.

5.8.1 Emergency Generators and Fire Pumps Screen

The user must enter the number of pieces of equipment, fuel type, and hours of operation for each selected equipment type. Defaults are available for equipment horsepower and load factor. Emissions for emergency generators and fire pumps are calculated using the following equation.

$$E_p = \sum_i (EF_i \times Pop_i \times hp_i \times Load_i \times Activity_i)$$

Where:

E = total daily generator and/or fire pump equipment emissions (g/day).

EF = emission factor in grams per horsepower-hour (g/bhp-hr) (see below) (Table G-40).

Pop = population, or the number of pieces of equipment (number/day).

hp = average horsepower for the equipment (unitless).

Load = load factor of the equipment (unitless).

Activity = hours of daily operation of the equipment (hr/day/number).

p = pollutant.

i = equipment type.

Emission factors for selected equipment are displayed in the **Generators/Pumps Emission Factors** screen. The factors were obtained from a combination of sources, as identified in Table G-40. For natural gas emergency generators, conversion from the source emission factor in lb per MMBTU of fuel input (lb/MMBTU) to CalEEMod emission factor in grams per brake horsepower hour is derived according to the following equation.

$$CF = UC_1 \times UC_2 \times BSFC \div UC_3$$

Where:

CF = conversion factor (3.1752 g/hp-hr).

UC_1 = unit conversion from MMBTU to lb (1 lb/MMBTU).

UC_2 = unit conversion from BTU to MMBTU (1 MMBTU/1,000,000 BTU).

BSFC = average brake-specific fuel consumption (7,000 BTU/hp-hr).

UC_3 = unit conversion from grams to lb (0.00220462262 lb/g).

For natural gas emergency generators, conversion from the source emission limit of parts per million by volume (ppmv) to CalEEMod emission factor in lb per MMBTU of fuel input (lb/MMBTU) is performed as:

$$EF_p = EL_p \times \frac{1}{M_{vol}} \times MW \times Fd \times vv\% \div (vv\% - O_2)$$

Where:

EF = emission factor (lb/MMBTU).

EL = emission limit (ppmv).

M_{vol} = molar volume (379.5 dscf/lbmol @ 14.696 psia, 60 deg. F).

MW = molecular weight (lb/lb-molar volume). The molecular weight for ROG is set at 86 lb/lbmol based on Hexane.

Fd = 8,579 dscf/MMBTU for 1020 BTU/scf Natural Gas @60 deg F.

vv% = reference concentration of oxygen in the air (20.9%)

O_2 = oxygen percentage (South Coast AQMD Rule 1110.2 limits are based on 15 percent oxygen).

p = pollutant.

5.8.2 Process Boilers Screen

The user must enter the number of boilers, fuel type, boiler rating, daily heat input, and annual heat input. Emissions for process boilers are calculated according to the following equation.

$$E_p = \sum_i (EF_i \times Pop_i \times F_i)$$

Where:

E = total daily boiler emissions (lb/day).

EF = emission factor (lb/MMBTU) (Table G-41).

Pop = population, or the number of boilers (number/day).

F = boiler fuel consumption (MMBTU/number).

p = pollutant.

i = boiler type.

5.8.3 Boilers Emission Factors Screen

Emission factors for selected boilers are displayed in the **Boiler Emission Factors** screen. The factors were obtained from a combination of sources, as identified in Table G-41. Where applicable, a diesel heat value of 140 MMBTU/10^3 gal is used to convert the source emission factor in terms of lb/10^3 gal to the CalEEMod emission factor in terms of lb/MMBTU. A natural gas heat value of 1,020 BTU/scf is used to convert the source emission factor in terms of lb/10^6 scf to the CalEEMod emission factor in terms of lb/MMBTU.

5.9 User Defined Submodule

5.9.1 User Defined Screen

The **User Defined** screen allows the user to input daily and annual emissions in terms of lb per day and tons (short and metric) per year, respectively, generated by any emission source not captured in prior screens. Emissions must be manually entered by the user. Any emissions entered on the screen will be transferred to the appropriate reports.

6 Vegetation Module

The **Vegetation** module calculates GHG emissions (or removals) from land use change and changes in sequestration from tree planting (or removal).

6.1 Land Use Change Screen

The **Land Use Change** screen estimates changes in CO_2 associated with soil and aboveground and belowground biomass resulting from a project-induced change in land use type. The user must define the initial acres of each vegetation land use type prior to construction of the project and the final acres after implementation of the project. CalEEMod will calculate the stored carbon under both conditions. If the existing land use cover currently includes stored carbon, and that value exceeds that of the new land cover type, the land use change would result in GHG emissions. Conversely, if the stored carbon under the final with project conditions exceeds that of initial conditions, the land use change would result in a GHG benefit (i.e., reduction).

Aboveground and belowground carbon storage is calculated according to the following equation.

$$E = (((H_{initial} - H_{final}) \times BCA) \times ((H_{initial} - H_{final}) \times SCA \times SC)) \times R$$

Where:

E = CO_2 benefit (or emissions) from land cover type over the accumulation period (MT CO_2 per year).

$H_{initial}$ = initial acres of land by land-cover type prior to implementation of the project (acres). Available land cover types are based on those defined in CARB's natural and working lands (NWL) GHG inventory.

H_{final} = final acres of land by land-cover type after implementation of the project (acres).

BCA = annual above and belowground biomass carbon accumulation by land cover type (MT carbon per acre per year) (Table G-42). CalEEMod selects the appropriate accumulation rate based on the project location (at the air basin scale) and user-selected land cover type. The rates were developed by CARB (2021f) from their NWL inventory. The rates have been annualized over the following accumulation periods.

- *Forest* = 60 years. This is the median project duration under the California Climate Investments Forest Health Quantification Method for the California Department of Forestry and Fire Protection's Forest Health Program. The median project duration represents one stand rotation, which is the typical time to harvest (CARB 2021g).
- *Grasslands* = 20 years. This represents the typical amount of time for restored grasslands on former agricultural sites to accumulate the same amount of biomass carbon as native grasslands (Matamala et al. 2008).
- *Shrublands* = 35 years. This rate represents the average frequency of wildfires in Southern California Chaparral systems (Luo et al. 2007).

Note that CalEEMod assumes a 0 biomass carbon accumulation rate for the "Urban" land cover type. Users must provide the accumulation rate when the "Other" land cover type is selected.

$H_{initial}$ = initial acres of land by soil type prior to implementation of the project (acres). The soil types and land use types are based on those defined in CARB's Benefits Calculator Tool for Agricultural Lands Conservation (CARB 2020e). The soil type for the project area can be obtained from UC Davis' SoilWeb (UC Davis n.d.). CARB's Agricultural Lands Conservation Easement Quantification Methodology provides detailed instructions for using this tool (CARB 2020f).

H_{final} = final acres of land by soil type after implementation of the project (acres).

SCA = annual soil carbon accumulation by soil type and land use type (MT carbon per acre per year) (Table G-43). The rates are from CARB's (2020e) Benefits Calculator Tool for Agricultural Lands Conservation. The rates have been annualized over a 20-year accumulation period, consistent with IPCC's (2006) GHG inventory framework.

SC = soil carbon gain from conversion from settlements to vegetated land (30%) (CARB 2020a).

R = molecular weight ratio of CO_2 to carbon (44 g CO_2 /12 g carbon).

6.2 Sequestration Screen

The **Sequestration** screen allows the user to input changes in GHGs, criteria pollutants, and energy from tree planting and/or removal. The user is directed to the U.S. Forest Service (USFS) (2021) i-Tree Planting tool. The i-Tree Planting tool quantifies increased carbon sequestration from urban tree planting using species-based biomass equations that account for user defined site-specific variables and tree growth rates. The tool also quantifies GHG reductions from energy savings (e.g., kWh), if applicable.

While simplified quantification methods for increased carbon sequestration resulting from urban tree planting have been used in the past, CalEEMod does not recommend their application given the number and dynamic nature of variables that can influence the amount of CO_2 reduced. Tools like i-Tree Planting comprehensively account for these variables, enabling the user to easily calculate the approximate benefits from individual trees.

The i-Tree Planting tool is available at: https://planting.itreetools.org/. The following user inputs are required for the i-Tree Planting tool.

- *Project state/province*.
- *Project county/division*.
- *Project city*.
- *Project lifetime*. Trees sequester CO_2 while the trees are actively growing. The i-Tree Planting tool will project the benefits for up to 99 years into the future. The tool defaults to 40 years.
- *Tree mortality over project lifetime*. The i-Tree Planting tool will incorporate tree mortality into the projected benefits.
- *Tree species planted by the project*. The user may select from a dropdown menu.
- *Diameter breast height of each tree*. The diameter of the trunk measured at 4.5 feet above the ground at the time of planting.
- *Distance to the nearest building*. For trees that will be planted to shade buildings, enter the distance class to the nearest building (0–19 feet, 20–39 feet, 40–59 feet, > 60 feet). Note that this could be a building on an adjacent site. The i-Tree tool will not calculate shade benefits (i.e., energy savings) for trees more than 60 feet away from the building.
- *Direction of tree from the building*. General direction of the tree from the building (e.g., north 0 degrees). This input can be ignored if the tree is more than 60 feet from the building.
- *Building vintage*. The age of the building affects its energy efficiency and therefore the potential benefits the trees can bring. Available inputs are built after 1980, built 1950–1980, and built before 1950. If the specific age of the building is unknown, the user can input the typical age of buildings for the area where the user is working. This input can be ignored if the tree is more than 60 feet from the building.
- *Building climate controls*. Trees can only have an impact on energy use in buildings where energy is used to heat or cool. Available inputs are heating and air conditioning (A/C), heat only, A/C only, and none. If the climate controls of the building are unknown, the user can input the option that is most common for the area where the user is working. This input can be ignored if the tree is more than 60 feet from the building.
- *Tree condition*. The condition of the trees will affect how well they grow and thus future benefits. Available inputs are excellent, good, fair, poor, critical, dying, and dead. New plantings are likely to be excellent.

- *Tree exposure to sunlight*. The exposure to sunlight affects both how the trees grow and the degree to which a new tree adds shade to a building. Available inputs are full sun, partial shade, and full shade.
- *Carbon intensity of local electricity provider.* See the **Utility Information** screen to obtain the utility emission factors for the project run (Table G-3).
- *Carbon intensity of natural gas*. See Table G-4.

The i-Tree outputs are all expressed over the project lifetime. It is critically important that the user input the same operational lifetime in the "Operational Lifetime (years)" text box as assumed in the i-Tree Planting Calculator model run. This is because CalEEMod divides the user-input lifetime values by the operational lifetime (years) to obtain annual results for the report.

The input field labels in CalEEMod match the i-Tree Planting Calculator outputs. The user should directly copy the outputs from the i-Tree Planting Calculator to the applicable fields in the **Sequestration** screen. If the i-Tree output reports a negative result, be sure to include the negative sign when copying the value to CalEEMod. For example, if i-Tree outputs -1,000 MMBTU for "Fuel Saved," this means that the project would increase fuel consumption by 1,000 MMBTU. CalEEMod is programmed to read all negative user inputs as increases and positive user inputs as reductions (except as noted in the following paragraph). Note that the "PM2.5 Removed" field represents total PM2.5. CalEEMod internally calculates PM2.5 dust and PM2.5 exhaust from this input assuming each constituent represents 50 percent of total PM2.5. This fraction is based on ambient air monitoring presented in the Bay Area Air Quality Management District's (2017:2-18) 2017 Clean Air Plan. Because the i-Tree Planting Calculator does not output PM10 removed or avoided, CalEEMod calculates these values as the product of PM2.5 and 367 percent. The value of 367 percent represents the percent of PM10 that is PM2.5, based on the South Coast AQMD's (2006) *Methodology to Calculate Particulate Matter (PM) 2.5 and PM 2.5 Significance Thresholds*.

The input field labels are identified in terms of *avoided* emissions or energy consumption. These labels are used in both the "Removed Trees" and "Added Trees" sections to maintain consistency with the i-Tree output. CalEEMod automatically reverses the sign of all user inputs to the "Added Tree" section to account for the fact that these emissions and energy uses would be *reductions* (except when new trees increase fuel consumption by overshading, in which case, addition of the trees would yield a fuel consumption increase). Therefore, users should run i-Tree in the same manner for both removed and added trees.

7 Measures Module

7.1 Emissions Reduction Submodule

The **Introduction** screen provides instructions for navigating through the nine sector screens within the **Emissions Reduction** submodule. The sector names generally match the sector names used in CAPCOA's *Handbook for Analyzing Greenhouse Gas Emission Reductions, Assessing Climate Vulnerabilities, and Advancing Health and Equity: Designed for Local Governments, Communities, and Project Developers* (Handbook), except for the Area Sources sector, which is a combination of the Handbook's lawn and landscaping measures, one of its energy measures, and various measures not included in the Handbook that result in non-GHG emission reductions.

Within each sector screen, measures are categorized as either "Quantified" or "Qualitative or Supporting Measures." Click the notepad icon to the right of the measure title to show the measure factsheet (if available) or measure description. Measures that were preselected on the **Climate**

Map and **Health and Equity Map** screens are shown in *italics*. The five most relevant measures, if any for the screens, for addressing environmental and health burdens of the project site are identified with an asterisk (*).

Most of the emission reduction measures are from quantification methods and underlying data sourced directly from the Handbook, with some modifications being made to facilitate automated quantification based on available information contained within the CalEEMod interface. Handbook measure numbers and titles are directly used in CalEEMod for easy cross reference. CalEEMod also includes a handful of measures that are not presented in the Handbook. These measures exclusively target criteria pollutants, like fugitive dust from construction and VOCs from architectural coatings. The CalEEMod specific measures are numbered sequentially following Handbook measures within the same sector.

CalEEMod includes analytics to estimate emission reductions and some co-benefits achieved by quantified measures. Not all measures reduce the same pollutants or achieve the same co-benefits. Table C-11 identifies the quantified emissions and co-benefits by measure. See Section 4.3.7, *Measures Module*, in the User Guide for definitions of the co-benefit categories. Table C-11 only identifies those co-benefits quantified by CalEEMod. Table G-44 presents all co-benefits that are likely to result from measure implementation (inclusive of quantified measured and qualitative or supporting measures). Use the “Filter Measures” button to view measures that achieve desired co-benefits.

Table C-11. Quantified Emission Reductions and Co-Benefits by Measure

Measure #	Quantified Criteria Pollutants											Quantified Greenhouse Gases							Quantified Co-Benefits [a]				
	TOG	ROG	NO_x	CO	SO_2	PM10			PM2.5			CO_2			CH_4	N_2O	R	CO_2e	VMT	Electricity	Natural Gas	Water	Waste
						Ex	Dust	Tot	Ex	Dust	Tot	Bio	N-Bio	Tot									
C-1-A	X	X	X	X	X	X		X	X		X		X	X	X	X		X		X			
C-1-B	X	X	X	X	X	X		X	X		X		X	X	X	X		X					
C-3	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				
C-5	X	X	X	X	X	X		X	X		X		X	X	X	X		X					
C-6						X		X	X		X												
C-7			X																				
C-8		X	X	X		X		X	X		X												
C-9							X	X		X	X												
C-10-A							X	X		X	X												
C-10-B							X	X		X	X												
C-10-C							X	X		X	X												
C-11							X	X		X	X												
C-12							X	X		X	X												
C-13		X																					
T-1	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				
T-2	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				
T-3	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				
T-4	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				
T-5	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				
T-6	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				
T-7	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				
T-8	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				
T-9	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				
T-10	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				
T-12	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				
T-13	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				
T-15	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				
T-16	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				
T-17	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				
T-18	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				
T-19-A	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				
T-19-B	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				
T-20	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				
T-21-A	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				
T-21-B	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X			
T-22-A	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				
T-22-B	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				
T-22-C	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				
T-23	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				
T-24	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				
T-25	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				

Measure #	Quantified Criteria Pollutants											Quantified Greenhouse Gases							Quantified Co-Benefits [a]				
	TOG	ROG	NO_x	CO	SO_2	PM10			PM2.5			CO_2			CH_4	N_2O	R	CO_2e	VMT	Electricity	Natural Gas	Water	Waste
						Ex	Dust	Tot	Ex	Dust	Tot	Bio	N-Bio	Tot									
T-27	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				
T-29	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X				
E-1	X	X	X	X	X	X		X	X		X		X	X	X	X		X		X	X		
E-2	X	X	X	X	X	X		X	X		X		X	X	X	X		X		X	X		
E-4	X	X	X	X	X	X		X	X		X		X	X	X	X		X		X	X		
E-5	X	X	X	X	X	X		X	X		X		X	X	X	X		X		X	X		
E-6													X	X	X	X		X		X			
E-10-A													X	X	X	X		X		X			
E-10-B													X	X	X	X		X		X			
E-10-C													X	X	X	X		X		X			
E-11													X	X	X	X		X		X			
E-12-A	X	X	X	X	X	X		X	X		X		X	X	X	X		X			X		
E-12-B	X	X	X	X	X	X		X	X		X		X	X	X	X		X		X	X		
E-13	X	X	X	X	X	X		X	X		X		X	X	X	X		X		X	X		
E-15													X	X	X	X		X		X			
E-16													X	X	X	X		X		X			
E-17													X	X	X	X		X		X			
LL-1	X	X	X	X	X	X		X	X		X		X	X	X	X		X					
W-1												X	X	X	X	X		X				X	
W-2												X	X	X	X	X		X				X	
W-3												X	X	X	X	X		X					
W-4												X	X	X	X	X		X				X	
W-5												X	X	X	X	X		X				X	
W-6												X	X	X	X	X		X				X	
W-7												X	X	X	X	X		X				X	
S-1/S-2												X	X	X	X	X		X					X
R-1																	X	X					
R-2																	X	X					
R-3																	X	X					
R-4																	X	X					
R-5																	X	X					
R-6																	X	X					
N-1													X	X				X					
N-2		X	X		X	X	X	X	X	X	X		X	X	X	X		X		X	X		
AS-1		X																					
AS-2		X																					
E-14	X	X	X	X	X	X		X	X		X	X	X	X	X	X		X			X		
M-1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					
M-2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					
M-3	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					

CH_4 = methane; CO = carbon monoxide; CO_2e = carbon dioxide equivalent; Ex = exhaust; tot = total; Bio = biological; N-bio = non-biological; N_2O = nitrous oxide; NO_x = nitrogen oxides; R = refrigerant; ROG = reactive organic gases; SO_2 = sulfur dioxide; TOG = total organic gases; VMT = vehicle miles travelled.
[a] "X" does not necessarily mean the co-benefit is always quantified. For some emissions and co-benefits, quantification depends on user inputs.

As discussed further in Section 4.3.7.1, *Emissions Reduction Submodule*, in the User Guide, emissions reductions achieved by several measures may be quantified by equally applying the reduction efficacy to all land use subtypes in the project run, or through targeted application to specific land use subtypes. The user may be prevented from selecting certain measures because they are not applicable to the project land use types and/or project scale, are exclusive to other measure selections, or depend on other measures selections that have not been made. See Tables G-45 and G-46 for the applicable land use subtypes and project scales by measure, respectively. Further detail on measure dependencies and mutual exclusivity is provided below in the below sections, where relevant.

The following sections provide additional information on assumptions, calculations, or parameters that are unique to quantified measures in individual screens within the **Emissions Reduction** submodule.

7.1.1 Construction

CalEEMod includes 14 quantified construction measures. Measures C-1-A through C-8 (non-inclusive) reduce combustion emissions. Measures C-9 through C-12 reduce fugitive dust. Measure C-13, *Low VOC-Paints for Construction*, reduces VOC emissions from architectural coatings.

CalEEMod prohibits the user from selecting measures that would not be feasible based on prior user inputs. Specifically:

- Measure C-5, *Use Advanced Engine Tiers*, and Measure C-6, *Use Diesel Particulate Filters*, only apply to diesel-fueled equipment. They cannot be selected if the equipment inventory defined in the **Off-Road Equipment** screen does not include diesel equipment.
- Measure C-6, *Use Diesel Particulate Filters*, and Measure C-8, *Use Renewable Diesel,* cannot be implemented for Tier 4 Final equipment, either identified in **Off-Road Equipment** screen or through application of Measure C-5, *Use Advanced Engine Tiers*.
- Measures C-6, *Use Diesel Particulate Filters*, and C-8, *Use Renewable Diesel,* are mutually exclusive.
- Measure C-9, *Use Dust Suppressants*, and Measure C-10-A, *Water Exposed Surfaces*, are mutually exclusive.
- Measures C-9 through C-12 cannot be selected if the user has already selected them as a control strategy in the **Dust from Material Movement**, **Demolition**, and/or **On-Road Fugitive Dust** screens.

Default low-VOC limits for Measure C-13, *Low VOC-Paints for Construction,* are provided based on the MPI Green Performance Standard. The user may override these defaults with a project-specific performance standard, if available. The low-VOC content limit must not exceed the VOC content in the **Architectural Coatings** screen that is used to quantify unmitigated emissions.

7.1.2 Transportation

CalEEMod includes 27 quantified transportation measures. Most of the measures aim to reduce VMT and encourage mode shifts from single-occupancy vehicles to shared (e.g., transit) or active modes of transportation (e.g., bicycle). Quantification of some measures that are quantified in the Handbook is not currently supported by CalEEMod due to differences in underlying analysis methods and/or limitations around appropriately accounting for the net change in emissions resulting from measure implementation. Handbook transportation measures that are not quantified by CalEEMod are presented as “Qualitative or Supporting Measures.”

As discussed above, for all emission reduction measures, CalEEMod has identified the land use subtypes and project scale to which they are applicable (see Tables G-45 and G-46). The user is precluded from selecting measures that are not applicable to the project land use subtype(s) and project scale. The applicability analysis for transportation measures also accounts for the project locational context, as defined in the **Administrative Map** and **Project Detail** screens. The locational context refers to the level of development at the census tract level. The three locational contexts identified in CalEEMod are suburban, urban, and rural, as defined in Table C-12. Most transportation measures are applicable to development within at least one of these three locational context areas (refer to Table G-47).

Table C-12. CalEEMod Locational Context Options [a, b]

Place Type Name	Place Type Description	CalEEMod Locational Context
Urban Low Transit	Good accessibility, low vacancy, middle-aged housing stock (San Jose, Orange County, San Diego, Los Angeles outside of downtown area)	Urban
Central City Urban	Very high density, excellent accessibility, high public transit access, low single-family homes, older high-value housing stock (mostly downtown San Francisco)	Urban
Urban High Transit	High density, good accessibility, high public transit access, low single-family homes, middle-aged and older housing stock (downtown Los Angeles, Berkeley, Oakland, San Francisco outside downtown area)	Urban
Suburb With Multi-Family Housing	Average on most indicators for the state, low single-family homes and low housing values	Suburban
Suburb With Single-Family Homes	Low density and accessibility, low vacancy, high newer single-family homes and high housing values	Suburban
Rural	Very low access, high vacancy, high newer single-family homes with lower housing values (mainly outside population centers of any kind)	Rural
Rural-In-Urban	These tracts have slightly better accessibility than the truly "rural" tracts, and are more likely to have multifamily housing (select tracts within urbanized areas that had been classified as "Rural")	Rural

[a] The CalEEMod locational context inputs were developed from the eight place types described in *Quantifying the Effect of Local Government Actions on VMT* (Salon 2014).
[b] A “NA” value will be returned for the locational context if the project census tract is identified as “preserve land” or if the project census tract is not mapped in the locational context geospatial domain.

CalEEMod accounts for potential interactions among transportation measures. As discussed further in the Handbook, each transportation measure has a maximum allowable VMT reduction. Measures are grouped into six subsectors (e.g., Land Use, Neighborhood Design), which also have a maximum allowable sub-sector VMT reduction. Finally, the Handbook adopts 70 percent as a maximum for the combined VMT impact from the Land Use, Neighborhood Design, Parking or Road Pricing/Management, and Transit subsectors. CalEEMod applies the measure and sub-sector maxima from the Handbook to the suite of user-selected measures to ensure that emissions are not double counted.

Many of the transportation measures are mutually exclusive. CalEEMod is programmed with mutual exclusivity rules as outlined in the Handbook (see the Mutually Exclusive Measures section of the quantification methods for each transportation measure, as applicable). CalEEMod prohibits the user from selecting mutually exclusive transportation measures.

7.1.3 Energy

CalEEMod includes 14 quantified energy measures. The measures aim to improve building energy efficiency, increase renewable energy generation, and electrify building end uses. Like transportation sector measures, not all energy measures that are quantified in the Handbook are currently supported as quantified measures in CalEEMod. Handbook energy measures that are not quantified by CalEEMod are presented as "Qualitative or Supporting Measures."

CalEEMod is programmed with a series of rules to account for potential interactions among energy measures. These rules are applied after the user has selected all energy measures to recalculate building energy consumption and quantify mitigated emissions. Specifically, if selected:

- Energy reductions (or increases) from Measure E-4, *Install Cool Roofs and/or Cool Walls in Residential Development*, and Measure E-5, *Install Green Roofs in Place of Dark Roofs*, are quantified as absolute values and are assessed first.
- Energy reductions from Measure E-1, *Buildings Exceed 2019 Title 24 Building Envelope Energy Efficiency Standards*, are quantified as a percent reduction and are assessed next.
- Building electrification measures (E-12-A, E-12-B, E-13, and E-15) change the energy consumption profile and are assessed after energy efficiency measures (E-1, E-2, E-4, and E-5).
- Electricity reductions from renewable energy measures (E-10-A, E-10-B, E-10-C) are assessed next.
- Energy reductions from net zero and renewable surplus buildings (E-16 and E-17) are assessed last.

The recalculated building electricity consumption (kWh) is translated to mitigated emissions using the same utility emission factors as specified in **Utility Information** screen, unless the user selects Measure E-11, *Procure Electricity from Lower Carbon Intensity Power Supply*. If this measure is selected, mitigated electricity emissions are calculated using the utility emission factors input by the user for the measure.

CalEEMod is also programmed with mutual exclusivity rules as outlined in the Handbook (see the *Mutually Exclusive Measures* section of the quantification methods for each energy measure, as applicable). CalEEMod prohibits the user from selecting mutually exclusive energy measures.

7.1.4 Water

CalEEMod includes seven quantified water measures. The measures aim to reduce water consumption and/or require a less energy-intensive water source. Like energy sector measures, CalEEMod is programmed with a series of rules to account for potential interactions among water measures. These rules are applied after the user has selected all water measures to recalculate indirect energy consumption and quantify mitigated emissions. Specifically, if selected:

- Measure W-3, *Use Locally Sourced Water Supply*, reduces the energy intensity required to treat and distribute water. The user supplied electricity intensity value is applied to subsequent water measures, as applicable.
- Indirect electricity reductions from measures W-1, *Use Reclaimed Non-Potable Water*; W-2, *Use Grey Water*; W-4, *Require Low-Flow Water Fixtures*; W-5, *Design Water-Efficient Landscapes*; and W-6, *Reduce Turf in Landscapes and Lawns*, are quantified as absolute values and are assessed next.
- Indirect electricity reductions from Measure W-7, *Adopt a Water Conservation Strategy*, are quantified as a percent reduction and are assessed next.

The recalculated indirect electricity consumption (kWh) is translated to mitigated emissions using the same utility emission factors as specified in **Utility Information** screen.

7.1.5 Waste

CalEEMod includes one quantified waste measure. Measure S-1/S-2, *Implement Waste Reduction Plan*, allows the user to identity the percent reduction in project waste that will be sent to regional landfills, avoiding CH_4 emissions from landfill waste decomposition and combustion, if applicable.

7.1.6 Refrigerants

CalEEMod includes six quantified refrigerant measures. Most of these measures aim to decrease the charge size and/or leak rate of equipment or replace the baseline refrigerant with a lower GWP refrigerant. Measure R-2, *Install Secondary Loop and/or Cascade Supermarket Systems in Place of Direct Expansion Systems*, and Measure R-3, *Install Transcritical CO_2 Supermarket Systems in Place of High-GWP Systems*, are mutually exclusive.

7.1.7 Natural Lands

CalEEMod includes two quantified natural lands measures. These measures are linked to the **Vegetation** module. User inputs to the **Land Use Change** screen will auto-load under Measure N-1, *Create New Vegetated Open Space*, and user inputs to the **Sequestration** screen will auto-load under Measure N-2, *Expand Urban Tree Planting*. These inputs inform the calculation of unmitigated emissions. If through the implementation of mitigation, the project changes or expands any of these inputs, the user should provide the necessary information in this screen. For example, consider a scenario in which the user identifies in the **Land Use Change** screen that there are 10 acres of initial grazing area, and the project reduces that to 5 acres. These inputs will automatically show as the "Initial Acres" and "Final Acres" under Measure N-1. With Measure N-1, the project will avoid impacting the 5 acres previously identified in the **Land Use Change** screen. In this example, the user should change the auto-loaded "Final Acres" (5 acres) under N-1 in the **Natural Lands** screen to 10 acres.

7.1.8 Area Sources

CalEEMod includes four quantified area source measures. Measures AS-1, *Use Low-VOC Cleaning Supplies*, and AS-2, *Use Low-VOC Paints*, reduce VOC emissions from cleaning supplies and architectural coatings (i.e., paints), respectively. The emission factor for low-VOC cleaning supplies is further defined in Appendix D3, *Consumer Products Use*. Default low-VOC limits for paints are provided based on the MPI Green Performance Standard. The user may override these defaults with a project-specific performance standard, if available. The low-VOC content limit must not exceed the VOC content in the **Architectural Coatings** screen that is used to quantify unmitigated emissions.

Measure E-14, *Limit Wood Burning Devices and Natural Gas/Propane Fireplaces in Residential Development*, allows the user to require only natural gas hearths, no hearths, or no wood-burning fireplaces.

Measure LL-1, *Replace Gas Powered Landscape Equipment with Zero-Emission Landscape Equipment*, allows the user to require electric landscaping equipment. This measure is only available if the user manually inputs gasoline-powered landscaping equipment in the **Landscaping Equipment** screen.

7.1.9 Miscellaneous

CalEEMod includes three quantified miscellaneous measures. There are no available defaults. The efficacy of each measure is influenced by specific implementation consideration that are unique to each individual project. These parameters and conditions cannot be known or anticipated by CalEEMod. Accordingly, all three measures require the user to input the amount of pollutant reduced per year.

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Appendix D
Technical Source Documentation for Emissions Calculations

Prepared for:
California Air Pollution Control Officers Association (CAPCOA)

Prepared by:
ICF
in collaboration with
Sacramento Metropolitan Air Quality Management District, Fehr & Peers, STI, and Ramboll

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Table of Contents

1 Overview

This appendix contains additional technical detail related to the quantification of some emission sources, as cross-referenced in the User Guide and Appendix C, *Emission Calculation Details for CalEEMod*. Much of the information is based on studies and analysis completed for prior versions of CalEEMod. The source date in the footer reflects the date the material was last revised.

Appendix D1 - Construction Survey by South Coast AQMD

South Coast AQMD performed some construction surveys in order to develop default equipment usage and construction phase lengths. The initial survey was for projects less than five acres in size and is described in the following reference: The Sample Construction Scenarios for Projects Less than Five Acres in Size (http://www.aqmd.gov/ceqa/handbook/LST/FinalReport.pdf)

An additional 16 sites between five and 30 acres were surveyed for mid-sized projects. The amount and types of equipment was developed by attempting to find trends in data (i.e., comparing projects within the same project size, length of construction phases, number of pieces of equipment with areas disturbed, etc.).

The results of these surveys are included in the following tables.

Appendix D1 - Construction Survey By South Coast AQMD

Demolition
One Acre

Equipment Type	No. of Equip	hr/day
Rubber Tired Dozers	1	1
Concrete/Industrial Saws	1	8
Excavators		
Bore/Drill Rigs		
Tractors/Loaders/Backhoes	2	6
	4	

Demolition
Two Acre

Equipment Type	No. of Equip	hr/day
Rubber Tired Dozers	1	8
Concrete Saw	1	8
Excavators		
Bore/Drill Rigs		
Tractors/Loaders/Backhoes	3	8
	5	

Demolition
Three Acre

Equipment Type	No. of Equip	hr/day
Rubber Tired Dozers	1	8
Concrete Saw	1	8
Excavators		
Bore/Drill Rigs		
Tractors/Loaders/Backhoes	3	8
	5	

Demolition
Five Acre

Equipment Type	No. of Equip	hr/day
Rubber Tired Dozers	2	8
Concrete Saw	1	8
Excavators	3	8
Bore/Drill Rigs		
Tractors/Loaders/Backhoes		
	6	

Grading
One Acre

Equipment Type	No. of Equip	hr/day
Rubber Tired Dozers	1	6
Excavators		
Graders	1	6
Scrapers		
Tractors/Loaders/Backhoes	1	7
	3	

Grading
Two Acre

Equipment Type	No. of Equip	hr/day
Rubber Tired Dozers	1	8
Excavators		
Graders	1	8
Scrapers		
Tractors/Loaders/Backhoes	2	7
	4	

Grading
Three Acre

Equipment Type	No. of Equip	hr/day
Rubber Tired Dozers	1	8
Excavators		
Graders	1	8
Scraper		
Tractors/Loaders/Backhoes	2	7
	4	

Grading
Five Acre

Equipment Type	No. of Equip	hr/day
Rubber Tired Dozers	1	8
Excavators	1	8
Graders	1	8
Scrapers		
Tractors/Loaders/Backhoes	3	8
	6	

Construction
One Acre

Equipment Type	No. of Equip	hr/day
Cranes	1	4
Welders		
Excavators		
Forklifts	2	6
Generator Sets		
Tractors/Loaders/Backhoes	2	8
	5	

Construction
Two Acre

Equipment Type	No. of Equip	hr/day
Cranes	1	6
Welders	3	8
Excavators		
Forklifts	1	6
Generator Sets	1	8
Tractors/Loaders/Backhoes	1	6
	7	

Construction
Three Acre

Equipment Type	No. of Equip	hr/day
Cranes	1	8
Welders	3	8
Excavators		
Forklifts	2	7
Generator Sets	1	8
Tractors/Loaders/Backhoes	1	6
	8	

Construction
Five Acre

Equipment Type	No. of Equip	hr/day
Cranes	1	7
Welders	1	8
Excavators		
Forklifts	3	8
Generator Sets	1	8
Tractors/Loaders/Backhoes	3	7
	9	

Coating/Paving
One Acre

Equipment Type	No. of Equip	hr/day
Pavers	1	7
Paving Equipment		
Cement and Mortar Mixers	4	6
Plate Compactors		
Rollers	1	7
Tractors/Loaders/Backhoes	1	7
	7	

Coating/Paving
Two Acre

Equipment Type	No. of Equip	hr/day
Pavers	1	6
Paving Equipment	1	8
Cement and Mortar Mixers	1	6
Plate Compactors		
Rollers	1	7
Tractors/Loaders/Backhoes	1	8
	5	

Coating/Paving
Three Acre

Equipment Type	No. of Equip	hr/day
Pavers	1	8
Paving Equipment	1	8
Cement and Mortar Mixers	1	8
Plate Compactors		
Rollers	2	8
Tractors/Loaders/Backhoes	1	8
	6	

Coating/Paving
Five Acre

Equipment Type	No. of Equip	hr/day
Pavers	1	8
Paving Equipment	2	6
Cement and Mortar Mixers	2	6
Plate Compactors		
Rollers	2	6
Tractors/Loaders/Backhoes	1	8
	8	

Site Preparation
One Acre

Equipment Type	No. of Equip	hr/day
Grader	1	8
Bulldozer		
Excavator		
Scraper		
Tractor/Loader/Backhoe	1	8
	2	

Site Preparation
Two Acre

Equipment Type	No. of Equip	hr/day
Grader	1	8
Bulldozer	1	7
Excavator		
Scraper		
Tractor/Loader/Backhoe	1	8
	3	

Site Preparation
Three Acre

Equipment Type	No. of Equip	hr/day
Grader	1	8
Bulldozer		
Excavator		
Scraper	1	8
Tractor/Loader/Backhoe	1	7
	3	

Site Preparation
Five Acre

Equipment Type	No. of Equip	hr/day
Grader		
Bulldozer	3	8
Excavator		
Scraper		
Tractor/Loader/Backhoe	4	8
	7	

Appendix D1 - Construction Survey By South Coast AQMD

Demolition

Equipment Type	Ten Acre No. of Equip	Ten Acre hr/day	Fifteen Acre No. of Equip	Fifteen Acre hr/day	Twenty Acre No. of Equip	Twenty Acre hr/day	Twenty-five Acre No. of Equip	Twenty-five Acre hr/day
Rubber Tired Dozers	2	8	2	8	2	8	2	8
Concrete Saw	1	8	1	8	1	8	1	8
Excavators	3	8	3	8	3	8	3	8
Bore/Drill Rigs								
Tractors/Loaders/Backhoes								
	6		**6**		**6**		**6**	

Grading

Equipment Type	Ten Acre No. of Equip	Ten Acre hr/day	Fifteen Acre No. of Equip	Fifteen Acre hr/day	Twenty Acre No. of Equip	Twenty Acre hr/day	Twenty-five Acre No. of Equip	Twenty-five Acre hr/day
Rubber Tired Dozers	1	8	1	8	1	8	1	8
Excavators	1	8	2	8	2	8	2	8
Graders	1	8	1	8	1	8	1	8
Scrapers			2	8	2	8	2	8
Tractors/Loaders/Backhoes	3	8	2	8	2	8	2	8
	6		**8**		**8**		**8**	

Construction

Equipment Type	Ten Acre No. of Equip	Ten Acre hr/day	Fifteen Acre No. of Equip	Fifteen Acre hr/day	Twenty Acre No. of Equip	Twenty Acre hr/day	Twenty-five Acre No. of Equip	Twenty-five Acre hr/day
Cranes	1	7	1	7	1	7	1	7
Welders	1	8	1	8	1	8	1	8
Excavators								
Forklifts	3	8	3	8	3	8	3	8
Generator Sets	1	8	1	8	1	8	1	8
Tractors/Loaders/Backhoes	3	7	3	7	3	7	3	7
	9		**9**		**9**		**9**	

Coating/Paving

Equipment Type	Ten Acre No. of Equip	Ten Acre hr/day	Fifteen Acre No. of Equip	Fifteen Acre hr/day	Twenty Acre No. of Equip	Twenty Acre hr/day	Twenty-five Acre No. of Equip	Twenty-five Acre hr/day
Pavers	2	8	2	8	2	8	2	8
Paving Equipment	2	8	2	8	2	8	2	8
Cement and Mortar Mixers								
Plate Compactors								
Rollers	2	8	2	8	2	8	2	8
Tractors/Loaders/Backhoes								
	6		**6**		**6**		**6**	

Site Preparation

Equipment Type	Ten Acre No. of Equip	Ten Acre hr/day	Fifteen Acre No. of Equip	Fifteen Acre hr/day	Twenty Acre No. of Equip	Twenty Acre hr/day	Twenty-five Acre No. of Equip	Twenty-five Acre hr/day
Grader								
Bulldozer	3	8	3	8	3	8	3	8
Excavator								
Scraper								
Tractor/Loader/Backhoe	4	8	4	8	4	8	4	8
	7		**7**		**7**		**7**	

Appendix D1 - Construction Survey By South Coast AQMD

Demolition
Thirty Acre

Equipment Type	No. of Equip	hr/day
Rubber Tired Dozers	2	8
Concrete Saw	1	8
Excavators	3	8
Bore/Drill Rigs		
Tractors/Loaders/Backhoes		
	6	

Demolition
Thirty-four Acre

Equipment Type	No. of Equip	hr/day
Rubber Tired Dozers	2	8
Concrete Saw	1	8
Excavators	3	8
Bore/Drill Rigs		
Tractors/Loaders/Backhoes		
	6	

Grading
Thirty Acre

Equipment Type	No. of Equip	hr/day
Rubber Tired Dozers	1	8
Excavators	2	8
Graders	1	8
Scrapers	2	8
Tractors/Loaders/Backhoes	2	8
	8	

Grading
Thirty-four Acre

Equipment Type	No. of Equip	hr/day
Rubber Tired Dozers	1	8
Excavators	2	8
Graders	1	8
Scrapers	2	8
Tractors/Loaders/Backhoes	2	8
	8	

Construction
Thirty Acre

Equipment Type	No. of Equip	hr/day
Cranes	1	7
Welders	1	8
Excavators		
Forklifts	3	8
Generator Sets	1	8
Tractors/Loaders/Backhoes	3	7
	9	

Construction
Thirty-four Acre

Equipment Type	No. of Equip	hr/day
Cranes	1	7
Welders	1	8
Excavators		
Forklifts	3	8
Generator Sets	1	8
Tractors/Loaders/Backhoes	3	7
	9	

Coating/Paving
Thirty Acre

Equipment Type	No. of Equip	hr/day
Pavers	2	8
Paving Equipment	2	8
Cement and Mortar Mixers		
Plate Compactors		
Rollers	2	8
Tractors/Loaders/Backhoes		
	6	

Coating/Paving
Thirty-four Acre

Equipment Type	No. of Equip	hr/day
Pavers	2	8
Paving Equipment	2	8
Cement and Mortar Mixers		
Plate Compactors		
Rollers	2	8
Tractors/Loaders/Backhoes		
	6	

Site Preparation
Thirty Acre

Equipment Type	No. of Equip	hr/day
Grader		
Bulldozer	3	8
Excavator		
Scraper		
Tractor/Loader/Backhoe	4	8
	7	

Site Preparation
Thirty-four Acre

Equipment Type	No. of Equip	hr/day
Grader		
Bulldozer	3	8
Excavator		
Scraper		
Tractor/Loader/Backhoe	4	8
	7	

Appendix D2 - Building Construction Worker and Vendor Trip Rates

Construction Vendor Trips - Defaults for CalEEMod Based on 2008 SMAQMD Field Survey - South Coast AQMD 2010 Update

				Square Footage			*Raw Data Collection in Field*				
Site	**Location**	**Type**	**# Units**	**Residential Area, sq ft**	**Commerical Area, sq ft**	**Office Area, sq ft**	**Light Duty**	**Medium Duty**	**Heavy Duty**	**Observation Time (minutes)**	**Multiplier to Equate Mins to 8 hrs/day**
Heritage Park	Woodland	Single Family Residential	2,037				13	3	6	37	12.97
Heritage Park (2nd visit)	Woodland	Single Family Residential	2,037				13	3	2	30	16
Yolo Co. Emergency Service	Woodland	Commercial			43,560		2	2	0	30	16
Woodshire	Woodland	Single Family Residential	2,000				5	3	5	35	13.71
Woodshire (2nd visit)	Woodland	Single Family Residential	2,000				10	0	3	30	16
815 H St.	Davis	Multi-Family Residential	8				1	0	0	30	16
Eleanor Roosevelt Cr.	Davis	Multi-Family Residential	60				2	0	0	30	16
Parlin Ranch	West Sac	Single Family Residential	306				2	1	3	30	16
Bridgeway Lakes 2	West Sac	Single Family Residential	487				7	2	0	30	16
The Rivers	West Sac	Single Family Residential	1,139				7	2	0	30	16
The River's Side	West Sac	Single Fam/ Multi Fam/ Comm	29	43,560	3,850		2	2	0	30	16
Carriage Lane	Sacramento	Multi-Family Residential	156				0	2	1	30	16
Promenade	Sacramento	Office/ Comm & Retail			751,000	504,000	10	1	6	40	12
Serenade	Sacramento	Single Family Residential					5	7	2	30	16
1801 L St. Building	Sacramento	Multi-Fam Res/ Comm & Retail	176	48,226	9,600		2	0	0	30	16
800 J Lofts	Sacramento	Multi-Fam Res/ Retail		144,035	50,965		2	1	0	30	16
Marriott Hotel	Sacramento	Multi-Family Res/ Comm	30	80,143	187,000		1	0	1	30	16
Anatolia I	Rancho Cordova	Single Fam Res/ Comm	1,038	7,122,060	631,620		19	15	10	30	16
Pappas Gateway Ctr	Elk Grove	Comm/ Retail			11,200		1	0	2	30	16
Sheldon Place	Elk Grove	Single Family Residential	164				6	2	0	30	16
Laguna Ridge (east pt)	Elk Grove	SF Res/ MF Res/ Office/ Comm & Retail	7,826	1,132,560	2,853,180	307,969	4	5	51	30	16
Laguna Ridge (west pt)	Elk Grove	SF Res/ MF Res/ Office/ Comm & Retail	7,826	1,132,560	2,853,180	307,969	7	8	8	30	16
		Total Units/SqFt	27,319	9,703,144	7,395,155	1,119,938					

Appendix D2 - Building Construction Worker and Vendor Trip Rates

Construction Vendor Trips - Defaults for CalEEMod

Based on 2008 SMAQMD Field Survey - South Coast AQMD 2010 Update

	Daily Count			Residential			Commercial			Office			
Site	**Light Duty**	**Medium Duty**	**Heavy Duty**	**Light Duty**	**Medium Duty**	**Heavy Duty**	**Light Duty**	**Medium Duty**	**Heavy Duty**	**Light Duty**	**Medium Duty**	**Heavy Duty**	**References for the Residential SqFt**
Heritage Park	169	39	78	169	39	78	0	0	0	0	0	0	
Heritage Park (2nd visit)	208	48	32	208	48	32	0	0	0	0	0	0	
Yolo Co. Emergency Service	32	32	0	0	0	0	32	32	0	0	0	0	
Woodshire	69	41	69	69	41	69	0	0	0	0	0	0	
Woodshire (2nd visit)	160	0	48	160	0	48	0	0	0	0	0	0	
815 H St.	16	0	0	16	0	0	0	0	0	0	0	0	
Eleanor Roosevelt Cr.	32	0	0	32	0	0	0	0	0	0	0	0	
Parlin Ranch	32	16	48	32	16	48	0	0	0	0	0	0	
Bridgeway Lakes 2	112	32	0	112	32	0	0	0	0	0	0	0	
The Rivers	112	32	0	112	32	0	0	0	0	0	0	0	
The River's Side	32	32	0	29	29	0	3	3	0	0	0	0	http://www.mintierharnish.com/projects/westsac/pdf/2008-2013HousingElementUpdate.pdf
Carriage Lane	0	32	16	0	32	16	0	0	0	0	0	0	
Promenade	120	12	72	0	0	0	72	7	43	48	5	29	
Serenade	80	112	32	80	112	32	0	0	0	0	0	0	Serenade at Regency Park Homeowners Association (916) 925-9000
1801 L St. Building	32	0	0	27	0	0	5	0	0	0	0	0	http://www.kuchman.com/architecture-portfolio/urban/1801L.html
800 J Lofts	32	16	0	24	12	0	8	4	0	0	0	0	http://www.cityofsacramento.org/econdev/development-projects/documents/700-800_K_Street_Final_Proposal_web.pdf
Marriott Hotel	16	0	16	5	0	5	11	0	11	0	0	0	http://sacramento.bizjournals.com/sacramento/business_travel/guide/hotels.html
Anatolia I	304	240	160	279	220	147	25	20	13	0	0	0	http://www.cityofranchocordova.org/Modules/ShowDocument.aspx?documentid=758
Pappas Gateway Ctr	16	0	32	0	0	0	16	0	32	0	0	0	
Sheldon Place	96	32	0	96	32	0	0	0	0	0	0	0	
Laguna Ridge (east pt)	64	80	816	17	21	215	43	53	542	4	6	59	http://sacramento.bizjournals.com/sacramento/stories/2008/05/12/story7.html
Laguna Ridge (west pt)	112	128	128	30	34	34	74	85	85	8	9	9	http://sacramento.bizjournals.com/sacramento/stories/2008/05/12/story7.html
Total Daily Vehicle Trips	1,846	925	1,547										
Total Daily Vehicle Trips				1,496	701	724	289	204	727	60	20	97	
Vehicle Trips per Unit or 1k Sq Ft				0.0548	0.0256	0.0265	0.0391	0.0275	0.0983	0.0538	0.0176	0.0863	
TOTAL Vehicle Trips per Unit or 1k SqFt					**0.1069**			**0.1649**			**0.1577**		

Appendix D2 - Building Construction Worker and Vendor Trip Rates

Construction Vendor Trips - Defaults for CalEEMod Based on 2008 SMAQMD Field Survey - South Coast AQMD 2010 Update

		Commercial and Office Daily Count		
Site	**Commerical and Office Area, sq ft**	**Light Duty**	**Medium Duty**	**Heavy Duty**
Heritage Park	0	0	0	0
Heritage Park (2nd visit)	0	0	0	0
Yolo Co. Emergency Service	43,560	32	32	0
Woodshire	0	0	0	0
Woodshire (2nd visit)	0	0	0	0
815 H St.	0	0	0	0
Eleanor Roosevelt Cr.	0	0	0	0
Parlin Ranch	0	0	0	0
Bridgeway Lakes 2	0	0	0	0
The Rivers	0	0	0	0
The River's Side	3,850	3	3	0
Carriage Lane	0	0	0	0
Promenade	1,255,000	120	12	72
Serenade	0	0	0	0
1801 L St. Building	9,600	5	0	0
800 J Lofts	50,965	8	4	0
Marriott Hotel	187,000	11	0	11
Anatolia I	631,620	25	20	13
Pappas Gateway Ctr	11,200	16	0	32
Sheldon Place	0	0	0	0
Laguna Ridge (east pt)	3,161,149	47	59	601
Laguna Ridge (west pt)	3,161,149	82	94	94
TOTALs	**8,515,093**	**349**	**223**	**823**
		0.0410	0.0262	0.0967
			0.1639	

Consumer Products Summary

Statewide Volatile Organic Compound (VOC) emissions data was obtained from the 2008 California Air Resources Board (CARB) Consumer Product Emission Inventory.[1] Statewide total VOC emissions were 239.6 tons/day.

The statewide total building area is 22,435,267,518 square feet. The general building stock inventory was obtained from the HAZUS-MH software and backup databases prepared by the Federal Emergency Management Agency.[2] This inventory was found to be the most comprehensive statewide data available that included building area for all land use types. The inventory was developed from the following information:

- Census of Population and Housing, 2000: Summary Tape File 1B Extract on CDROM prepared by the Bureau of Census.
- Census of Population and Housing, 2000: Summary Tape File 3 on CD-ROM prepared by the Bureau of Census.
- Dun & Bradstreet, Business Population Report aggregated by Standard Industrial Classification (SIC) and Census Block, May 2002.
- Department of Energy, Housing Characteristics 1993. Office of Energy Markets and End Use, DOE/EIA-0314 (93), June 1995.
- Department of Energy, A Look at Residential Energy Consumption in 1997, DOE/EIA-0632(97), November 1999.
- Department of Energy, A Look at Commercial Buildings in 1995: Characteristics, Energy Consumption, and Energy Expenditures, DOE/EIA-0625(95), October 1998.

Statewide VOCs per building square feet are therefore:
(239.6 tons/day x 2000 lbs/ton) / 22,435,267,518 sq. ft. = ***2.14e-5 lbs/(sq.ft.-day)***

[1] http://www.arb.ca.gov/app/emsinv/emssumcat_query.php?F_YR=2008&F_DIV=-4&F_SEASON=A&SP=2009&F_AREA=CA#5

[2] Detailed information is contained in the HAZUS-MH Earthquake Technical Manual, Chapter 3.2.1.3 available here: http://www.fema.gov/plan/prevent/hazus/

Appendix D3 - Consumer Products Use

Data Grouping	Total VOC (tons/day)	Population*	Total VOC (lbs/person-day)	Total Building Area (Square Feet)	
2003 Survey Commercial *(45.3% of 2003 Land Use Total)*	47.4				
2003 Survey Residential *(48.0% of 2003 Land Use Total)*	50.3				
2003 Survey Industrial *(6.7% of 2003 Land Use Total)*	7.0				
2003 Survey Land Use Total *(42.3% of Grand Total)*	*104.7*			8,600,000,000	from South Coast AQMD draft staff report for consumer products rule
2003 Survey CARB Data Total	186.3	34,650,690	1.08E-02		
2006 Survey CARB Data Total	61.1	36,457,549	3.35E-03		
Grand Total	***247.3***		***1.41E-02***	***22,435,267,518***	from HAZUS-MH, data from late 1990's - early 2000's

*Data from American Communities Survey from the US Census

		Total VOC (lbs/building sq. ft.)	
2008 ARB Emission Inventory (Consumer Products)	***239.6***	*2.14E-05*	Statewide Factor
South Coast AQMD Rule 1143 reduction to 300 g/l	11.3	*2.04E-05*	
(as of 1/1/11) If 25 g/L gets upheld by the courts	17.5	1.98E-05	South Coast AQMD

Degreaser Use on Parking Surfaces

Statewide VOC emissions data from degreasers used for general purposes (aerosols and non-aerosols combined) were obtained from CARB's California Emissions Projection Analysis Model (CEPAM2019v1.03). Using a 2017 base year inventory, CEPAM forecasts emissions for degreasers, among other things, based on growth and control data available at the time of development of the model version. CEPAM estimated 2.00 short tons per day of VOC in 2021, the most recent year with available data.[1]

In San Francisco County, the census indicated that in 2014 there were 166,455 non-residential off-street parking spaces. This was calculated based on the number of publicly accessible car parking spaces minus on-street parking spaces (441,905 – 275,450 = 166,455).[2] Further, CARB's EMFAC2021 (v1.0.0) data shows that there were 268,749 registered cars in San Francisco County in 2014, which results in a 0.6 parking space per registered car (166,455 parking spaces / 268,749 cars).

This analysis applies the San Francisco County parking rate of 0.6 parking spaces per registered car to all of California. Using CalEEMod's default of 400 square feet per parking space, and CARB's EMFAC2021 data of 28,439,815 registered cars in California for the year of 2021, the calculation to estimate the total parking area in California in 2021 is as follows.

28,439,815 cars x 0.6 parking spaces/car x 400 sq ft/parking space = 7,045,904,879 square feet

Thus, the estimate for the statewide parking surface degreaser VOC emission factor in 2021 is calculated as follows.

(2.00 short tons VOC/day x 2000 lbs/short ton) / (7,045,904,879 sq ft) = **5.68 x 10^{-7} lb VOC/sq ft/day**

[1] Available at: https://ww2.arb.ca.gov/applications/cepam2019v103-standard-emission-tool.
[2] Available at: http://sf.streetsblog.org/2014/05/22/census-sf-has-enough-public-parking-spaces-to-fill-cas-coastline.

Fertilizer/Pesticide Use for City Parks and Golf Courses

Statewide VOC emissions from fertilizers/pesticides for agricultural use for the most recent year with available data, 2020, was obtained from CARB's California Emissions Projection Analysis Model (CEPAM2019v1.03). Using a 2017 base year inventory, CEPAM forecasts emissions for fertilizers/pesticides, among other things, based on growth and control data available at the time of development of the model version. CEPAM estimated 41.62 short tons per day of VOC from fertilizers/pesticides for agricultural (not including structural) in 2021.[3] The inventory data for structural pesticides was excluded from this sum because these chemicals are not utilized for groundskeeping activities associated with maintaining city parks and golf courses.

According to the U.S. Department of Agriculture, the statewide total acres of farm operations in 2020 was 24.3 million acres.[4]

The calculation to determine what the average statewide VOC emissions factor would be from fertilizers/pesticides for agricultural use in the year 2020 is as follows.

(41.62 short tons VOC/day x 2000 lbs/short ton) / (24,300,000 acres * 43,560 sq ft/acre) = **7.86 x 10^{-8} lb VOC/sq ft/day**

This statewide agricultural VOC emission factor is used as a surrogate emission factor for estimating VOC emissions associated with using fertilizers/pesticides for landscaping city parks and golf courses.

[3] Available at: https://ww2.arb.ca.gov/applications/cepam2019v103-standard-emission-tool.
[4] Available at: https://quickstats.nass.usda.gov/results/7441DB63-2C95-33F5-9320-18EDE52C459E.

Analysis of Building Energy Use Data

The following information describes the steps and assumptions used in preparing building energy intensities used in CalEEMod Version 2022.1 (see Appendix G, Table G-28).

Background

Emissions result from activities in residential and commercial buildings when electricity and natural gas are used as energy sources. CalEEMod calculates criteria pollutant and GHG emissions from building natural gas combustion, and GHG emissions from building electricity use (indirectly emitted at regional fossil fuel–fired power plants).

Within Title 24 of the California Code of Regulations (Building Standards Code) is Part 6, the Building Energy Efficiency Standards (Energy Code). The latest Energy Code is for 2019. The California Energy Commission (CEC) adopted the 2022 Energy Code in August 2021, and it will take effect January 1, 2023 (CEC 2022). The Energy Code contains energy conservation standards applicable to particular end use categories for all new or altered residential and non-residential buildings throughout California.

Methodology

Datasets

The default electricity and natural gas consumption are provided to the user based on 2019 consumption estimates from the CEC's (2020, 2021) 2018–2030 Uncalibrated Commercial Sector Forecast (Commercial Forecast) and the 2019 Residential Appliance Saturation Survey (RASS).

The CEC prepared the Commercial Forecast in October 2019. The Commercial Forecast is generated by a computer model developed by the CEC to forecast electricity and natural gas consumption for commercial building types in California. The data that informs the model includes previous commercial end use surveys, floor space and vacancy estimates (based on econometric and demographic data), adopted building and appliances standards, weather data (cooling and heating degree days), and electricity and natural gas rates. The Commercial Forecast provides energy consumption estimates for 10 commercial end uses: space heating, cooling, ventilation, water heating, cooking, refrigeration, miscellaneous, office equipment, indoor lighting, and outdoor lighting.

The CEC administered the statewide RASS in 2019. The study yielded energy consumption estimates for 27 electric and 10 natural gas residential end uses.

- **Electricity**: conventional heat, heat pump, auxiliary heat, central air conditioning, room air conditioning, evaporative cooler, water heat, solar water heat, range/oven, microwave, dish washer, spa heat, clothes washer, dryer, outdoor lighting, TV, home office, personal computer, pool pump, well pump, furnace fan, attic ceiling fan, miscellaneous, refrigerator, freezer, and total.
- **Natural gas**: primary heat, auxiliary heat, conventional gas water heat, solar water heat with gas backup, range/oven, dryer, pool heat, spa heat, miscellaneous, and total.

CEC's Commercial Forecast and RASS also disaggregate energy consumption end use categories by those that are subject to Title 24 standards and those that are not. CalEEMod provides default building electricity and natural gas use disaggregated into these two categories. The distinction is required to enable accurate calculation of several energy sector emission reduction measures. The following end uses, separated by energy source, are subject to Title 24.

- **Electricity**: space heating, cooling, ventilation, water heating, outdoor lighting, and the majority of indoor lighting.
- **Natural gas**: space heating and water heating.

The following end uses, separated by energy source, are not subject to Title 24.

- **Electricity:** all other end uses, including cooking appliances, clothes washers, electric dryers, refrigeration, office electronics, electric pool/spa heating, well pumping, fans, miscellaneous plug-in uses, and the remainder of indoor lighting.
- **Natural gas:** all other end uses, including range/oven, dryer, pool/spa heating, and other miscellaneous uses.

Baseline Energy Use Calculations

The RASS and Commercial Forecast datasets were used to derive the energy intensities of different end use categories for different land use subtypes in different electricity demand forecast zones (EDFZ). It is important to note that although the RASS was completed in 2019, that does not mean the energy intensity estimates derived from the dataset are representative of buildings constructed in compliance with the energy efficiency requirements of the 2019 Energy Code. For example, of the 40,000 residences surveyed in the RASS, the average residence was constructed in 1974, the oldest residences were constructed in 1935, and the newest residences were constructed in 2015. Therefore, the default energy consumption estimates provided in CalEEMod based on the RASS are very conservative, overestimating expected energy use compared to what would be expected for new buildings subject to the latest Energy Code with more stringent energy efficiency measures. While this is certainly a downside to using the RASS dataset, it is counterbalanced by the fact that this dataset is the only known source that provides energy intensity estimates delineated by EDFZ and land use subtype, both of which are important variables that affect a project's energy consumption (e.g., a retirement community in an EDFZ with a hot climate consumes much more energy per dwelling unit than that same land use in an EDFZ with a temperate climate).

The below sections detail some of the key processing and underlying assumptions made for the RASS and Commercial Forecast.

Commercial Forecast for Non-Residential Buildings

The Commercial Forecast provides electricity and natural gas demand per square foot of building space by EDFZ, land use subtype, and end use for the year 2019.

- There are 28 unique EDFZ shapes in CEC's statewide dataset, all of which are included in CalEEMod (see Figure D-1). The Commercial Forecast only contains data for 19 of the EDFZs. The 9 EDFZs missing from the dataset were assigned a proxy EDFZ listed in the Commercial Forecast based on a manual review of the closest EDFZ that shared the longest border with the missing EDFZ. See Table D-1 for each proxy EDFZ.
- There are 12 building types in the Commercial Forecast. Each of the nonresidential land use subtypes in CalEEMod was matched to the appropriate Commercial Forecast building type. See Table D-2 for each non-residential land use subtype's corresponding building type.
- Based on recommendations from CEC staff, it was assumed that 90 percent of total interior lighting electricity was required by fixtured overhead lighting subject to Title 24 and the remaining 10 percent of lighting electricity was associated with plug-in lamps not subject to

Title 24. The interior lighting electricity was accordingly apportioned 90 percent to Title 24 electricity and 10 percent to non-Title 24 electricity.

2019 RASS for Residential Buildings

The RASS provides unit energy consumption (UEC) of electricity and natural gas and appliance saturations by EDFZ, land use subtype, and end use based on surveys administered in 2019. A UEC represents the amount of energy a single appliance or end use is estimated to use in a single year.

- There are 28 unique EDFZ shapes in CEC's statewide dataset, all of which are included in CalEEMod (see Figure D-1). The RASS only contains data for 15 of the EDFZs. The 13 EDFZs missing from the dataset were assigned a proxy EDFZ listed in the RASS based on a manual review of the closest EDFZ that shared the longest border with the missing EDFZ. See Table D-1 for each proxy EDFZ.
- There are five residential building types in the RASS. Each of the nine residential land use subtypes in CalEEMod was matched to the appropriate RASS residential building type. See Table D-2 for each residential land use subtype's corresponding building type.
- The RASS does not report interior lighting as an end use. Instead, it is a component of the miscellaneous end use category. In an effort to isolate the portion of electricity in the miscellaneous category from interior lighting, it was assumed to represent 20 percent of total electricity, mirroring the assumption of the 2009 RASS (CEC 2010). This value was subtracted from the miscellaneous end use category to avoid double counting.
- The RASS also does not report ceiling fans as an end use. Instead, it is a component of the miscellaneous end use category. In an effort to isolate the portion of electricity in the miscellaneous category from ceiling fans, it was assumed there was an average of one ceiling fan per dwelling use and that it requires 84.1 kilowatt hours per year (NREL 2009). This value was subtracted from the miscellaneous end use category to avoid double counting.
- Based on recommendations from CEC staff, it was assumed that 90 percent of total interior lighting electricity was required by fixtured overhead lighting subject to Title 24 and the remaining 10 percent of lighting electricity was associated with plug-in lamps not subject to Title 24. The interior lighting electricity was accordingly apportioned 90 percent to Title 24 electricity and 10 percent to non-Title 24 electricity.
- Saturation refers to the prevalence of an appliance in the average residence. The saturation data was used to create weighted average residential energy intensity values. For example, perhaps only 30 percent of Apartment or Condo (2-4 Units) dwelling units in EDFZ 4 have electric dryers, which require an average of 500 kilowatt hours per year. Another 30 percent of dwelling units have gas dryers requiring an average of 200 thousand British Thermal Units (kBTU) per year. The remaining 40 percent of dwelling units have no onsite dryer. Therefore, the average Apartment or Condo (2-4 Units) from EDFZ 4 would use 150 kWh per year for electric dryers (30 percent * 500 kWh/yr) and 60 kBTU for gas dryers (30 percent * 200 kBTU/yr).

Figure D-1. California Energy Commission Electricity Demand Forecast Zones

Source: CEC 2017.

Note: This figure is intended to provide a general depiction of the forecast zones as not all details can be clearly depicted at this scale. Those interested in additional detail should refer directly to the interactive version of this map, which is available on CEC's website at the following URL: https://cecgis-caenergy.opendata.arcgis.com/datasets/86fef50f6f344fabbe545e58aec83edd_0/data?geometry=-165.327%2C31.004%2C-72.427%2C43.220.

Table D-1. Electricity Demand Forecast Zones Used in CalEEMod to Proxy Missing Zones

EDFZ Name	EDFZ	Residential (RASS) Proxy Zone	Commercial Proxy Zones
Other-A	0-A	4	4
Other-B	0-B	2	2
Other-C	0-C	3	3
Other-D	0-D	3	3
Other-E	0-E	10	10
Other-F	0-F	3	3
Other-G	0-G	3	3
Other-H	0-H	4	4
Greater Bay Area	1	—	—
North Coast	2	—	—
North Valley	3	—	—
Central Valley	4	—	—
Southern Valley	5	—	—
Central Coast	6	—	—
LA Metro	7	—	—
Big Creek West	8	—	—
Big Creek East	9	—	—
Northeast	10	—	—
Eastern	11	—	—
SDG&E	12	—	—
SMUD Service Territory	13	—	—
Turlock Irrigation District	14	4	—
Rest of BANC Control Area	15	3	—
LADWP Coastal	16	—	—
LADWP Inland	17	—	—
Burbank/Glendale	18	17	—
Imperial Irrigation District	19	11	—
Valley Electric	20	10	10

Source: CEC 2017.
- = N/A. EDFZ is already included in the RASS or commercial end use forecast. Numbers only listed for missing zones.
EDFZ = Electricity Demand Forecast Zone; RASS = Residential Appliance Saturation Study; LA = Los Angeles; LADWP = Los Angeles Department of Water and Power; BANC = Balancing Authority of California; SDG&E = San Diego Gas & Electric; SMUD = Sacramento Municipal Utility District.

Table D-2. Land Use Mapping of Residential Appliance Saturation Study and Commercial Forecast to CalEEMod

Building Type	CalEEMod Land Use Type
College	Junior college (2yr), University/college (4yr)
Grocery	Convenience market (24 hour), Convenience market with gas pumps, Supermarket
Hospital	Hospital
Hotel/motel	Hotel, Motel
Large office	General office building, Government (civic center), Government office building, Industrial park, Medical office building, Office park, Research & development
Miscellaneous	Arena, automobile care center, Bank (with drive-through), Gasoline/service station, General heavy industry, General light industry, Health club, Library, Manufacturing, Movie theater (no matinee), Place of worship, Racquet club
Refg. Warehouse	Refrigerated warehouse
Restaurant	Fast food restaurant w/o drive thru, Fast food restaurant with drive thru, High turnover (sit down restaurant), Quality restaurant
Retail	Discount club, Electronic superstore, Free-standing discount store, Free-standing discount superstore, Hardware/paint store, Home improvement superstore, Pharmacy/drugstore, Regional shopping center, Strip mall
Schools	Day-care center, Elementary school, High school, Junior high school
Small office	n/a
Warehouse	Unrefrigerated warehouse
Single family detached	Single family housing
Apartment or condo (2-4 units)	Apartments low rise, Retirement community
Apartment or condo (5+ units)	Apartments mid rise, Apartments high rise, Condo/townhome high rise, Congregate care
Townhome, duplex, or row house	Condo/townhouse
Mobile home	Mobile home park

RASS = Residential Appliance Saturation Study; Refg. = refrigerated; yr = year; n/a = no mapped land use type.

References

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Introduction

This paper recommends electricity energy use rates to calculate the energy consumption from the operation of car parking facilities in California. The energy uses considered include lighting, ventilation, and elevator use. Recommendations apply to open air parking lots, parking facilities with open walls and access to fresh air, and fully enclosed parking facilities, such as those that are underground, and require ventilation systems. These energy use rates allow the user to calculate lighting, ventilation and elevator use energy impacts separately.

Purpose

This effort was undertaken in conjunction with the CalEEMod Land Use Model ("CalEEMod") 2012 updates. Our intent is to determine if enough information is available to support the development of energy use rates for parking facilities in CalEEMod, and if so, what these recommended energy use rates should be.

Limitations

Energy use rates from water pumps, for fire safety systems or for storm water removal, were not considered because CalEEMod does not include emissions estimates from any stationary sources located at land use development projects. Our research has not identified energy use rates for operational systems, such as from systems designed to collect payments or secure the property, such as computer, ticketing, camera surveillance, or automated and human-activated gate systems. To our knowledge, research is not available to determine in which situations or size of facilities these systems would be utilized. Likewise, research is not available to determine in which situations parking facilities include energy use from natural gas, heating, cooling, and water delivery. Therefore, these energy use rates are not considered.

Proposed Energy Use Rates: Lighting and Ventilation

Energy Star is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy to promote energy efficient products and practices. As part of a larger project to evaluate the efficiency of buildings, Energy Star developed energy factors for parking facilities based on data from the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE), and a review of existing building codes and local ordinances in the United States. **Table 1** below presents factors for energy use in parking facilities, based on the Energy Star "Performance Ratings Technical Methodology for Parking" technical paper.[i]

Table 1: Energy Use for Lighting and Ventilation by Parking Type			
		Hourly Watts or Horse Power Per Square Foot	**Assumed Hours of Operation**
Open Parking	Lighting	0.15 W/ft^2	16 hours/day
	Ventilation	none	
Unenclosed Parking (no walls)	Lighting	0.30 W/ft^2	24 hours/day
	Ventilation	none	
Fully Enclosed Parking (walls)	Lighting	0.30 W/ft^2	24 hours/day
	Ventilation(1)(2)	0.6 hp/1,000 ft^2	

Notes:
1. Ventilation is characterized in terms of flow rate (cubic feet per minute per square foot, cfm/ft^2 equals 0.6 horse power per 1,000ft^2).
2. One horse power(hp) is equal to 0.746 kiloWatts.

Table 2 shows the results of these factors in annual kWh per square foot of parking area.

Table 2: Energy Use for Lighting and Ventilation by Parking Type					
Type of Parking	**Use**	**Days/Year**	**Hours/Day**	**Annual kWh/SqFt**	**Total Annual kWh/SqFt**
Open Parking	Lighting	365	16	0.876	0.876
	(No) Ventilation				
Unenclosed Parking (no walls)	Lighting	365	24	2.63	2.63
	(No) Ventilation				
Fully Enclosed Parking (walls)	Lighting	365	24	2.63	6.55
	Ventilation			3.92	

The Energy Star energy rates are generally consistent with California Title 24 standards. The Title 24 year 2008 standard for indoor parking structure lighting is 0.30 Watts per foot squared; Title 24 year 2005 outdoor parking lighting standard is 0.15 Watts per foot squared; and the proposed Title 24 year 2013 standard for ventilation is 0.6 horse power per 1,000 feet squared[ii]. We have not identified any other sources to compare these factors to that are more appropriate. Note that the energy intensity of parking structures is one of the few land uses that the California Energy Commission (CEC) does not include in the California Commercial End-Use Survey (CEUS) analysis[iii].

None of the other land uses already accounted for in CalEEMod have energy use rates as low as the Energy Star rates for parking facilities, and this is to be expected. Based on the analysis above, parking facilities use between 0.05 and 0.40 kW per square foot per year, and this is much lower when compared to some of the land uses already represented in CalEEMod. The lower end of electric energy rates in CalEEMod includes manufacturing, unrefrigerated warehouses and racquet ball clubs. Depending upon the climate zone, CalEEMod estimates the kW per square foot in unrefrigerated warehouses to be between 3 and 10 kW, and for racquet clubs between 2 and 12 kW. While this doesn't confirm the appropriateness of the Energy Star energy use rates, it is reasonable that parking facilities would have lower energy use rates than other uses.

Proposed Energy Use Rates: Elevators

There are various elevator energy calculations available on the web[iv]. To our knowledge, none are independently verified by a public, private or government agency. This section presents three energy use rates for elevators. Energy use rates will depend on the manufacturer, the type and size of elevator, how many floors the elevator serves, the idle mode settings selected, how often the elevator is used and with how many people. For example, buildings with seven or fewer floors may use elevators powered by hydraulic motors, whereas buildings with eight or more floors will need more powerful and energy-intense "geared or gearless traction" elevators. These elevators are driven by direct current motor-generator sets (DC MG), silicon controlled rectified (SCR) DC motors, or variable voltage variable frequency (VVVF) drives coupled to alternate current (AC) motors. All of these configurations provide variable and high-speed operation and provide regeneration, but exhibit different operating efficiencies[v].

For our purposes, it is assumed that a parking structure elevator will serve ten or fewer floors. Elevators serving more than 10 floors are likely to be located in buildings with uses in addition to parking, and therefore CalEEMod will assume the energy use rates (including elevator use) associated with the other land uses in its calculations.

Table 3 presents the **first example**. Dover Elevators has calculated the average kWh required per day for a single elevator equipped with MG, SCR, and VVVF drives. Based on these daily estimates, Table 3 calculates the per hour and annual energy use for two to five floors and six to ten floors based on the type of elevator technology employed.

Table 3: Average Energy Consumption (kWh) for 2,500 Pound Capacity Elevators (1)						
Number of Floors	**kW Energy Use Based On How Electrical Current is Controlled (per hour)**					
	Variable Voltage Variable Frequency (VVVF)		Silicon Controlled Rectified *(SCR)*		DC MG Sets *(MG)*	
2 to 5	3.875		6.625		9	
6 to 10	4.875		6.75		9.5	
Number of Floors	**kW Energy Use Based On How Electrical Current is Controlled (per year)(2)**					
	16 hrs/day	24 hrs/day	16 hrs/day	24 hrs/day	16 hrs/day	24 hrs/day
2 to 5	22,630	33,945	38,690	58,035	52,560	78,840
6 to 10	28,470	42,705	39,420	59,130	55,480	83,220

Notes:
1. Based on calculations from Dover Elevators.
2. Combines calculations from Dover Elevators and Energy Star assumptions about hours of operations per day.

The **second example** is cited in the California Energy Commission (CEC) *2013 Nonresidential ACM Manual – Draft Version*, June 2011, (the "CEC Draft Manual")[vi]. These estimates are based on a TIAX report cited by the U.S. Energy Information Administration entitled, "Commercial and Residential Spector Miscellaneous Electricity Consumption: Y2005 and Projections to 2030" (the "TIAX Report") and includes buildings with at least 50 percent of space dedicated to non-residential uses, including agricultural, industrial, schools, and institutional uses[vii]. **Table 4** below presents unit energy consumption data from a sample of approximately 5,200 buildings for 2,500 pound capacity elevators, based on time spent in different elevator modes – active, ready, standby, and off:

Table 4: Average Energy Consumption (kWh) for 2500 Pound Capacity Elevators (1)				
Elevator Mode	**Percent of Time in Each Mode**	**Annual Hours in Each Mode**	**kWh Use in Each Mode**	**Annual kWh**
Active	3%	300	10	300
Ready	84%	7,365	0.5	3683
Standby	13%	1,095	0.25	274
Off	0%	0	0	0
Total	100%	8760 (2)	11	6,956 (3)

Notes:
1. TIAX LLC. *Commercial and Residential Spector Miscellaneous Electricity Consumption: Y2005 and Projections to 2030*. September 22, 2006.
2. Assumes operation 365 days per year for 24 hours per day.
3. This energy use represents rates from 2003 projected out to 2005. Year 2005 shows only a slight decrease from the year 2003 baseline.

The differences in energy use estimates in Table 3 and Table 4 is astonishing. The TIAX Report estimates the energy use from the average 2,500 pound capacity elevator to be approximately 20 percent of the kWhs needed for a 24-hour day of the least-energy intensive elevator in the Dover estimates.

The **third example** is based on calculations provided by Kone Elevators documenting the energy savings between a hydraulic elevator and Kone's elevators with the most energy efficient features selected.[viii] These features include energy-saving LED lighting, standby modes for lights, signalization, ceiling fans, and destination control systems, a lightweight hoisting system, and energy regenerating technology. According to Kone, the bulk of energy use in hydraulic elevators comes from the hoisting system. **Table 5** below is based on the information presented by Kone on annual energy consumption from hydraulic elevators and its "EcoSpace" option.

Table 5: Kone Average Energy Consumption (kWh) for 3500 Pound Capacity Elevator (1)			
Energy Use	**Hydraulic Elevator (kWh/year)**	**Kone EcoSpace Elevator (kWh/year)**	**Percent Reduction**
Lighting	2,015	153	- 92%
Electrification	1,139	1,360	+19%
Hoisting	6,024	895	-85%
Total	9,178	2,408	-74%

Notes:
1. Based on information provided by Kone, Inc.

These estimates are based on a 3,500 pound capacity serving four floors with 200,000 starts per year, or 34 starts an hour, assuming 16 hours of operation per day.

Evaluation of Data

It is a challenge to compare the three available examples. The Dover (*first example*) data are detailed and offer specifics about energy use based on the types of elevator systems, but no information on the usage, such as hours per day of operation, speed, or starts per day. This source also presents energy consumption much higher than the other two sources. The Dover information was collected from a website maintained by Washington State University and the Western Area Power Administration and is not dated. It is not clear if these data are current. The Kone (*third example*) estimates are also based on very specific elevator specifications that will not necessarily transfer to our application, which requires a much more general approach. It is not anticipated that CalEEMod users will have detailed information about the size, capacity, usage rates, and type of elevators (hydraulic, geared or gearless traction, etc.) or other specifications, such as type of lighting or ceiling fans selected.

The CEC Draft Manual reports that that elevators are custom designed for each building and "little information is known on how to model elevators." Our research also resulted in few sources that were either specific to the manufacturer or very general.

TIAX (*second example*) is a reliable and reputable company who has conducted a robust study (5,200 buildings) of a variety of elevator types that would be more reflective of the real world and provides a simpler and direct method of determining energy use from an average-used elevator. The question still remains as to whether there is a standard in determining the number of elevators for a size of a parking lot. However, aside from the Americans with Disabilities Act requiring "one passenger elevator serving each level in all multi-story buildings," a building code does not seem to exist requiring how many per size or square footage. It should be noted that the Americans with Disabilities Act does allow parking structures that provide the correct number of accessible spaces on the ground floor to not install an elevator[ix]. As elevators would increase building costs and consume valuable square feet, it seems reasonable to conclude that parking structures are constructed with as few elevators as required by local building codes.

The TIAX Report does include energy use rate projections for a selected future year (2015, 2020, etc.) based on project build out year[x] but, at this time, such programming would be more complex and would require more information from the User. Thus, it is concluded for the default to use a fixed value in time.

Ultimately, decisions regarding the number of elevators is left to the developer who may choose based on a number of reasons. However, there are other sources, including this "rule of thumb" based on all modern American construction (not just commercial buildings):

Table 6: Estimates for Number of Elevators Needed [1]			
No. of Floors	**Building Meters Squared (gross)**	**Building Square Feet (gross)**	**Recommended No. of Elevators**
Up to 3	5,000	53,820	1
4 or more	6,000	64,583	2
4 of more	10,000	107,639	3

Notes:

1. Bhatia, A. *Building Elevator Systems*, CED Engineering.com. Course No: A06-001. Note that if elevators are distributed throughout the building, instead of at a centralized bank of elevators, to account for inefficiencies and imbalances in demand, increase the number of elevators by 60 percent.

Using TIAX study conclusion that one 2500 pound elevator consumes 7,000 kWh per year (**Table 4**) and the number of elevators for a particular sized parking lot (**Table 6**), data can be extrapolated to determine the energy factor to apply (**Table 7**).

Table 7: Annual kWh per Square Foot			
Gross Sq Ft	Elevators	Annual kWh	Annual kWh/square foot
54,000	1	7000	0.13
65,000	2	14000	0.22
108,000	3	21000	0.19
162,000	4	28000	0.17
216,000	5	35000	0.16
270,000	6	42000	0.16
324,000	7	49000	0.15
378,000	8	56000	0.15
432,000	9	63000	0.15
486,000	10	70000	0.14
540,000	11	77000	0.14
594,000	12	84000	0.14
648,000	13	91000	0.14
702,000	14	98000	0.14
756,000	15	105000	0.14
810,000	16	112000	0.14
864,000	17	119000	0.14
918,000	18	126000	0.14
972,000	19	133000	0.14
1,026,000	20	140000	0.14
1,080,000	21	147000	0.14
1,134,000	22	154000	0.14
1,188,000	23	161000	0.14

Conclusion

For the purposes of estimating energy use rates in parking lots and structures in California, CalEEMod should base energy use rate assumptions on the Energy Star estimates for lighting and ventilation. That would require CalEEMod to establish the following new sub-land uses (*with energy impact calculated*) under Parking:

1. Parking lot (*lighting energy use only*)
2. Unenclosed parking structure (*lighting energy use only*)
3. Enclosed parking structure (*lighting and ventilation energy use*)
4. Unenclosed parking structure with elevator (*lighting and elevator energy use*)
5. Enclosed parking structure with elevator (*lighting, ventilation, and elevator energy use*)

The default energy factor (annual kWh/square foot) recommended and used in CalEEMod is 0.19 annual kWh/sq ft which is based on the real data in Tables 4 and 6 and not the highest or lowest factor. CalEEMod will provide the ability for the User to override the default factor if the number of elevators is known (per total square feet) and is different than the default. For example, if a parking lot structure is known to be 200,000 sq ft with 6 elevators, then using the 7,000 annual kWh/elevator x 6 elevators is 42,000 annual kWh/200,000 sq ft equals a new factor of 0.21 annual kWh/sq ft that would be used to replace the CalEEMod default factor of 0.19 annual kWh/sq ft. In addition, if new data is known about kWh usage from a particular elevator (e.g., green elevator technology), the same methodology could be applied replacing the 7,000 annual kWh/elevator with a new known value.

Endnotes

[i] www.energystar.gov/ *Energy Star Performance Ratings Technical Methodology for Parking*. http://www.energystar.gov/ia/business/evaluate_performance/parking_tech_desc.pdf.

[ii] Parking and Title 24 standards: We have not adjusted the outdoor parking lighting factors in the Energy Star to meet 2008 or proposed 2013 Title 24 standards, which are lower than 2005 requirements, because additional lighting is often allowed in outdoor zones that are considered in need of additional safety lighting.

[iii] California Energy Commission. http://www.energy.ca.gov/ceus/

[iv] For example, see http://www.thyssenkruppelevator.com/energy%20calculator/energy.aspx and http://www.kone.com/media/en_US/green/index.html

[v] Washington State University and Western Area Power Administration. Energyexperts.org. http://energyexperts.org/EnergySolutionsDatabase/ResourceDetail.aspx?id=1709

[vi] CEC 2013 Nonresidential ACM Manual – Draft Version (CEC Alternative Calculation Method – June 2011). http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/2011-06-21_workshop/review/2013_NACM_Approval_Manual_Draft.pdf. The CEC website reports the final document will be released in January 2013.

[vii] TIAX LLC. *Commercial and Residential Spector Miscellaneous Electricity Consumption: Y2005 and Projections to 2030*. September 22, 2006. http://wpui.wisc.edu/news/EIA%20Posts/TIAX_EIA_MiscElecReport.pdf

[viii] Kone. *Kone Eco-efficient Solutions* (Brochure); *Elevator Energy Calculation Report*, 10/11/2011. Provided by Kone, Inc.

[ix] Email communication with the US Access Board (tel: 800-872-2253 email: ta@access-board.gov). The US Access Board referred us to local building codes to determine elevator requirements.

[x] Table 4 above presents the 2003 energy use average projected to 2005. The TIAX Report projects elevator energy use rates out in 5 year increments to 2030, however, the estimated decrease in energy use is slight between year 2005 and 2030 and unlikely to affect model results.

Three Studies were Conducted in 2012 on the Amount of Parking Lot Area was Painted (for parking stalls, markings, etc)

Since the release of CalEEMod v2011.1.1, the percentage of space in parking lots that is painted has been questioned, so it was decided to re-evaluate the default currently used. A literature search was performed, but no studies were identified that provided information on the amount of coatings used for parking lots. As a result, contractors were contacted to assist in this research effort. It was determined that most contractors contacted use large volume containers of coatings and do not keep record of the specific amount used on individual parking lot jobs. Consequently, three of the California air district provided data on their own lots and the size of area painted to generate the following data. The compilation relies on the assumption that only one coat of paint was used to make the markings (e.g., stall lines, handicap symbols, no-parking curbs, traffic direction arrows, etc.). The results of the three studies showed a range in percentage of coatings applied. Because the sample size is so small, it was decided to set the default at the highest percentage of the 3 studies (6 percent of total square footage area). Using the highest percentage would also generate a more conservative impact evaluation of VOC emissions from coatings on parking lots. As additional information is obtained the default will be reevaluated and modified as necessary.

SMAQMD Parking Garage Painted Area Calculation (May 15, 2012)

19,000	Gross square footage of parking garage
1,000	Subtract office, storage cage, etc.
18,000	Net parking garage square footage
17	2 deep parking stalls
3456	square inches for a 2 deep parking stall paint
407.7	**square feet for 17 2 deep parking stalls paint**
12	3 deep parking stalls
5376	square inches for a 3 deep parking stall paint
447.7	**square feet for 12 3 deep parking stalls paint**
4	disabled parking stalls
2160	square inches for 1 handicapped parking stall paint
60.0	**square feet for 4 handicapped parking stalls paint**
36.0	**square feet of paint for handicapped square parking signs (4 of them)** (3 feet x 3 feet squares)
14.0	**square feet of no parking signs next to handicapped stalls (4 of them)** (3.5 feet x 1 feet rectangles)
77.0	**square feet of extra space/diagonals handicapped area next to and above parking stall** (5 8 feet diagonals, 4 11 feet diagonals, 5 6 feet diagonals, 13 9 feet diagonals)
1042.4	**square feet for paint in SMAQMD parking garage**
5.8%	**percent of total square footage of parking garage**

4	inches - width of stall painted line
192	inches - length of side stall line
96	inches - length of top stall line
4	inches - width of stall painted line
216	inches - length of side stall line handicapped
108	inches - length of top stall line handicapped

Actual Surface Area Painted & Emissions - South Coast AQMD Parking Lot (June 2012)

Line Type	Width (ft)	Length (ft)	Quantity	Total Painted Surface Area (sq ft)	
Parking Stall Lines	0.33	18	224	1343.87	
"Compact" Denotation	1.00	5	7	35.00	
Arrows	4.00	3.5	6	84.00	
"Slow 5 MPH" Denotation	5.00	6	2	60.00	
Handicap Lines	0.33	18	8	48.00	
Handicap Symbol	3.00	3	4	36.00	
No Parking Red Curbs	0.50	32	4	64.00	
No Parking Red Curbs	0.50	13	2	13.00	
No Parking Red Curbs	1.00	20	1	20.00	
No Parking Red Curbs	0.50	11	2	11.00	
"Stop" Denotation	6.00	8	1	48.00	
			A_{actual} =	1763	Total Actual Painted Surface Area (sq ft) South Coast
				37,869	AQMD Repaved Parking Lot Area (sq ft)
				4.7%	**% Painted Using Single Coat**

NOTE: The South Coast AQMD's parking stalls were separated by single lines (112), however, most commercial/recreational parking lots use double lines (224).

Actual Surface Area Painted & Emissions - SLO County APCD Parking Lot (June 2012)

Line Type	Width (ft)	Length (ft)	Quantity	Total Painted Surface Area (sq ft)	Width (inches)
Parking Place	0.33	18	29	174.00	4
Handicap Lines	0.33	9	5	15.00	4
Handicap Symbol	3.50	3.5	1	12.25	-
Bike Locker Protection	0.33	4	7	9.33	4
Red Curbs - Horizontal Paint	0.33	232	1	77.33	4
Red Curbs - Vertical Paint	0.50	232	1	116.00	6
			A_{actual} =	404	Total Actual Painted Surface Area (sq ft)
				14,900	APCD Parking Lot Size (sq ft)
				2.7%	**% Painted Using Single Coat**

Default Water Use Determination for Industrial Land Uses *(for Version 2013.2 and later)*

Since the release of CalEEMod v2011.1.1, the default water usage from industrial land uses has been questioned, so it was decided to re-evaluate the default currently used. The following are the assumptions used to determine the operation period of a typical industrial facility and the published water usage values (see web link). Specifically for industrial land use categories, the default water use rate is 925 gallons/workday/thousand square feet. This value was computed by dividing the annual water use in California industry (Table ES-6 in Gleick et al. 2002) by the industrial work area in California (Dun & Bradstreet, Business Population Report aggregated by Standard Industrial Classification (SIC) and Census Block, May 2002) where 225 was the annual number of workdays in a year.

365	days/year
7	days/week
52.14	weeks/year
5	Workdays/week
260.71	Potential Workdays/year
36	Average Holidays + Maintenance Shutdowns/year
225	Probable Days/year of Industrial Operations
AF	Acre-foot
SF	Square-foot

225	Industrial Work Days - *see CalEEMod User Manual Appendix A*
665	TAF; *Best Estimate of Water Use/year by California Industry - As identifed in Table ES-6 of Gleick et al. 2003* : www.pacinst.org/reports/urban_usage/waste_not_want_not_full_report.pdf
2,955.6	AF/Work Day ; *Best Estimate of Water Used by CA Industry/Industrial Work Day*
325,851.4	Gal/AF (*conversion)*
963,071,916	Gal Used by CA Industry/Industrial Work Day
1,041,386	TSF of Industrial Work Area in CA - *As identified by: Dun & Bradstreet, Business Population Report aggregated by Standard Industrial Classification (SIC) and Census Block, May 2002, the Industrial component reference identfied in the CalEEMod User Manual Appendix D3 on Consumer Products.*
925	**Gals/WorkDay/TSF**

Default Solid Waste Generation for Industrial Land Uses *(for version 2013.2 and later)*

Since the release of CalEEMod v2011.1.1, the default solid waste generation from industrial land uses has been questioned, so it was decided to re-evaluate the default currently used. There is limited information available linking employment and solid waste generation for the various individual industrial land uses types as analyzed in CalEEMod. However, the Southern California Association of Governments (SCAG) that represents the six-county region of Los Angeles, Orange, Ventura, Riverside, San Bernardino and Imperial counties conducted a study in 2001 called the 'Employment Density Study' (http://www.scag.ca.gov/forecast/downloads/employ_den.pdf). Given the known challenge in locating statewide data and the fact that SCAG data represents close to half the state's population, the information is quasi-applicable to the state. In the study, SCAG identifies the following region-wide median employment densities for these specific industrial land use types:

Light manufacturing = 924 square foot (sq ft)/employee
Warehouse = 1,225 sq ft/employee

Using the 1999 CalRecycle Waste Characterization generation rate of 1.15 tons/employee/year, it has been determined to modify the current default of solid waste generation for industrial land use types using the following rates in CalEEMod:

Warehouses (all types) = 0.94 tons/1000 sq ft/year
All other industrial = 1.24 tons/1000 sq ft/year

Employee based rate for all industrial uses = 1.15 tons/employee/year

These rates seem more in line with other land use generation rates and also have the advantage of using employment densities that correspond more closely with trip generation rates.

Default N Load Factor for Wastewater Calculations *(for version 2013.2 and later)*

Since the release of CalEEMod v2011.1.1, the Sanitation Districts of Sacramento and Los Angeles have raised a concern that the default N load factor of 40mg/L from USEPA's database (2008) is too high. The N load is the mass of nitrogen dischared per volume of wastewater effluent. The factor is used in calculating nitrous oxide emissions produced when treated wastewater is discharged in aquatic environments such as rivers and estuaries. A high N load factor will overestimate the GHG emission throughout much of the State. US EPA has provided an online database (http://cfpub.epa.gov/dmr/ez_search.cfm) for plant-specific effluent results for various pollutants including nitrogen. Performing a query just for California, calculations show that the statewide average would be **26 mg/l** instead of 40 mg/l (current default). CalEEMod does not, at this time, allow the user to enter plant-specific numbers, so the default offers a more representative number for the state.

The following equation was used to determine statewide average:

$$Flow{-}weighted\ effluent\ Nitrogen\ in\ California\ (mg/L)=203{,}953{,}373\ (N{-}lbs)/year *(2586502000\ Gals/day)^\wedge(-1)*(1year/(365.25\ days))*(453592.37mg/1lb)*(1Gal/3.785l)=\mathbf{25.87\ mg/l}$$

The following data was retrieved from the USEPA database (2013) for the equation:

Source: http://cfpub.epa.gov/dmr/ez_search.cfm

Statewide Sum: 203,953,373 lb/yr 2,586,502,000 gal/day

Calif POTWs	Total Pounds (lbs/yr)	Average Flow (MGD)	
CA0107417*	1,020,535	17.4	*Corrected to reflect actual
CA0107611*	755,263	15.4	plant effluent as per discussion
CA0053813	47,848,683	273	with plant facility staff
CA0109991	46,073,447	267	
CA0107409	15,195,624	267	
CA0110604	12,660,447	152	
CA0077682	12,360,199	146	
CA0037664	9,556,191	148	
CA0037702	7,402,404	66.25	
CA0037869	5,197,299	61.4	
CA0038008	5,197,299	61.4	
CA0037613	4,822,150	57.3	
CA0037648	3,237,605	39.5	
CA0107395	2,620,463	24.6	
CA0054097	2,102,347	21.6	
CA0037681	1,886,655	32.4	
CA0053911	1,450,084	57.01	
CA0038318	1,284,429	1.18	
CA0107433	1,113,164	12.4	
CA0037737	962,571	6.88	
CA0048551	949,029	8.038	

CA0037541	913,876	12.2
CA0048194	904,330	8.46
CA0038130	860,572	9.29
CA0038547	778,946	8.77
CA0038628	762,472	9.31
CA0056227	727,201	27.7
CA8000304	709,805	34.8
CA0105350	683,282	29.4
CA8000409	608,790	26.7
CA0038024	562,781	4.606
CA0054011	553,291	19.6
CA0104523	525,445	3.69
CA0079189	504,795	8.46
CA0038539	484,861	8.94
CA0048216	479,712	5.09
CA0048160	456,062	4.054
CA0053856	417,294	13.09
CA0048143	367,016	15.2
CA0054119	362,093	12.2
CA0053953	352,926	14.2
CA0049224	349,790	3.89
CA0107981	349,112	10.3
CA0079103	344,510	10.6
CA0079260	333,956	3.069
CA0104973	316,751	4.015
CA0056294	285,797	9.77
CA7000009	283,784	2.73
CA0037788	262,829	3.41
CA0079219	261,626	8.013
CA0037796	255,924	3.082
CA0108031	254,610	1.21
CA0037842	244,169	100
CA0055221	241,546	8.83
CA0054216	202,111	14.5
CA0104426	196,783	3.54
CA0053651	194,981	5.63
CA0053716	190,189	8.047
CA0038091	182,140	2.52
CA0079138	168,719	26.6
CA0105295	165,877	5.89
CA8000188	162,763	6.23
CA0037532	160,569	1.53
CA0055531	154,954	6.71
CA0104400	145,679	1.24
CA0053619	142,296	4.83
CA0022764	115,563	4.27
CA0054313	110,962	4.97

CA0084573	100,294	6.54
CA0053597	97,150	3.18
CA0082589	94,621	3.37
CA0047996	92,294	0.71
CA8000316	86,643	5.74
CA0079235	84,324	2.97
CA0082660	80,744	3.23
CA0105015	76,603	0.72
CA8000027	74,164	8.066
CA0079651	73,795	1.15
CA0037575	71,906	8.35
CA0056014	67,209	3.36
CA0079154	63,785	9.06
CA8000383	59,920	2.81
CA0079731	59,579	7.42
CA0037621	58,350	11.05
CA0079197	57,484	3.92
CA0079049	52,185	4.65
CA8000326	47,842	3.42
CA0038067	40,548	1.54
CA0079111	36,353	49.2
CA0102695	35,497	0.96
CA0022888	35,088	1.93
CA0077704	34,804	1.22
CA0085235	34,282	1.96
CA0038598	30,598	1.68
CA0037753	30,300	0.63
CA0078671	29,039	1.601
CA0102822	28,556	8.65
CA0037826	27,040	0.74
CA0037711	26,202	2.76
CA0053961	25,767	1.99
CA0109045	24,679	3.54
CA0079022	23,671	0.89
CA0105619	19,761	3.77
CA0023345	19,753	0.91
CA0079511	18,563	0.97
CA0037834	18,079	20.1
CA0079243	16,843	3.025
CA0048127	15,525	2.83
CA0037810	13,909	4.104
CA0022756	13,284	1.67
CA0037851	12,955	2.25
CA0081434	12,534	1.209
CA0079316	12,134	2.201
CA0023060	12,025	0.74
CA0081558	11,221	5.702

CA0078981	10,228	0.54
CA0085260	9,257	0.34
CA0105376	8,569	2.82
CA0037800	7,266	2.18
CA8000395	6,652	0.58
CA0024449	6,336	9.048
CA0054372	6,277	0.38
CA8000100	5,890	0.81
CA0078891	4,768	1.48
CA0038776	4,591	3.017
CA0084727	4,292	0.107
CA0077712	4,075	1.56
CA0107492	3,943	0.84
CA0022730	3,912	0.42
CA0038768	2,485	3.019
CA0084239	2,480	0.063
CA0078948	2,146	9.86
CA0025135	1,521	1.12
CA0078662	1,493	4.71
CA0037770	1,309	1.72
CA0084271	1,252	0.54
CA0048151	1,059	1.074
CA0079898	787	2.25
CA0079081	749	6.54
CA0047364	743	1.33
CA0079502	706	9.209
CA0078956	613	0.74
CA0078590	481	1.65
CA0083771	480	0.19
CA0004995	418	0.71
CA0047899	248	0.95
CA0084476	216	2.15
CA0078034	194	0.73
CA0107999	191	1.77
CA0077828	184	0.38
CA0085201	117	0.095
CA0077836	115	1.57
CA0024490	0.033	4.40E-07
CA0005241	0	0
CA0022977	0	0
CA0023355	0	0
CA0048828	0	0.71
CA0049675	0	0
CA0059501	0	0
CA0064556	0	0
CA0077691	0	8.45
CA0077950	0	5.078

CA0081485	0	0
CA0108944	0	0
CA0110116	0	0.34
	203,953,373	**2586.50**

Additional Construction Defaults

Construction surveys and literature review to inform the additional construction defaults are currently ongoing. This appendix will be updated and republished with recommended defaults once the analysis is complete.

CalEEMod
California Emissions Estimator Model

Appendix E
Support Documentation for Climate Change Analyses

Prepared for:
California Air Pollution Control Officers Association (CAPCOA)

Prepared by:
ICF
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Table of Contents

1 Overview

The California Emissions Estimator Model (CalEEMod) displays data for extreme heat, precipitation, sea level rise, and wildfire through an application programming interface (API) with Cal-Adapt. Based on the Cal-Adapt data and user inputs, the model provides a method to quantify and score the vulnerability of a project or asset to projected climate change. The vulnerability assessment includes the four Cal-Adapt hazards, as well as flooding, air quality degradation, decrease in snowpack, and drought. This appendix provides the methodology for the vulnerability assessment performed by the **Climate Risk** module. The appendix describes the types of emission reduction measures included in the **Measures** module. Because information from the **Climate** map screen underpins much of the analysis in the **Climate Risk** module and **Measures** module, additional context for the map screen is also provided.

The method for scoring climate risks is largely based on the guidance presented in Chapter 4, Assessing Climate Exposures and Measures to Reduce Vulnerabilities, of CAPCOA's *Handbook for Analyzing Greenhouse Gas Emission Reductions, Assessing Climate Vulnerabilities, and Advancing Health and Equity: Designed for Local Governments, Communities, and Project Developers* (Handbook). Relevant information and guidance from the Handbook have been directly incorporated into this appendix.

2 Climate Map Screen

The **Climate** map screen displays extreme heat, precipitation, sea level rise, and wildfire risks that are relevant to the project area. The climate projections are from Cal-Adapt under Representative Concentration Pathway (RCP) 8.5 for the mid-century timeframe. The RCP 8.5 assumes greenhouse gas (GHG) emissions will continue to rise strongly through the year 2050 and then plateau around 2100; this pathway reflects a scenario in which society does not significantly reduce its GHG emissions and closely resembles the current trajectory in global GHG concentrations. The following variables are used to define the climate risk for each hazard.

- *Extreme heat:* Projected number of annual extreme heat days for the 6 kilometer (km) by 6 km, or 3.7 miles (mi) by 3.7 mi, grid cell in which a project is located. The projection is based on the 98th historical percentile of daily maximum/minimum temperatures from observed historical data (32 climate model ensemble from Cal-Adapt, 2040–2059 average under RCP 8.5).
- *Precipitation:* Projected number of annual days with precipitation above 20 millimeters (mm) for the 6 km by 6 km grid cell in which a project is located (32 climate model ensemble from Cal-Adapt, 2040–2059 average under RCP 8.5). The threshold of 20 mm is equivalent to about 0.75 inch of rain, which would be light to moderate rainfall if received over a full day or heavy rain if received over a period of 2 to 4 hours.
- *Sea level rise:* Projected sea level rise inundation depth reported in meters (m) for the 50 meter (m) by 50 m, or 164 feet (ft) by 164 ft, grid cell in which a project is located. The projections are from Radke et al. (2017), as reported in Cal-Adapt (2040–2059 average under RCP 8.5), and consider different increments of sea level rise coupled with extreme storm events. The user may click the dropdown menu to select from four model simulations to view the range in potential inundation depth for the grid cell. Note that the sea level rise geospatial layer must be selected for the dropdown menu to activate. Click the circle button to select the

layer. The four simulations make different assumptions about expected rainfall and temperature, defined as follows.

- Warmer/drier (HadGEM2-ES).
- Cooler/wetter (CNRM-CM5).
- Average conditions (CanESM2).
- Range of different rainfall and temperature possibilities (MIROC5).

- *Wildfire:* Projected annual area burned reported in hectares (ha) for the 6 km by 6 km grid cell in which a project is located (1 ha is equivalent to about 2.5 acres). The projections are from the University of California, Davis, as reported in Cal-Adapt (2040-2059 average under RCP 8.5), and consider historical data of climate, vegetation, population density, and large (>400 ha or 988 acres) fire history. The user may click the dropdown menu to select from four model simulations to view the range in potential wildfire probabilities for the grid cell, as defined above for the sea level rise hazard. Note that the wildfire geospatial layer must be selected for the dropdown menu to activate.

3 Climate Risk Module

The **Climate Risk** Module is comprised of seven screens that guide the user through calculating the climate risks of their project to the eight different hazards. Each of these screens is discussed below.

3.1 Introduction Screen

The **Introduction** screen offers a high-level outline of the process the user will go through to assess climate hazards and develop a vulnerability score. No calculations are performed on this screen. The user should select the climate hazards they wish to analyze further. Climate hazards most applicable to the project analysis based on the project location will be preselected.

3.2 Determine Exposure Score Screen

The methodology behind climate exposure score screening consists of two components: Cal-Adapt data to develop an initial exposure score and guiding questions to refine the initial score into the user's final exposure score.

The exposure scores represent the change in the eight climate hazards that the site is projected to experience. These scores are quantile-based (1 to 5) and draw from site-specific climate projections relative to all projection values in the California climate region of interest. These regions, which come from California's *Fourth Climate Change Assessment* (OPR, CEC, and CNRA 2018), include the following.

- Central Coast
- Inland Desert
- Los Angeles
- North Coast
- Sacramento Valley
- San Diego

- San Francisco Bay Area
- San Joaquin Valley
- Sierra Nevada

For example, future climate projections show that the Los Angeles region will experience higher change in number of extreme heat days than the Sierra Nevada region. Therefore, an extreme heat score of "5" in Los Angeles may (for example) represent 20 additional days of extreme heat, while the same score in the Sierra Nevada may represent 10 additional days of extreme heat. The purpose of these region-specific scores is to emphasize the importance of change in climate hazard. Communities and systems are already adapted to the climate they are in but may experience more serious impacts under significant change.

The climate projections used are based on a 2050 time horizon (assuming a 20-year climatology from 2040 to 2059) under RCP 8.5. Projection values are the ensemble mean of the four priority California statistically downscaled Global Climate Models (HadGEM2-ES, CNRM-CM5, CanESM2, and MIROC5). These projections use a single time horizon and RCP to address computational and storage constraints. The 2050 time horizon and RCP 8.5 are commonly used to assess exposure within a typical planning horizon.

The four Cal-Adapt hazards and their indicators are as follows.

- **Extreme heat** (also referred to as temperature and extreme heat): Change in number of extreme heat days per year based on the 98th percentile temperature. This addresses location relative exposure and is a common variable definition used by Cal-Adapt and in exposure assessments. Note that 98th percentile temperature may be a much hotter temperature in the Central Valley than in the North Coast; thus, even a small projected number of extreme heat days may lead to impacts for vulnerable communities.
- **Extreme precipitation**: Change in number of extreme precipitation days per year based on the 95th percentile temperature. This addresses location relative exposure and is a common variable definition used by Cal-Adapt and in exposure assessments.
- **Wildfire**: Change in wildfire probability using the Westerling (2018) dataset.
- **Sea level rise**: Change in coastal flooding depth as a result of sea level rise and a coastal storm event using the Radke et al. (2017) dataset.

The other four hazards–flooding, drought, air quality degradation, and snowpack reductions–do not have adequate datasets available through Cal-Adapt, so these were not analyzed quantitatively. (While Cal-Adapt does have a snowpack indicator, existing datasets do not address exposure to basin-wide water supply reductions.) Instead, a series of guiding questions help the user determine their exposure score to these hazards.

Tables E-1 through E-5 summarize the guiding questions and outline the parameters applied by the model to score the hazards of flooding, temperature and extreme heat, wildfire, drought, and air quality degradation based on user responses. Exposure scores for sea level rise and extreme precipitation are determined exclusively from Cal-Adapt. No additional questions are asked for the user. The exposure score for decreased snowpack is determined after the user responds.

Table E-1. Exposure Questions and Scoring Parameters for Flooding

Question	User Response	Scoring Action
Is the project located in a 100-year FEMA floodplain?	Yes	Score of 5. No further questions asked.
	No	User advanced to the next question.
Is the project located in a 500-year FEMA floodplain?	Yes	Score of 4. User advanced to the next question.
	No	User advanced to the next question.
Has the project area experienced flooding in the past?	Yes	Score of 5. No further questions asked.
	No	User advanced to the next question.
Is the project area projected to experience an expansion in flood risk areas, increased flood depths, or increased extreme precipitation events?	Yes	User asked to score their exposure using the slider.
	No	

Table E-2. Exposure Questions and Scoring Parameters for Temperature and Extreme Heat

Question	User Response	Scoring Action [a]
Is the project located in an urban heat island (UHI)? (Is the project located in dense urban or suburban environment?)	Yes	+1 is added to the initial Cal-Adapt score. User advanced to the next question.
	No	No change in initial Cal-Adapt score. User advanced to the next question.
Is the project area projected to have higher projected temperature and extreme heat values compared to the region as a whole?	Yes	+1 is added to the initial Cal-Adapt score.
	No	No change in initial Cal-Adapt score.

[a] Scores are added up to a maximum score of 5.

Table E-3. Exposure Questions and Scoring Parameters for Wildfire

Question	User Response	Scoring Action [a]
Is the project located in the wildland-urban interface (WUI) (as defined by CAL FIRE hazard and/or county WUI maps) (the WUI is a zone of transition between wilderness and land developed by human activity)?	Yes	Score of 5. No further questions asked.
	No	No change in initial Cal-Adapt score. User advanced to the next question.
Has the project site experienced wildfire in the past?	Yes	Score of 5. No further questions asked.
	No	No change in initial Cal-Adapt score. User advanced to the next question.

Question	User Response	Scoring Action [a]
Is the project in or near an area that experiences high wind events?	Yes	+1 is added to the initial Cal-Adapt score. User advanced to the next question.
	No	No change in initial Cal-Adapt score. User advanced to the next question.
Is the area around the project composed of vegetation that could serve as significant wildfire fuel?	Yes	+1 is added to the initial Cal-Adapt score. User advanced to the next question.
	No	No change in initial Cal-Adapt score. User advanced to the next question.
Is the project area projected to have higher wildfire risk compared to the region as a whole?	Yes	+1 is added to the initial Cal-Adapt score.
	No	No change in initial Cal-Adapt score.

[a] Scores are added up to a maximum score of 5.

Table E-4. Exposure Questions and Scoring Parameters for Drought

Question	User Response	Scoring Action [a]
Is the project area projected to experience an increase in the frequency or severity of drought in the future?	Yes	Score of 5. User advanced to the next question.
	No	Score of 1. User advanced to the next question.
Is or has the project area ever been identified in a state drought emergency declaration?	Yes	Score of 5. User advanced to the next question.
	No	Score of 1. User advanced to the next question.
Has or does the project area's local government impose water conservation requirements beyond the statewide requirements?	Yes	Score of 4. User advanced to the next question.
	No	Score of 1. User advanced to the next question.
Has the project site area experienced curtailments in water deliveries from imported water sources in the past?	Yes	Score of 4.
	No	Score of 1.

[a] Once all questions are answered, CalEEMod averages scores as (Q1 * 0.40) + (Q2* 0.40) + (Q3 * 0.10) + (Q4 * 0.10). The result is rounded to the nearest whole number.

Table E-5. Exposure Questions and Scoring Parameters for Air Quality Degradation

Question	User Response	Scoring Action
Is the project area within a nonattainment area for federal or state ambient air quality standard?	Yes	Score of 5. User advanced to the next question.
	No	User advanced to the next question.
Is the user's project located within 0.25 mile of a major freeway?	Yes	Score of 5. User advanced to the next question.
	No	User advanced to the next question.
Is the user's project located within 0.25 mile of a major industrial zone or logistics center?	Yes	Score of 5. User advanced to the next question.
	No	User advanced to the next question.
Is this project located in the wildland-urban interface?	Yes	Score of 2 (or +2 to existing score). User advanced to the next question.
	No	User advanced to the next question.
Is the project area projected to experience a decrease in future air quality due to climate change (e.g., due to increased smoke from wildfires)?	Yes	Score of 1 (or +1 to existing score).
	No	Score of 1.

The exposure score for decreased snowpack is determined after the user responds to all guiding questions according to the following logic.

- If the user answers yes to **all** questions, a score of 5 is given.
- If the user answers yes to either question 1 or question 2 **and** yes to question 3, a score of 5 is given.
- If the user answers no to either question 1 or question 2 **and** no to question 3, a score of 3 is given.
- If the user answers no to question 1 **and** Q2 but yes to question 3, a score of 2 is given.
- If the user answers no to **all** questions, a score of 1 is given.

The user may refine any of the exposure scores determined for the climate hazards by adjusting the slider. When refining the exposure score, it may be useful to refer to climate projection tools to consider climate hazard exposure in the specific area where the project will be located. The user is also encouraged to consult any local climate vulnerability assessments, local hazard mitigation plans, or other climate planning documents for their region or project area. The following resources provide additional guidance on understanding climate exposures, as well as exposure maps, that can be used to further refine the exposure score. In some cases, selecting a refined exposure score may require the user to make certain assumptions or judgements.

- Cal-Adapt: This is the official statewide climate hazard mapping tool. Use this tool to assess exposure to temperature, precipitation, and wildfire-related hazards by location.[1]

[1] Available: https://cal-adapt.org/.

- Our Coast, Our Future: A web visualization tool based on data from the US Geological Survey's Costal Storm Modeling System (CoSMoS). Use this tool to assess exposure to sea level rise and coastal flooding hazards.[2]
- Adaptation Planning Guide (APG): The California Governor's Office of Emergency Services (Cal OES) provides detailed guidance for conducting vulnerability studies that can help the user expand on the baseline assessment here.[3]
- Integrated Climate Adaptation and Resiliency Program (ICARP) Adaptation Clearinghouse: OPR's official database of adaptation case studies and technical reports. The user can search the ICARP database to look for detailed vulnerability assessments covering the project site.[4]
- Caltrans 2019 Climate Change Vulnerability Assessments: The California Department of Transportation (Caltrans) has conducted climate change vulnerability assessments for each of its 12 regions. While the focus is on resilience of the state highway system, the climate hazard analysis and recommendations can be generalized to other land uses and projects. Each region also has an interactive map that provides localized climate impact projections.[5]

3.3 Determine Sensitivity Score Screen

This screen guides the user through determining the sensitivity score. The sensitivity score reflects the extent to which a project would be adversely affected by exposure to a climate hazard. There are multiple aspects of sensitivity to consider.

- **Physical**: How sensitive the project may be to physical damage from climate hazards. For example, wildfire can impair the structural integrity of buildings through incineration and exposure to extreme temperatures. Historical data on events for the project site and similar projects can provide insights for how sensitive the project may be to physical effects from different hazards.
- **Operational**: How sensitive the project may be to disruptions of regular operations from climate hazards. For example, flooding along roads may disrupt public transportation operations. Wildfire smoke events may disrupt operations of recreational or commercial land uses. Historical data on events for the project site, similar projects, and critical interconnections (e.g., local energy utilities, transportation networks) will be helpful in understanding potential operational disruptions.
- **Safety**: How sensitive populations associated with a project may be to different climate hazards. For example, apartments in urban areas may become hot and not cool down easily during extreme heat events due to urban heat island effects, endangering the health of residents. Some projects may serve populations that are more vulnerable to climate hazards, such as hospitals or nursing homes.

The screen presents a series of guiding questions to assess how project specifics and site historical data can help provide insights to the sensitivities of a project to climate hazards. Some of the questions, such as those on populations served by the project or project elements vulnerable to physical impacts, are specific to the project type and the user's knowledge of the

[2] Available: https://coast.noaa.gov/digitalcoast/tools/ocof.html.

[3] Available: https://www.caloes.ca.gov/HazardMitigationSite/Documents/CA-Adaptation-Planning-Guide-FINAL-June-2020-Accessible.pdf.

[4] Available: https://resilientca.org/.

[5] Available: https://dot.ca.gov/programs/transportation-planning/2019-climate-change-vulnerability-assessments.

project. Other questions may require the user to access existing reports for the project area. For example, historical data on hazard impacts for the project area and similar projects may be found in local hazard mitigation plans or through engaging local community planners and decision makers.

CalEEMod calculates the final sensitivity score for each hazard by averaging the scores across all questions. The user may refine any of the sensitivity scores determined for the climate hazards by adjusting the slider.

3.4 Determine Adaptive Capacity Score Screen

The adaptive capacity of a project refers to its ability to manage and reduce vulnerabilities from projected climate hazards. For example, a housing development with heating, ventilation, and air conditioning (HVAC) throughout the building will provide residents with cooling and air filtration against projected increases in heat waves and smoke from wildfire events. Identifying the adaptive capacity of a proposed project will help the user understand the degree to which vulnerabilities may be addressed before taking adaptation actions.

The screen presents a series of guiding questions to assess the adaptive capacity of the project. Like sensitivity, CalEEMod calculates the final adaptive capacity score for each hazard by averaging the scores across all questions. The user may refine any of the sensitivity scores determined for the climate hazards by adjusting the slider.

3.5 Develop Potential Impacts Score Screen

This screen presents the potential impacts score for the climate risk analysis. CalEEMod averages the exposure and sensitivity scores for each climate hazard to develop potential impacts scores. If the result is a decimal score (e.g., 2.5), CalEEMod rounds up or down to the nearest whole number (e.g., 2.5 is rounded to a score of 3; 2.1 is rounded to a score of 2). Because the potential impacts scores are based on the previously calculated exposure and sensitive scores, the values cannot be modified on this screen.

3.6 Develop Overall Vulnerability Score Screen

This screen presents the overall vulnerability score for the climate risk analysis. CalEEMod combines the potential impacts and adaptative capacity assessments for each climate hazard to develop overall vulnerability scores. Figure E-1 illustrates how CalEEMod converts the results of the two assessments into a single score. Specifically, the intersection between potential impacts score (1 to 5) in the first column and the adaptive capacity rating (low to high) in the bottom row is the resulting vulnerability score for the climate hazard. Because the vulnerability scores are based on the previously calculated scores, the values cannot be modified on this screen.

Potential Impacts	Low	Low-Med	Med	Mid-High	High
5	5	5	4	3	2
4	5	4	3	2	1
3	4	3	2	2	1
2	3	2	2	1	1
1	2	1	1	1	1

Adaptive Capacity

Figure E-1. CalEEMod Vulnerability Score Matrix

3.7 Select Highest Scoring Vulnerabilities

This screen shows overall vulnerability scores for all climate hazards and selects the hazards that have a vulnerability score of 3 or above. The user can click on additional hazards to include them when selecting risk reduction measures or uncheck preselected hazards based on their risk tolerance and/or other considerations (e.g., policy objectives).

4 Climate Risk Reduction Module

The **Climate Risk Reduction Measures** screen provides 99 measures for a user to select from to reduce their project's vulnerability. To help a user identify the measures that are most applicable to their project, the **Climate** map screen will generate a list of measures based on user input of their project's specific scale and land use subtype(s) on the **Start a New Project** splash screen. Land use subtypes are assigned for all measures based on reasonable judgment. For example, a measure to improve building efficiency would not be applicable to outdoor land use subtypes, like parks. See Tables G-45 and G-46 for the applicable land use subtypes and project scales by measure, respectively. Measures not applicable to the project based on the user identified land use subtype(s) and project scale are shown in gray on the **Climate Risk Reduction Measures** screen. Measures that were preselected on the **Climate** and **Health and Equity** map screens are automatically checked.

4.1 Selecting and Scoring Measures

Each measure could have one or more of the following risk reduction benefits: reduces exposure, reduces sensitivity, and increases adaptive capacity. Some measures may not reduce an element of climate risk (zero value), whereas others may provide a range of potential reduction depending on implementation (e.g., 2 to 4). When a range is provided, a user should select the appropriate reduction benefit score for the project using the dropdown menu. The following sections provide guiding questions to consider when scoring the benefit and further define risk reduction benefits.

4.1.1 Reduces Exposure

The primary driver of exposure is location. A project's proximity to areas susceptible to a hazard will affect the extent to which the project will be subjected to a climate hazard. For example, a project located in a flood zone or in the WUI will be exposed to flooding and wildfire, respectively. While location primarily drives exposure, the user can use adaptation actions to lessen the degree to which a project is exposed to a hazard. The degree to which an adaptation measure lessens the amount of exposure determines its exposure reduction. The following guiding questions can help the user determine the extent to which a measure lowers exposure to a specific hazard.

- How does the measure remove exposure (e.g., relocating a project)?
- How much does the measure change the project design to reduce future exposure (e.g., raising a building to reduce flood exposure)?
- Does the measure change post-construction operations and management to reduce future exposure (e.g., wildfire fuel removal or management)?

4.1.2 Reduces Sensitivity

To lower sensitivity, a measure must reduce the degree to which a project is affected by exposure to a hazard. The following guiding questions can support the user in determining the extent to which a measure decreases harm to a project.

- How much does the measure mitigate the hazards' effect on fragile or critical components of the project (e.g., cooling systems for equipment sensitive to overheating)?
- Does the measure lower the hazard's effect on individuals, particularly members of vulnerable populations (e.g., greater access for underserved populations to parks)?
- Does the measure lower the impact to an operational component affected by the climate hazard (e.g., conduct regular cleaning and maintenance of storm drains along key roadways)?

4.1.3 Increases Adaptive Capacity

Adaptation measures can also increase a project's adaptive capacity. A measure provides adaptive capacity benefits if it improves the project's capacity to take advantage of opportunities or mitigate the hazard's consequences. These guiding questions support the user in considering how a measure bolsters adaptive capacity.

- Does the measure add climate resilient components to the project (e.g., drainage system, cool roof)?
- Does the measure incorporate policies or standards that account for climate change (e.g., adopt or update heat emergency plan)?
- How does the measure improve the project's management of climate hazards (e.g., incorporating projected changes in precipitation and flooding into planned wastewater systems)?
- Does the measure reduce how project users are exposed to the hazard (e.g., using a notification system to provide evacuation information)?

4.2 Calculating Measure Effects on Vulnerability Scores

Based on the user provided scores, CalEEMod estimates the extent to which the user selected climate risk reduction measure(s) reduce exposure and sensitivity and increases adaptive capacity for each climate hazard. No measure, with the exception or relocating a project, can completely remove the threat from a particular climate hazard with a defined geographic footprint (e.g., floodplain). Measures mitigate, rather than remove, potential impacts from a hazard. Likewise, no measure can increase adaptive capacity to the extent to which overall vulnerability is eliminated. Rather, measures can only strengthen a project's overall adaptive capacity score. For these reasons, measure scores are not additive, and a user's exposure, sensitivity, and adaptive capacity score will not go below 0 or surpass 5. CalEEMod recalculates these scores according to the following method.

1. Subtracts the maximum user-identified points across all measures for reduced exposure from the initial exposure score.
2. Subtracts the maximum user-identified points across all measures for reduced sensitivity from the initial sensitivity score.
3. Adds the maximum user-identified points across all measures for increased adaptive capacity to the initial adaptive capacity score.

CalEEMod then recalculates the potential impacts score and the overall vulnerability score.

5 References

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Appendix F
Support Documentation for Health and Equity Association Scoring

Prepared for:
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Table of Contents

1 Overview

The California Emissions Estimator Model (CalEEMod) displays environmental and health burdens relevant to the project census tract based on data from CalEnviroScreen® 4.0 (CES) and the Healthy Places Index (HPI). Based on the CES 4.0 indicator scores and the project scale and land use subtypes, CalEEMod can identify measures to address the environmental and health burdens of the project site. CalEEMod also includes a **Health and Equity Evaluation Scorecard** to evaluate how well a project has adopted specific measures and practices to deliver greater health, equity, and other benefits to support the existing community. This appendix provides additional detail on the CES 4.0 and HPI indicators displayed in the **Health & Equity** map screen and presents the methodology and assumptions underpinning measure identification analysis and scorecard.

2 Health & Equity Map Screen

The **Health & Equity** map screen displays CES 4.0 and HPI indicator scores relevant to the project census tract. The scores are defined as follows.

- *Overall CES 4.0 Score:* Calculated by CES 4.0 by multiplying the pollution burden percentile and population characteristics percentile for the census tract. The maximum score is 100. An area with a high score is one that experiences a much higher pollution burden than areas with low scores.
- *HPI Composite Score:* Calculated by HPI as the composite score of all HPI indicators. The score range is from 0 to 100 and represents the percentile ranking of the project census tract relative to other census tracts in the state. In contrast to CES, higher scores represent healthier community conditions. For example, a score of 97 indicates that the census track has healthier community conditions than 97 percent of other California census tracts. Please note that the geographic coverage of the HPI is limited and is not available for the entire state. The score will show as N/A or 0 if data are not available for the project location.

Based on the CES 4.0 indicator scores, the **Health & Equity** map screen identifies the five most relevant emissions reduction, climate risk, and health and equity measures that address the environmental and health burdens of the project site. The next section describes the approach CalEEMod takes to identify these measures.

3 Identifying Measures Addressing Health and Equity by Project and Census Tract

CalEEMod contains 287 measures, many of which have co-benefits for climate adaptation, public health, and equity. To help users identify the measures that may have the most benefits for addressing existing environmental and health inequities at the project location, the **Health & Equity** map screen will generate a list of measures that are associated with a project's location and land use subtype(s). These measures are identified based on the following.

- **Is it applicable to the project land use subtype?** The land use subtype(s) applicable to the project are selected by the user in the initial screen. There are 79 land use subtypes in CalEEMod, and not every measure would apply or be appropriate for each land use subtype. If a measure is not applicable for the input land use subtype, it will not be recommended.

- **What are the existing health, environmental, and socioeconomic conditions in the project location?** The map uses CES 4.0 and HPI indicators to represent the existing health, environmental, and socio-economic conditions in each census tract. As only CES is available statewide, CalEEMod uses CES for the measure association scores. Note that only individual indicators are used, such as for ozone, diesel particulate matter (DPM), or unemployment, not the final CES 4.0 score.
- **How effectively do measures applicable to this project type address these existing conditions?** Each measure has been evaluated for its potential to address the health and socioeconomic conditions represented by each of the CES 4.0 indicators. The strength of the association between the measure and the CES indicator is represented in the indicator association score. Each measure was assigned indicator association scores for each of the 21 CES indicators (refer to Table G-48). Note that most indicator association scores are zero, due to the lack of a strong, research-supported relationship between the measure action and the relevant impact or health condition.

To determine the measures that may be the most relevant for a particular project location, CalEEMod takes the following steps:

1. From the user's input project location, CalEEMod identifies the census tract and pulls all available CES 4.0 indicators for that census tract.
2. CalEEMod also pulls all measures that are applicable to the project's land use subtype(s) and scale, as provided by the user.
3. Next, *for each applicable measure,* CalEEMod multiplies its CES indicator association scores by the census tract-specific percentile value for each CES indicator. The resulting indicator products are then combined across each measure, following the methodology and principles outlined in the CES 4.0 report (see Section 3.3, *CalEnviroScreen® 4.0 Measure Association Scoring Methodology*) to deliver that measure's census tract-specific association score (OEHHA 2021).
4. The combined association scores for all measures are then ranked, with the highest-ranking measures reported on the CalEEMod map screen. No actual scores are reported on the screen, as the scoring is not sufficiently refined to allow for measures to be ranked based on numeric values. The scoring is only intended to identify the measures with the strongest associations to the existing health and equity conditions in each census tract.

3.1 Land Use Applicability

For each of its 138 emission reduction measures, 99 climate risk reduction measures, and 50 health and equity measures, CalEEMod has identified the land use subtypes and project scale to which they are applicable. Based on user input of their project's specific scale and land use subtype(s) on the **Start a New Project** splash screen, CalEEMod generates a list of all measures that may be reasonably applied to the project.

Land use subtypes are assigned for all measures based on reasonable judgment. For example, a measure to replace residential water heaters with a more sustainable alternative would only be applicable to residential land uses. Similarly, a measure to implement workplace commuting programs would only be relevant to land uses with workers. Some measures, such as establishing onsite renewable energy, have wide applicability and are available to nearly all land use subtypes.

See Appendix G, *Default Data Tables*, Tables G-45 and G-46 for the applicable land use subtypes and project scales by measure, respectively.

3.2 Determining Measure-Specific Indicator Association Scores

Each measure was scored for the strength of its association with reductions for each of the conditions represented by CES 4.0 (refer to Table G-48). For example, a measure to expand the bicycle network would have a stronger association with increases in physical activity but likely a smaller association with reductions in air pollution. The scale for scores was set as follows.

- 0 – no association
- 1 – low association
- 2 – medium association
- 3 – high association

Thus, in the example above, the measure to expand the bike network would have an association score of 2 for Active Commuting (an HPI indicator), and a 1 for Ozone and Particulate Matter (CES).

Where feasible, indicator association scores for air quality—ozone, particulate matter (PM), and DPM—are based on a quantifiable outcome, specifically the emissions reduced or trips eliminated by that measure as determined in the California Air Pollution Control Officers Association *Handbook for Analyzing Greenhouse Gas Emission Reductions, Assessing Climate Vulnerabilities, and Advancing Health and Equity* (Handbook). If qualitative methods are used, indicators are scored using best scientific judgment, using both the co-benefits documented for each measure in the Handbook and published scientific research.

The following considerations guided the derivation of other indicator scores from the indicator scores for air quality.

- In general, the score for DPM was one level lower than the score for PM, as DPM emissions are already partly accounted for in PM emissions. If the score for PM is 2, then the DPM score is 1; if the score for PM is 1, then the DPM score is generally 0. However, if the measure primarily focuses on reducing emissions from diesel-fueled vehicles—for example, creating zero-emissions delivery zones—then the DPM score will be scored the same or 1 level higher than the PM.
- Health outcomes associated with air pollution were also scored 1–2 levels lower than the ozone and PM scores. This reflects that health outcomes result from a multiplicity of factors, not only air pollution and, moreover, the sources of air pollution in a community are also diverse. Thus, a small decrease in air pollution will translate into a smaller decrease in incidences of asthma, cardiovascular diseases, and emergency room visits. Ozone, fine PM (PM2.5), and heat exposure during pregnancy are also linked with the increased risk of low-birth weights, but similarly due to the complex factors in pregnancy, only measures likely to generate larger reductions in air pollution were associated with the low-birth weight indicator (Bekkar et al. 2020).
- Measures that increase physical activity, such as by supporting bicycling and walking, may also have a higher indicator score for cardiovascular-related health outcomes than for asthma. This is due to the substantial research demonstrating the greater health benefits resulting from increases in physical activity than improvements in air quality (Maizlish 2016; Maizlish et al. 2017).
- Measures that increase transit, increase walking and bicycling infrastructure, or otherwise support active transportation have also been associated with indicators for active commuting,

auto access, park access, and supermarket access—all components of the social determinants of health. These are also associated with small reductions in traffic.

- Measures are associated with housing burden if they increase housing supply, increase affordable housing, or reduce costs (such as unbundling parking). Measures are also considered supportive of housing if they reduce exposure to climate risks at home, such as by installing air filters, increasing the urban tree canopy, stabilizing burned slopes, or expanding access to community resources. While these measures do not directly address the housing cost burden, it can be inferred that those facing high housing costs may have fewer resources to increase the climate resilience of their home and would thus benefit from these measures.
- Measures are associated with education if they are likely to facilitate accessing education (school buses) or build community capacity, such as through community-focused climate change outreach and engagement, enhanced local network support, or increased community resources and spaces for community-based organizations. Measures may also increase local employment and training opportunities. Similarly, measures that have been associated with linguistic isolation also focus on public outreach and education, community planning efforts, and any public-focused climate resilience solutions, such as public alert systems or shuttles to cooling centers. It is critical for these efforts to consider potential language barriers as part of their successful deployment.
- Measures that address poverty and unemployment may either increase employment opportunities, facilitate people accessing employment opportunities (e.g., through expanding mobility choices or transportation networks), or support higher wages and improved working conditions. Measures addressing poverty may also help to decrease cost of living, support healthful food access, reduce climate exposures, or increase climate adaptive capacity.
- Many indicators in CES 4.0 have weak or no associations with the majority of measures in CalEEMod that could be significantly supported by published research to justify their scoring. Thus, the scoring takes a conservative approach to avoid overstating the health and equity benefits of any measure. Examples of indicators with little or no association to CalEEMod measures include drinking water, lead risk housing, pesticides, toxic releases, and hazardous waste facilities. These indicators have scores of 0 for the majority of measures.

See Appendix G, *Default Data Tables*, Table G-48 for the measure indicator scores.

3.3 CalEnviroScreen® 4.0 Measure Association Scoring Methodology

CES 4.0's methodology to calculate the overall CES score is used as a guide to aggregate the individual CES indicator association scores for each measure. CES's 21 indicators are divided across four components: Exposure Indicators, Environmental Effect Indicators, Sensitive Population Indicators, and Socioeconomic Factor Indicators. The first two of these components represent pollution burden, and the latter two population characteristics. Indicators in these four components are first averaged and then combined to determine the overall CES score, with the component score for Environmental Effect Indicators receiving a 0.5 weighting.

To remain consistent with CES, CalEEMod adopts the same methodology and component categories to calculate a final CES measure association score from individual indicator association scores. First, the percentiles for each indicator in a specific census tract are multiplied by each applicable measure's indicator association score (on a 0 to 3 scale).[1] The resulting values are then averaged by component to generate component association scores for Exposure, Environmental Effects, Sensitive Population, and Socioeconomic Factor.

Next, the Exposure component association score is averaged with the Environmental Effects component association score, which receives a 0.5 weighting, to produce the *Pollution Burden Association Score*. The Sensitive Population component score is averaged with the Socioeconomic Factor component score at equal weights to obtain the *Population Characteristics Association Score*. Finally, these two scores are multiplied together to determine the final CES measure association score. Table F-1 displays this process.

Table F-1. CalEEMod Method for Calculating the CalEnviroScreen® 4.0 Measure Association Score

Pollution Burden		Population Characteristics	
Exposure Indicators	**Environmental Effects Indicators [a]**	**Sensitive Populations Indicators**	**Socioeconomic Factors Indicators**
Ozone percentile [b] × IAS_{ozone} [c]	Cleanup Sites × $IAS_{cleanup}$	Asthma × IAS_{asthma}	Educational Attainment × IAS_{EDU}
PM2.5 × $IAS_{PM2.5}$	Groundwater Threats × $IAS_{groundwater}$	Cardiovascular Disease × $IAS_{cardiovascular}$	Housing Burden × $IAS_{housing}$
Diesel PM × IAS_{DPM}	Hazardous Waste Facilities/Generators × $IAS_{hazwaste}$	Low Birth Weight × IAS_{LBW}	Linguistic Isolation × $IAS_{linguistic}$
Drinking Water × $IAS_{drinkwtr}$	Impaired Water Bodies × $IAS_{impwater}$		Poverty × $IAS_{poverty}$
Children's Lead Risk from Housing × IAS_{lead}	Solid Waste Sites/Facilities × IAS_{waste}		Unemployment × $IAS_{unemployment}$
Pesticide Use × $IAS_{pesticide}$			
Toxic Releases × IAS_{toxic}			
Traffic × $IAS_{traffic}$			
Weighted Average Exposure Component Association Score (Max score 300)	Weighted Average Environmental Effects Component Association Score × 0.5 weighting (Max score 150)	Weighted Average Sensitive Populations Component Association Score (Max score 300)	Weighted Average Socioeconomic Factor Component Association Score (Max Score 300)
Pollution Burden Association Score = (Exposure Component Association Score + Environmental Effects Component Association Score) ÷ 1.5		*Population Characteristics Association Score =* (Sensitive Populations Component Association Score + Socioeconomic Factor Component Association Score) ÷ 2	

[1] CES has already transformed each indicator from its raw values (e.g., ozone concentration or asthma rate per 10,000 people) to a percentile score (max value 100).

CES Measure Association Score	=	Pollution Burden Association Score × Population Characteristics Association Score

[a] Per CES, the Environmental Effects component is given half the weight of the Exposures component.
[b] The ozone percentile, and the percentile from all indicators, will come from the CES 4.0 scores for each census tract. Thus, they will be unique to each census tract.
[c] The IAS is specific to each measure. See Section 3.2, *Determining Measure-Specific Indicator Association Scores*, for scoring.
CES = CalEnviroScreen® 4.0; PM = particulate matter; IAS = indicator association score.

Tables F-2 through F-5 demonstrate calculating scores for Exposure Indicators, Environmental Effect Indicators, Sensitive Population Indicators, and Socioeconomic Factor Indicators for Measure T-2, *Increase Job Density*, for census tract 067001101 in downtown Sacramento.

Table F-2. Example CalEnviroScreen® 4.0 Measure Association Score Calculation (Exposure)

Exposure Component Association Score			
CES Indicator (Exposure)	**CES Indicator Percentile**	**Indicator Association Score**	**CES Indicator Percentile × Indicator Association Score**
Ozone	45	3	$45 \times 3 = 135$
PM 2.5	40	3	$40 \times 3 = 120$
DPM	80	2	$80 \times 2 = 160$
Toxic Releases	31	0	$31 \times 0 = 0$
Traffic	12	1	$12 \times 1 = 12$
Pesticides	0	0	$0 \times 0 = 0$
Drinking Water	17	0	$17 \times 0 = 0$
Lead from Housing	48	0	$48 \times 0 = 0$
Average = $\frac{135+120+160+0+12+0+0+0}{8} = 53.375$			

CES = CalEnviroScreen® 4.0; PM = particulate matter; DPM = diesel particulate matter.

Table F-3. Example CalEnviroScreen® 4.0 Measure Association Score Calculation (Environmental Effects)

Environmental Effects Component Association Score			
CES Indicator (Environmental Effects)	**CES Indicator Percentile**	**Indicator Association Score**	**CES Indicator Percentile × Indicator Association Score**
Cleanup Sites	93	0	$93 \times 0 = 0$
Groundwater Threats	96	0	$96 \times 0 = 0$
Hazardous Waste	86	0	$86 \times 0 = 0$
Impaired Waters	98	0	$98 \times 0 = 0$
Solid Waste	67	0	$67 \times 0 = 0$
Average with 0.5 weight = $\frac{0+0+0+0+0}{5} \times 0.5 = 0$			

CES = CalEnviroScreen® 4.0.

Table F-4. Example CalEnviroScreen® 4.0Measure Association Score Calculation (Sensitive Populations)

Sensitive Populations Component Association Score			
CES Indicator (Sensitive Populations)	**CES Indicator Percentile**	**Indicator Association Score**	**CES Indicator Percentile × Indicator Association Score**
Asthma	93	2	$93 \times 2 = 186$
Low Birth Weight	73	2	$45 \times 3 = 146$
Cardiovascular Disease	72	1	$72 \times 1 = 72$
Average = $\frac{186+146+72}{3}$ = 134.66			

CES = CalEnviroScreen® 4.0.

Table F-5. Example CES Measure Association Score Calculation (Socioeconomic Factors)

Socioeconomic Factors Component Association Score			
CES Indicator (Socioeconomic Factors)	**CES Indicator Percentile**	**Indicator Association Score**	**CES Indicator Percentile × Indicator Association Score**
Education	42	0	$42 \times 0 = 0$
Linguistic Isolation	6	0	$6 \times 0 = 0$
Poverty	79	1	$79 \times 1 = 79$
Unemployment	51	1	$51 \times 1 = 51$
Housing Burden	64	0	$64 \times 0 = 0$
Average = $\frac{0+0+79+51+0}{5}$ = 26			

CES = CalEnviroScreen® 4.0.

In this example, based on the scores calculated in Tables F-2 through F-5, CalEEMod would calculate the final CES Measure Association Score as follows:

Pollution Burden Association Score = $\frac{53.375 + 0}{1.5}$ = 35.583

Population Characteristics Association Score = $\frac{134.66 + 26}{2}$ = 80.33

CES Measure Association Score: $35.583 \times 80.33 =$ 2,858.38

CalEEMod would use this method to calculate the association scores for all measures applicable to the example project in census tract 6067001101. The measures with the five highest CES association scores will be presented for the user's consideration, without scores. Other measures applicable to the project will also be displayed on the **Relevant Measures** splash screen.

3.4 Important Considerations

Despite the use of a scoring methodology, this effort is not intended to provide a quantified, prioritized, or ranked selection of measures. Communities have unique histories, experiences, and challenges, all of which are difficult to capture into datasets or quantify into indicators. CES 4.0, though comprehensive, is likely to only represent certain aspects of a community's existing environmental, health, and socioeconomic challenges. There is no replacement for thorough, inclusive community outreach and trust-building.

The purpose of the **Relevant Measures** splash screen is to identify those measures that are applicable to the project and are most closely associated with the existing health, equity, and socioeconomic conditions in the project community as identified by CES 4.0. This information is presented for user consideration to facilitate selection of measures that are more likely to deliver health and equity co-benefits and address the existing challenges in the community. It is recommended users work with community members directly to get their input on preferred measures.

4 Health and Equity Evaluation Scorecard

The **Health & Equity Measures** screen presents the 50 available health and equity measures for user consideration and selection. Of these, 40 measures from the categories of Community-Centered Development, Inclusive Engagement, Accountability, Construction Equity, Public Health and Air Quality, Inclusive Economics and Prosperity, and Inclusive Communities are included in the **Health and Equity Evaluation Scorecard**. The **Health and Equity Evaluation Scorecard** provides a simple process to evaluate how well a project has adopted specific measures and practices to deliver greater health, equity, and other benefits to support the existing community. Note that measures from the Affordable Housing and Climate Resilience categories are excluded from the scorecard due to the spectrum of implementation strategies and requirements that defy simple scoring.

4.1 Using the Scorecard

The **Health and Equity Evaluation Scorecard** is intended to be used in collaboration with community members, community-based organizations (CBOs), and community project steering committees. The scorecard evaluation is not intended to be conducted by users without direct community collaboration. Ideally, community members direct the scoring evaluation process to assign point values that are accurate and reflective of the community's lived experience with the project. Thus, the **Health and Equity Evaluation Scorecard** can serve as a tool for community members, organizers, and activists to ensure project accountability and to assist in analyzing a project's practice of equity. Developers can use scores to identify strength areas and areas for improvement. Furthermore, the **Health and Equity Evaluation Scorecard** can assist both community members and developers in relationship building and in setting expectations and goals. The **Health and Equity Evaluation Scorecard** can help inform local governments and decision-makers of a project's community engagement approach and the quality of benefits promised by developers. Local governments can refer to project scores to set goals and make informed decisions regarding project development.

Community needs are complex, individual, and ever-changing. Accordingly, the **Health and Equity Evaluation Scorecard** includes a custom function that allows the user to tailor the scorecard to reflect individual community priorities and capture practices otherwise missed in the preexisting measures. Users can develop new measures and point value assignments. Importantly, this custom function is intended to only be used by community groups or by proponents with explicit consent from a community group, CBOs, or community project steering committee.

4.2 Scoring the Measures

Measures are scored up to 5 points each. Each measure has tailored criteria to determine point values. Most measures follow a 1 to 5 scoring range, with higher point values corresponding to increasing levels of action. Some measures adopt a modified scoring scheme within this range (e.g., 1-3-5 or a 3-4-5), again with higher point values corresponding to greater levels of action. Other measures are scored cumulatively, with projects receiving one point for each criterion they meet, up to 5 points.

For the final evaluation score to tabulate properly, users must identify scores for all 40 measures, including those measures that are not applicable to the project. Measures that were preselected on the **Climate** and **Health & Equity** map screens are given a starting score of 0. The user should adjust this score to appropriately reflect measure implementation for the project, if necessary. Measures not applicable to the project based on the user identified land use subtype(s) and project scale are shown in gray with a score of "N/A." If additional measures do not apply to the project, the user should select "N/A," which would subtract the measure's total points possible (5) from the base value for the project. This is different from when a measure is applicable to a project but is either not implemented or not implemented in a manner that satisfies scoring criteria. In this scenario, the user would select "0," and the project would earn zero points for the measure (0/5).

Users may add custom health and equity measures to the scorecard if additional strategies will be implemented by the project. Click the plus sign to the right of the category title to add a custom measure under that category. Users will need to provide a measure title and measure description and identify the entity sponsoring the additional measure. Custom measures can be scored within a range of 0 to 5.

The following sections provide guidance for evaluating the project's performance within each measure category. Table F-6 presents the scoring criteria for each measure. The user should consult this table when completing the scorecard.

4.2.1 Process Measures

Underserved and marginalized communities have historically been excluded from project development and planning processes. Measures in this section seek to redefine the role community members play, particularly those from underserved or marginalized backgrounds, in project development. Process measures are designed to ensure community involvement across all phases of project development with an emphasis on promoting equitable community engagement, expanding community decision-making, and ensuring project accountability. Thus, measures evaluate the project's degree of working directly with community members, degree of centering community priorities in project planning, and approach to ensuring project accountability. High scores reflect a high degree of community-centered planning with mechanisms to ensure inclusive processes and strategies to guarantee planned benefits are delivered. Projects that score low for these measures are insufficient in their efforts to work directly with community members to understand their goals and needs, conduct inclusive outreach, and/or fail to implement strong accountability mechanisms.

The measures in this section are organized into three categories: Community-Centered Development, Inclusive Engagement, and Accountability.

4.2.1.1 Community-Centered Development

Centering community needs and priorities is foundational for equitable development. Community-centered development measures are designed to ensure that community knowledge, priorities, and needs are identified and uplifted. Community members should play central roles when determining community priorities and crafting solutions. Thus, measures in this section are scored based on the degree to which community members are actively engaged in identifying community priorities and project direction during the initial planning phases of project development. A high score reflects a project that meaningfully involves community residents, respects community knowledge and expertise, and directly responds to community-identified priorities. Low scores denote a project that limits the role of community members and excludes their perspectives and priorities in project development.

4.2.1.2 Inclusive Engagement

During all phases of project development, community members should have authority, confidence, and the necessary tools to participate and succeed in decision-making spaces. Measures in this section are designed to pursue the goal of an inclusive and empowering engagement process that brings underrepresented, underresourced, and underserved members of the community to the project development process. The spectrum of community engagement is used to inform the scoring of these measures; see Figure F-1, adapted from Equity Matters (2015), for detailed descriptions of the different levels along the spectrum of community engagement. High scores in this section reflect a high degree of equitable engagement to uplift people from underserved backgrounds into meaningful decision-making roles. Low scores indicate community members are informed or engaged but have little-to-no decision-making authority and have limited ability to affect real change in project development.

4.2.1.3 Accountability

Accountability measures are designed to ensure community members have oversight over project development and to ensure agreed-upon benefits are delivered. Measures in this section are scored based on two essential components: the degree to which the project proponent takes active steps ensure responsibility and promote transparency, and the degree to which community members have oversight authority and mechanisms to ensure proponent accountability. A high score reflects a project that is accessible and responsive to community concerns, and that implements strategies to guarantee community members play direct oversight roles in monitoring project development and in developing corrective solutions. Low scores indicate community members have limited access to information during project development and lack channels or effective mechanisms to ensure proponent accountability.

Figure F-1. The Spectrum of Community Engagement (adapted from Equity Matters)

	INFORM	CONSULT	DIALOGUE	COLLABORATE	DIRECT
DESCRIPTION	Project proponent or local jurisdiction initiates outreach and uses a variety of channels to inform community on project development.	Project proponent or local jurisdiction gathers information from the community to inform projects; obtains community feedback on analysis, alternatives, and /or decisions.	Project proponent or jurisdiction engages community to shape priorities and plans; directly works with community throughout process to understand and consider community issues and concerns.	Community and project proponent or jurisdiction share in decision-making authority to co-create solutions together. Partner with community in each aspect of planning, including initial development of alternatives and preferred solution.	Community takes leading role in decision-making and determing strategy with participation and technical assitance from project proponent or lead agency. The community or public has final decision-making.
EXAMPLE	Proponent-led presentations, factsheets, and flyers.	Proponent-led interviews, public meetings, surveys, and focus groups.	Proponent- or agency-led interactive workshops and forums.	Ongoing interactions between community and project proponent in a propoent-led format. Establishing a community advisory/steering committee. Consensus-building efforts, participatory decision-making.	Ongoing interactions between community and project proponent in a community-led format, with support from project or lead agency. Participatory budgeting. Decision-making powers delegated to community advisory/steering committee.

4.2.2 Outcome Measures

Outcome measures seek to encourage specific project features that can enhance equitable access to resources, promote public health and local economic development, build community capacity, and directly support underserved and marginalized communities. Users should seek to deliver benefits that maximize positive outcomes for low-income, underserved, and marginalized communities. Thus, measures are scored based on three components: the extent to which the project addresses local community needs or concerns; the degree to which the project directs investment toward communities of color and underserved groups; and the degree to which project features enhance public health, community capacity, and accessibility to resources. Projects with high scores in outcome measures implement meaningful project features that maximize inclusive benefits, build community capacity, enhance access to resources, and promote public health and equitable economic development. Projects with features that are likely to continue the status quo, or worse, further gentrification, displacement, and continued inequities receive low scores.

4.2.2.1 Construction Equity

Consequential disruptions and health impacts often arise during the construction phase of project development. Measures in this section are designed to mitigate these negative impacts and strengthen community resilience to construction activities. High scores in construction equity measures reflect projects that implement measures to actively monitor impacts, build community capacity to ensure construction impacts are quickly corrected, and are accessible and responsive to public complaints. Low scores in construction equity measures indicate a project that does not take into consideration community preferences is limited in its ability to respond to community complaints and/or limited in its approach to lessening construction-related impacts.

4.2.2.2 Public Health and Air Quality

Users have substantial opportunities to reduce environmental health threats through project development. Public health and air quality measures are designed to accomplish two goals: to encourage project features that actively reduce health-related impacts from air pollution, extreme heat, and other environmental threats; and to improve underserved communities' access to green spaces, food, and other healthful resources. Projects that earn a high score for these measures promote healthful and vibrant communities by implementing best practices in project design to reduce pollution and toxics exposure, while also enhancing access to healthful resources. The project will work with community members to deliver environmental conditions critical to good health. A low score indicates that a project is limited in its efforts to achieve these goals.

4.2.2.3 Inclusive Economics and Prosperity

Systemic racism has exploited communities of color in the name of economic development. At the same time, communities of color have been excluded from economic empowerment, left out of means to accumulate wealth, and experience extremely low levels of economic mobility when compared to white counterparts. Measures in this section are designed to leverage a project's economic impact potential to direct investment and capacity-building efforts specifically toward communities of color and local community members. Measures in the Inclusive Economics and Prosperity section are scored based on the degree to which project proponents dedicate resources toward such efforts. A high score reflects a project that takes substantial direct action to build capacity, directly invest resources toward underserved communities, and provide good wages, safe working conditions, training and education, and/or improved economic opportunities. Projects that overlook or take minimal steps toward these goals receive low scores.

4.2.2.4 Inclusive Communities

Measures in the Inclusive Communities section address how project development and the built environment can both be used to enhance underserved communities' access to resources and create spaces that foster prosperous community growth. Measures are scored based on three criteria: the degree to which community members are engaged when determining resource investment or creation, the degree to which project design features facilitate inclusivity, and the allocation of space or resources to enhance community assets. Projects with high scores enhance access to community resources, create spaces in which people of all abilities and needs can prosper, and deliver substantial opportunities for local community development. Low scores are reflective of a project that takes a narrow approach to investing in community assets and building inclusive and cohesive community spaces.

4.3 Developing an Overall Score

Once all measures are scored, CalEEMod will tabulate scores by category and calculate an overall score that will be displayed in the **Health and Equity Evaluated Scorecard** on the **Health and Equity Dashboard** screen and in the detailed and summary reports.

The scorecard presents the number of measures implemented by the project and total points earned by category (Community-Centered Development, Inclusive Engagement, Accountability, Construction Equity, and Inclusive Economics and Prosperity). The maximum points possible is also shown for each category, excluding measures designated as "Not Applicable" to the project. If all measures are applicable, the maximum total points possible is 200 (unless custom measures are added). Category scores are weighted. Users can see the project's total points earned out of the total points possible as well as the weighted category score (see Figure F-2).

Table F-6. Health and Equity Evaluation Scorecard Measure Criteria

Measure	Explanation of Scoring Criteria
Community-Centered Development (CCD)	
CCD-1. Consult Pre-existing Community Knowledge/Priorities	
The project will consult existing neighborhood/community plans or studies to understand community priorities, recognize the work that has already been done, avoid engagement fatigue, and address community concerns and needs that have already been identified.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	1 - Reviews governing plans (design guidelines, specific plans, general plans, etc.).
	2 - Reviews plans (community-led needs assessments, health needs assessments, asset mapping, etc.) that go beyond baseline requirements.
	3 - Consults with jurisdictional planner on community needs and plans.
	4 - Holds discussions with community groups to determine representativeness of plan(s).
	5 - Community leads discussion on different plans and their details, goals, and vision; project incorporates community priorities based on conversation and community input.
CCD-2. Conduct a Stakeholder Analysis and Develop a Community-Centered Outreach Plan	
The project will conduct a stakeholder analysis to identify stakeholders, recognize the degree of influence of different groups, and prioritize those who have been historically overlooked and excluded when it comes to development projects. The project will also conduct tailored outreach efforts to ensure that perspectives from underrepresented groups are included. Ideally, project proponents should invite community-based organizations (CBO) and community leaders to develop a community outreach plan together.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	1 - Identifies stakeholders impacted by project.
	2 - Identifies stakeholders impacted by project and identifies specific barriers to participation for different groups.
	3 - Collaborates with CBOs and community leaders to identify stakeholders impacted by project, barriers to participation for different groups, and takes actionable steps to reduce barriers through an inclusive outreach strategy.
	4 - Collaborates with CBOs and community leaders to identify stakeholders impacted by project, barriers to participation for different groups, and takes actionable steps to reduce barriers through an inclusive outreach strategy. Community members have ample opportunity to direct and co-create an outreach strategy that meets residents where they are, reaches marginalized and underrepresented residents, and is culturally and linguistically appropriate.
	5 - Criteria for 4; in addition, the project provides appropriate monetary compensation for community members' involvement in crafting/participating in outreach effort.

Measure	Explanation of Scoring Criteria
CCD-3. Conduct a Community Needs Assessment	
If existing community knowledge is outdated, lacks relevant detail, or does not represent the perspectives of marginalized groups, the project proponent should conduct a community needs assessment. This assessment asks community members to highlight what they see as the most important needs for their group or community.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	1 - Light community engagement to determine needs; documents made publicly accessible.
	2 - Engages in robust community outreach to register community needs and priorities; documents made publicly accessible.
	3 - Collaborates with CBOs, community leaders, property improvement district, local jurisdiction, and/or other community groups to design and lead approach to needs assessment; includes robust community outreach and publicly accessible documents.
	4 - All actions for 3; in addition, project works with community members to analyze the underlying root causes of demonstrated needs and identify appropriate local actions.
	5 - All actions for 4; in addition, project provides compensation for community member participation.
CCD-4. Conduct Community Asset Mapping	
The project will conduct community asset mapping to identify the people, places, institutions, and services in a community that support the resident's quality of life. Creating a community asset map can help reveal the gaps and areas where a project might be able to enhance levels of service, respond to community needs, and complement through project amenities and uses.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	1 - Conducts asset mapping without community involvement.
	2 - Conducts asset mapping and identifies additional needs, gaps, and opportunities without community involvement.
	3 - Collaborates with community to map assets and identify needs (amenities and land use).
	4 – All actions for 3; in addition, project design fulfills community needs (amenities).
	5 – All actions for 4; in addition, project design fulfills community needs (land use).

Measure	Explanation of Scoring Criteria
CCD-5. Establish a Community Benefits Agreement	
The project will negotiate a community benefits agreement (CBA) with the community. Community benefits agreements are legal agreements between project proponents and community representatives that explicitly describe the benefits a project will agree to fund or implement in exchange for the support of the local community. These contracts help communicate community priorities and outline how a project will contribute to the community and/or plans to address negative consequences and outcomes of the project.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	1 - Project proponent recruits community involvement to draft a CBA in response to community objections to project approval.
	2 - A large and diverse coalition of community members and groups is recruited to draft a CBA during the outset of project development/before approval process.
	3 - All actions for 2; in addition, a clear timeline for specific commitments is established and shared with the public. Roles and responsibilities are detailed with specific commitments to ensure long-term community oversight of the agreement. Reporting and monitoring provisions are included in the CBA. Systems to remedy nonperformance are established.
	4 - All actions for 3; in addition, the project proponent provides funding for long-term community goals. Funding is allocated for community-directed purposes (participatory budgeting).
	5 - All actions for 4; in addition, the project proponent commits to evaluating community satisfaction with CBA through survey questions. Project commits to taking corrective actions in alignment with community response to survey.
Inclusive Engagement (IE)	
IE-1. Prioritize Outreach to Communities of Color and Underserved Groups	
This measure recommends specific strategies to incorporate when attempting to reach under-served groups. The project will make direct, targeted efforts to reach communities of color and under-resourced groups to increase their opportunities for participation/engagement. Consult with community leaders and a variety of CBOs with relationships in the community to determine effective outreach approaches.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	1 - Local jurisdiction or related agency provides educational materials.
	3 - Local jurisdiction or related agency provides educational materials and sets up question and answer (Q&A) process/continuously responds to questions.
	5 - Proponent or local jurisdiction contracts with a responsible third-party community-focused advocacy group with direction to provide education for community members for the duration of project development process.

Measure	Explanation of Scoring Criteria
IE-2. Establish or Join a Community Project Steering Committee	
Community project steering committees help shift decision-making power back to the communities where the project is being developed. This power shift facilitates greater community engagement and enhances equity in decision-making. This measure is scored based on the extent to which a community steering planning committee is invested with decision-making authority.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	1 - Informed: The project proponent initiates an effort and uses a variety of channels to inform community on project development.
	2 - Consulted: The proponent gathers information from the community to inform proponent-led projects; obtains community feedback on analysis, alternatives, and/or decisions.
	3 - Dialogued: The project proponent engages community members to shape priorities and plans; works directly with communities throughout the process to ensure that community issues and concerns are understood and considered.
	4 - Collaborated: The community and proponent share in decision-making authority to co-create solutions together; the proponent partners with communities in each aspect of the decision, including the initial development of alternatives and the preferred solution.
	5 - Directs: Community plays leading, decision-making role in determining strategy and action with participation and technical assistance from project proponent, who places final decision-making in the hands of the public or community.
IE-3. Elevate Voices of Underrepresented Groups in Project Direction and Outreach	
The project will ensure that the Community Project Steering Committee is representative of the communities the project impacts. Amplify voices of frontline workers, people of color, women, LGBTQIA+ (lesbian, gay, bisexual, transgender, queer and questioning, intersex, asexual, and other gender identities), people with disabilities, and under resourced communities by empowering them with decision-making authority and incorporating their representation in the steering committee. Leverage community knowledge and available data to identify vulnerable and underrepresented groups in the project impact area and elevate their priorities. Take action on communicated needs and concerns, and report back to the community on how its input have informed the project.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	1 - Project recruits steering committee using the project proponent's social media channels and/or through the local jurisdiction.
	2 - Project recruits steering committee members using existing neighborhood associations, posts signs in communal or public spaces in the community.
	3 - Project works with community-based organizations to identify under-represented groups in the community to invite to the steering committee, and identifies and addresses barriers to participation (e.g., transportation, needs accommodation, translation/interpretation, stipend).
	4 - All actions for 3 and works with community-based organization to evaluate the representativeness and the degree of perceived influence individual Community Steering Committee members have on the project.
	5 - All actions for 4 and takes corrective actions to ensure members of Community Project Steering Committee feel empowered to participate.

Measure	Explanation of Scoring Criteria
IE-4. Inclusive Community Meetings	
The project proponent will incorporate the following best practices to ensure that project meetings are accessible and appropriate to the unique needs and characteristics of each community: - Hold community meetings in familiar spaces, including both physical spaces and technological platforms, or attend existing community events. - Ensure meetings are accessible via walking and public transit, and accessible to all people. - Hold meetings during times convenient for working members of the community. - Provide refreshments. - Provide childcare to support participation by families, parents, and caregivers. - Conduct outreach in community members' primary language(s), including meeting materials and interpretation. - Use accessible, nontechnical language and provide explanations where appropriate. Ensure all materials and information are readily accessible for disabled persons. - Provide monetary stipends/compensation.	N/A - Not applicable to the project. 0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria. 1 – 0–20% of applicable best practices. 2 – 21–40% of applicable best practices. 3 – 41–60% of applicable best practices. 4 – 61–80% of applicable best practices. 5 - 81% or more of applicable best practices.
IE-5. Provide Education on Essential Topics Related to Project	
The project proponent will work with the local jurisdiction or related agency to provide technical assistance, educational materials, relevant information on key issues related to the project to community members. Aspects of a project may require a high degree of specialized knowledge, and certain language may be inaccessible.	N/A - Not applicable to the project. 0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria. 1 - Local jurisdiction or related agency provides educational materials. 3 - Local jurisdiction or related agency provides educational materials and sets up Q&A process/continuously responds to questions. 5 - Proponent or local jurisdiction contracts with a responsible third-party community-focused advocacy group with direction to provide education for community members for the duration of project development process.

Measure	Explanation of Scoring Criteria
IE-6. Conduct an Equity Assessment with Community Project Steering Committee	
An equity assessment explores how a project addresses and performs across a variety of equity-related indicators. This type of assessment analyzes how a project impacts racial and ethnic groups, how it may enhance or exacerbate equity, and where positive outcomes are likely to be realized during project implementation or other phases.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	1 - Project proponent adopts and undertakes an equity assessment
	2 - Proponent collaborates with CBOs or community group to design and conduct equity assessment
	3 - CBOs and community groups lead in conducting equity assessment
	4 - Action for 3; in addition, proponent agrees to conducting assessments at regular intervals (e.g., annually) long-term and reports back to community
	5 - Action for 4, in addition, proponent commits to taking corrective action if deemed necessary
Accountability (A)	
A-1. Use Participatory Budgeting	
Proponent commits to using participatory budgeting to direct a portion of project funds. Participatory budgeting is a democratic process that allows community members to lead funding allocation for projects by giving community members voting powers when deciding how to spend part of a budget. Point allocation is determined by the funding amount dedicated to participatory budgeting per capita. The Participatory Budgeting Project recommends $1 million per 100,000 residents or 13–$22 per resident.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	1 - 10–$12 per capita.
	2 - 13–$15 per capita.
	3 - 16–$18 per capita.
	4 - 19–$21 per capita.
	5 - $22+ per capita.
A-2. Establish Incentive and Penalty Provisions for Community Priorities	
The project will include clawback provision, or a recapture provision, which requires the project to face penalties for failure to deliver on agreed-upon project goals (or, conversely, incentives to deliver goals).	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	1 - Incentives/penalties are established.
	3 - Incentives/penalties are established and shared with community members.
	5 - Incentives/penalties are drafted in collaboration with community members.

Measure	Explanation of Scoring Criteria
A-3. Evaluate Project Performance with Community Project Steering Committee/Community-Based Organization	
The project will develop reports in collaboration with the community project steering community or community-based organization to evaluate progress at every stage of project development, centering around agreed-upon focus areas and data metrics.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	1 - Project collaborates with community groups to draft performance metrics and establish a reporting process.
	3 - All actions for 1; in addition, an inclusive, on-going and transparent evaluation process (include funding and staff).
	5 - All actions for 3; in addition a specific process and contingency measures if goals not met. Community steering committee is able to propose and direct solutions to mitigate unintended consequences.
A-4. Establish Clear Points of Contact	
The project will establish accessible channels for the public to reach project proponents. Options include hotlines, websites, social media, email, and physical locations/mailing addresses. Post clear information detailing channels for communication and ensure that public inquiries are responded to promptly.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	1- Contact information is posted on project proponent's own website.
	3 - Contact information is posted on at least three of the following: project proponent's own website, project site itself, local jurisdiction website, and another location identified by community and/or steering committee.
	5 - All actions for 3; in addition, project proponent guarantees short turnaround timeframe, and meaningful responses and assistance.
A-5. Public Disclosure of Project Commitments	
The project proponent will make publicly available all commitments to improve equity, diversity, health, climate change and resilience, and other benefits.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	1 - Project commitments are posted publicly on local jurisdiction website.
	2 - Project commitments include clear metrics, timelines, goals, and points of contact.
	3 - All actions for 2; in addition are project commitments are posted at an easily accessible location or website (e.g., both digitally and on paper at a community center) in multiple languages.
	4 - All actions for 3; in addition project commitments are conducted in coordination with the project steering committee.
	5 - All actions for 4; in addition, contingency measures are implemented if goals are not met.

Measure	Explanation of Scoring Criteria
Construction Equity (CE)	
CE-1. Create a Construction Plan with Community Input	
The project will create a construction plan that is responsive to community input, reflecting community concerns and priorities. The plan should include construction hours, duration, access closures, detours, noise, dust, parking, deliveries, lighting, emissions, truck routes, and other potential impacts and nuisances that may affect the community. Meaningful choices should be presented to community.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	1 - Project develops a construction plan that includes at least five of the following elements: set construction hours, duration, access closures, detours, allowable noise, dust, parking, deliveries, lighting, emissions, truck routes, and other potential impacts and nuisances.
	2 - Project develops a construction plan that includes all of the elements listed above.
	3 - All of the above, plus project proponent posts plan publicly, holds at least one public meeting on the construction plan in an accessible location, and makes revisions to plan based on community input and comments.
	4 - All of the above, undertaken in coordination with project steering committee or a community-based organization, to ensure that community input is reflected throughout the community plan.
	5 - The construction plan includes all of the above as well as penalties for violations, including those beyond code.
CE-2. Ensure Active Modes Access During Construction	
The project will maintain pedestrian and cycling access along street frontage during construction. Any pedestrian detours will not require crossing the street. Bus stop relocations should be no more than two blocks away, with clear signage and a map at the original stop directing passengers.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	Score 1 point for each of the following (up to 5 points):
	- Pedestrian access (protected).
	- Bicycle access (protected).
	- Signage that does not block active mode uses.
	- Transit access (if access available).
	- Lighting.

Measure	Explanation of Scoring Criteria
CE-3. Post a Clear, Visible Enforcement and Complaint Sign	
The project will have conspicuous signs at the fence line listing hotline numbers for potential nuisance complaints and agency responsible for enforcement. The sign should be in clear, plain language.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	Score 1 point for each of the following (up to 5 points) (signs must be posted on each frontage):
	- Point of contact for project (proponent).
	- Point of contact for project (CBO or other community stakeholder).
	- Responsible enforcement agencies, listed by nuisance.
	- List of requirements (hours/days of construction, visible dust, allowable noise levels, etc.).
	- Translations into languages widely spoken in the community.
CE-4. Portable Indoor Air Filtration for Nearby Residents During Construction	
The project provides indoor air filtration for the duration of the construction project to potentially impacted residents and businesses. The project may either upgrade or equip heating, ventilation, and air conditioning (HVAC) systems to use MERV-13 or higher air filters capable of at least 0.5 air exchanges per hour or provide California-certified air-cleaning devices.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	3 - Project proponent identifies sensitive receptors and potentially impacted residents and provides air filters and California Air Resources Board-certified air-cleaning devices. Project proponent provides training and education on their use.
	4 - All of the above, and project proponent provides financial assistance to help offset increased energy costs of operating HVAC/air-cleaning devices as well as replacement filters.
	5 - All of the above, and project proponent works with community-based organization in identifying vulnerable and impacted residents, developing training and education, and providing assistance.
CE-5. Air Quality Monitoring and Response Plan	
The project will commit to fence-line monitoring of air pollution during the construction phase and take action to modify or limit construction activities if levels are exceeded.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	4 - Project sets up air quality monitors, understands historic or baseline emissions, and develops a response plan with contingency actions.
	5 - Project does all of the above, and in addition air monitors will provide real-time data that residents can easily check. In addition, project will seek community input and review of response plan and contingency measures.

Measure	Explanation of Scoring Criteria
CE-6. Provide Funds to Businesses Impacted by Construction Activities	
The project will provide financial assistance to businesses impacted by construction activities and consequently see a decline in revenue.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	3 - Project proponent provides financial assistance for a percentage of fixed operating costs only (based on Form 1040 from the Internal Revenue Service).
	4 - Project proponent provides financial assistance to make up all or portion of decline in revenue or sales (based on previous years' income forms).
	5 - Project proponent extends financial assistance to affected businesses that lack extensive records or tax forms and requires that financial assistance includes paycheck protection for employees.
Public Health and Air Quality	
PH-1. Establish Vegetative Barriers to Reduce Pollution Exposure	
For project within 1,000 feet of (1) major roads such as highways, freeways, or arterials; (2) major stationary sources as defined by local air district; or (3) locations with high volume of diesel trucks or other sources of pollution, proponent will commit to designing and establishing vegetative barriers.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	1 - Vegetative barrier meets minimum size requirements according to the U.S. Environmental Protection Agency.[2]
	2 - All of the above, and project will establish a clear maintenance, pruning, and care plan for vegetative barrier.
	3 - All of the above, and project will select vegetation with at least two of the following features: (1) no seasonal leaf shedding or large gaps; (2) small leaves, leaves with complex shapes, and/or rough leaf surfaces; (3) low-allergenic species; (4) low emissions of biogenic volatile organic compounds (VOC); and (5) drought- and heat-tolerant species.
	4 - All actions under 1 and 2, and project will select vegetation with at least four of the following features: (1) no seasonal leaf shedding or large gaps; (2) small leaves, leaves with complex shapes, and/or rough leaf surfaces; (3) low allergenic species; (4) low emissions of biogenic VOCs; (5) drought- and heat-tolerant species; and (6) incorporation of a solid wall or barrier in locations where it does not create barriers to walking and biking.
	5 - All actions under Criteria 4, and the project will coordinate and consult with their regional urban forester, local tree foundations, master gardeners, community-based organizations, neighborhood associations and other groups to design the vegetative barrier and select plant species.

[2] Available: https://www.epa.gov/sites/production/files/2016-08/documents/recommendations_for_constructing_roadside_vegetation_barriers_to_improve_near-road_air_quality.pdf

Measure	Explanation of Scoring Criteria
PH-2. Increase Urban Tree Canopy and Green Spaces	
The project will go above and beyond local requirements and standards to enhance urban forestry, tree canopy, and green spaces along streets and public spaces in under-served and low-income communities, which disproportionately lack tree canopy, parks, and green spaces in comparison to wealthier, whiter neighborhoods.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	Score 1 point for each of the following (up to 5 points):
	- Community directs tree/plant species selection and design.
	- Selected tree and plant species are adaptable to future climate conditions (drought-, heat-, and pest-tolerant, longevity, etc.) and enhance diversity of urban forest.
	- Proponent conducts offsite tree planting in communities with low tree canopy.
	- Proponent establishes 10 percentage points more tree canopy than required by code.
	- Proponent agrees to enforcement and remediation beyond code if the project fails to plant and maintain trees and vegetation.
PH-3. Highly Rated Air Filtration	
Project proponent will agree to install MERV-13 or higher-rated air filtration systems, and for vulnerable populations such as schools and nursing homes, MERV-14 or higher air filters should be used. This measure also encourages proponent to ensure community members are educated on air filtration best practices.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	1 - Proponent installs MERV-13/14 air filtration systems.
	3 - Provides occupants education and training on efficacy and use, hazards, persistent sources of toxic air contaminants, compatible use with windows, etc.
	5 - Proponent installs MERV-16 air filtration systems.
PH-4. Create Healthful, Sustainable Indoor Spaces	
To reduce occupant chemical exposure, the building materials that are nontoxic, low-toxic, and/or low-emitting will be used. Products should be certified by an independent, industry-recognized rating system. Also, ventilation systems will be installed to ensure adequate airflow to prevent the buildup of pollutants in indoor air will also occur.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	Score 1 point for each of the following (up to 5 points):
	- Use of independently certified nontoxic, low-toxic and/or low-emissions materials in flooring.
	- Use of nontoxic, low-toxic and/or low-emissions materials in interior furnishings, including cabinetry, furniture, doors, etc.
	- Use architectural coatings that are 20% below the VOC limits set the by the local air district or use "super-compliant" coatings.
	- Project is free of polyvinyl chloride (PVC).
	- Install ventilation systems that exceed airflow and fan efficacy requirements in Title 24 by 10%.

Measure	Explanation of Scoring Criteria
PH-5. Provide Equitable Food Access and Food Justice	
To provide equitable food access, especially for underserved, low-income communities of color, the project will provide space to grow, raise, or sell healthful foods in private or public spaces. The project will also aim to reduce barriers for communities to have greater access to food.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	Scored cumulatively for each condition fulfilled (up to 5 points):
	1 - Project increases food production by providing space for or making improvements to urban agriculture through edible landscaping, community gardens, rooftop gardens, etc.
	1 - Project increases food availability by adding grocery stores, markets, or farm stands; or providing space, funding, and equipment for mobile and standing farmers market, food banks, or market conversions (e.g., adding refrigeration for fresh produce at existing stores).
	1 - Project increases accessibility of existing food sources by expanding transportation access through carshare or bikeshare or improving sidewalk and bike lane connections and network.
	2 - Project consults with the local community or CBOs to understand the community's existing challenges around food access and food insecurity and prioritizes their needs, in conjunction with at least one other measure in PH-5.
Inclusive Economics & Prosperity	
IEP-1. Local Labor and Apprenticeships (Construction)	
To encourage economic development for the local community, the project will commit to hiring locally and provide apprenticeship and training opportunities for local residents during the construction phase of the project.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	Cumulatively score for each condition fulfilled (up to 5 points):
	2 - Project proponent sponsors apprenticeships and training opportunities for people from communities under-represented in the construction trades.
	2 - Project proponent hires 15% or more of construction workers from underrepresented, BIPOC (Black, Indigenous, and People Of Color), marginalized, or LGBTQIA+ communities.
	1 - Project proponent hires 15% or more of construction workers locally. Local is to be defined in consultation with community groups or, if consultation is not possible, as within two census tracts.

Measure	Explanation of Scoring Criteria
IEP-2. Local Labor and Apprenticeships (Operations)	
To encourage economic development for the local community, the project will commit to hiring locally and provide internship and training opportunities for local residents during the operations phase of the project, ideally by partnering with local education providers.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	Cumulatively score for each condition fulfilled (up to 5 points):
	2 - Project proponent sponsors internships for underrepresented people in industry.
	2 - Project proponent hires 15% or more of employees from underrepresented, BIPOC, marginalized, or LGBTQIA+ communities.
	1 - Project proponent hires 15% or more of employees locally. Local is to be defined in consultation with community groups or, if consultation is not possible, as within two census tracts.
IEP-3. Contract with Diverse Suppliers	
The project proponent will commit to contracting with diverse suppliers, as identified in the scoring criteria, for at least 15% of contracting dollars. Diverse suppliers are defined as disadvantaged business enterprises, women-owned business enterprises, minority-owned business enterprises, disabled veteran-owned businesses, and LGBTQIA+-owned businesses.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	1 - 15% of contracting dollars.
	2 - 30% of contracting dollars.
	3 - 45% of contracting dollars.
	4 - 60% of contracting dollars.
	5 - 75% or more of contracting dollars.
IEP-4. Use of Locally/Regionally Manufactured Products and Materials	
This measure calls for the procurement of locally and/or regionally manufactured products and materials. Different parts of California have different capacity in manufacturing and producing materials, and thus preference is to first source materials from within the commute shed of the project location (offering local employment opportunities), followed by within the region or adjacent counties, followed by sourced within California.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	1 - 10% of materials costs is dedicated to local/regional manufactured products and materials procurement.
	2 - 20% of materials costs is dedicated to local/regional manufactured products and materials procurement.
	3 - 30% of materials costs is dedicated to local/regional manufactured products and materials procurement.
	4 - 40% of materials costs is dedicated to local/regional manufactured products and materials procurement.
	5 - 50%+ of materials costs is dedicated to local/regional manufactured products and materials procurement.

Measure	Explanation of Scoring Criteria
IEP-5. Higher Wage and Working Condition Standards	
This measure calls for fair living-wage standards and safe working conditions, including safety protections from emerging climate risks such as extreme heat and wildfire smoke.	N/A - Not applicable to the project.
	Scored cumulatively for each condition fulfilled (up to 5 points):
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	1 - Project adopts policies, provides training to staff, and implements strategies to support safe working conditions on climate hazards, following the latest guidance from the State of California
	1 - Project pays 60% of all its employees the living wage for the project area, as determined by MIT's living wage calculator for 1 adult with 0 children (https://livingwage.mit.edu/)
	2 - Project pays 90% or greater of all its employees the living wage for the project area, as determined by MIT's living wage calculator for 1 adult with 0 children (https://livingwage.mit.edu/)
	2 - Project provides sick leave at twice the amount required by state law; healthcare; and other benefits
Inclusive Communities (IC)	
IC-1. Invests in Local Arts and Culture to Affirm Community Identity	
The project, working with local community groups, will invest at least 1% of the total project cost in local arts and culture projects, programs, or other initiatives. This could manifest as murals, heritage walks, arts education and artist in training programs, cultural district designation, youth-led arts, arts programs for people who are incarcerated, a small pavilion for performing arts in an onsite plaza, sponsorship of local artists and groups, or other priorities identified by community members.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	1 - Project proponent invests 1% of total project costs in local arts and culture groups, projects, programs, or other initiatives.
	2 - Project proponent invests 2% of total project costs in local arts and culture groups, projects, programs, or other initiatives.
	3 - Local artists and art groups from marginalized backgrounds and communities are prioritized in project art selection/investment.
	4 - Action for 3, and in addition, establishes a selection committee that's representative of the local community and marginalized residents, to determine art/artists for selection and/or support.
	5 - Project commits to providing ongoing financial support for local arts groups.
IC-2. Adopt Design Standards	
This measure requires project proponents to adopt a design standard to help guide and promote sustainable design throughout the project planning, constructions, and operations lifecycle	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	1 - Project adopts and implements a recognized design standard.
	3 - Project adopts a Leadership in Energy and Environmental Design (LEED) Silver equivalent or higher.
	5 - Project adopts a design standard that requires public engagement.

Measure	Explanation of Scoring Criteria
IC-3. Promotes Accessibility	
The project will increase ADA access beyond code requirements and also design for people with autism as well as other neurological or sensory processing conditions. The measure encourages project design to be inclusive to all, regardless of their age, size, or ability.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	Cumulatively score for each condition fulfilled (up to 5 points):
	1 - Project design accommodates and supports all levels of manual dexterity, handedness, and age.
	1 - Project design accommodates and supports all levels of physical mobility and other ability needs.
	1 - Project design accommodates and supports those with visual and auditory impairments.
	2 - Project design accommodates and supports those experiencing neurodivergent, neurosensory, and/or mental health conditions.
IC-4. Enhanced Open and Green Spaces	
Under this measure, residential projects will contribute their Quimby requirements and other park impact fees, plus an additional 15% or more in acreage-equivalents, to a Quimby plan area in the bottom quartile of a jurisdiction based on aggregated CES 4.0 score, or on the project if in a disadvantaged community. These additional funds may be given to the local jurisdiction or local open space community-based organization. Commercial and industrial projects would make a similar additional contribution based on equivalent dwelling units.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	1 - Additional 15% in acreage-equivalents contributed to a Quimby plan area in the bottom quartile of a jurisdiction based on aggregated score, or on the project if in a disadvantaged community.
	2 - Additional 25% in acreage-equivalents contributed to a Quimby plan area in the bottom quartile of a jurisdiction based on aggregated score, or on the project if in a disadvantaged community.
	3 - Project centers design of open and green spaces and/or related investments around intended community's priorities.
	4 - Investments are provided to local open space CBO and/or community members to direct design of the open space.
	5 - All actions above, plus enhanced open and green spaces are aligned with parks-related anti-displacement strategies.
IC-5. Designated Space for Community-Based Organizations, Disadvantaged Businesses, and Community Assets	
This measure requires project proponent to designate space for CBO, a community asset, or disadvantaged business that can contribute to local economic development, social wellbeing and resilience, education, health, capacity building, and other benefits.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	3 - Designates space to local assets, CBOs, and/or disadvantaged businesses to satisfy needs outlined in existing community plans.
	5 - Consults existing plans and collaborates with CBOs and community members to determine space allocation and occupant selection.

Measure	Explanation of Scoring Criteria
IC-6. Create Nonstandard Commercial or Retail Spaces	
To help support small and independent businesses this measure requires project proponents to allocate space for nonstandard commercial or retail spaces. Percent of leasable area is used to determine the amount of nonstandard commercial or retail space made available by proponent.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	1 - 20% of leasable area is designated for no-standard commercial or retail space.
	2 - 40% of leasable area is designated for nonstandard commercial or retail space.
	3 - 60% of leasable area is designated for nonstandard commercial or retail space.
	4 - 80% of leasable area is designated for nonstandard commercial or retail space.
	5 - 100% of leasable area is designated for nonstandard commercial or retail space.
IC-7. Equal Access to Building Amenities	
This measure requires mixed-income multi-family developments to provide equal access to all building entrances, amenities, lobbies, and other shared facilities for affordable housing units. Affordable housing units are to be built to the same energy efficiency and other design standards as the baseline market-rate units.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	5 - Project satisfies equal access requirements set in description.
IC-8. Enhanced Access to Community Resources	
This measure requires proponents to enhance and expand access of marginalized and underserved communities to resources such as additional green spaces, food, recreation areas, and healthcare. The project can also expand transportation access to existing resources, such as by improving access to transit stations, sidewalk and bike lane improvements, or other improvements to the active transportation infrastructure. The project should directly address the identified needs of the community and help support the creation of a healthier, more equitable, and more resilient environment for the people who live and work in the project area.	N/A - Not applicable to the project.
	0 - Applicable to project, but not included or not implemented in a manner that satisfies scoring criteria.
	1 - Project creates a new social and/or economic use that is not available within a half mile.
	3 - Project fulfills an identified community need based on community needs assessment or other community planning document.
	5 - CBOs/community members determine project proponent resource investment and/or creation.

Note: Measures from the Affordable Housing and Climate Resilience categories are excluded from the scorecard.

Figure F-2. Sample Health and Equity Evaluation Report

Category	Number of Applicable Measures	Total Points Earned by Applicable Measures	Max Possible Points	Weighted Score
Community-Centered Development	0	0	0	0
Inclusive Engagement	0	0	0	0
Accountability	0	0	0	0
Construction Equity	5	17	25	10
Public Health and Air Quality	4	15	20	11
Inclusive Economics & Prosperity	4	9	20	6
Inclusive Communities	7	14	35	6
Total	20	55	100	33

Weighted categorical scores are also shown in a spider chart to facilitate analysis of a project's strong and weak points (see Figure F-3).

Figure F-3. Sample Health and Equity Evaluation Report Spider Chart

CalEEMod uses the weighted category scores and maximum total points (unweighted) to identify the applicable health and equity award tier for the project. Table F-7 shows the different tier levels and their associated weighted total score values.

Table F-7. Health and Equity Evaluation Tier Levels

Weighted Score	Tier Level
0–40	
40–50	

Weighted Score	Tier Level
50–60	
60–80	
80+	

4.4 Interpreting the Scorecard Results

Importantly, equity and environmental justice cannot be condensed into a score. While scores are intended to reflect a project's implementation of equitable development practices, they should not be the only metric used to determine the project's overall impact on environmental justice and equity. A holistic approach that centers on community members' lived experiences, priorities, and concerns is essential when evaluating a project's approach to equity. Measures should serve as starting points, and project proponents and community members are encouraged to make use of the custom functions of the scorecard to capture local community priorities. Thus, scores are to be supportive materials that augment community-level project evaluation.

5 References

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CalEEMod
California Emissions Estimator Model

Appendix G
Default Data Tables

Prepared for:
California Air Pollution Control Officers Association (CAPCOA)

Prepared by:
ICF
in collaboration with
Sacramento Metropolitan Air Quality Management District, Fehr & Peers, STI, and Ramboll

April 2022
CalEEMod Version 2022.1

1 Introduction

Please refer to the Excel file for the data tables.

CalEEMod
California Emissions Estimator Model

Appendix H
Comparison to CalEEMod Version 2020.4.0

Prepared for:
California Air Pollution Control Officers Association (CAPCOA)

Prepared by:
ICF
in collaboration with
Sacramento Metropolitan Air Quality Management District, Fehr & Peers, STI, and Ramboll

April 2022
CalEEMod Version 2022.1

Table of Contents

1 What key updates are included in CalEEMod Version 2022.1?

Table H-1 provides a general comparison of key functions and features between CalEEMod Version 2022.1 and the prior version of CalEEMod (Version 2020.4.0). Table H-2 provides a more detailed comparison of the individual data fields for these two versions. The table identifies the data field names for both versions of CalEEMod. It further notes if the data field itself or if the assumptions/ analytics underlying defaults (if any) are new, updated, not updated, or removed in CalEEMod Version 2022.1. Table H-3 compares the quantified emission reduction measures in CalEEMod Version 2022.1 to the prior version, noting if the measure is new, removed, updated, or not updated. All climate risk reduction and health and equity measures are new and are therefore not specifically identified in Table H-3.

2 What key updates are included in the User Guide for CalEEMod Version 2022.1?

The User Guide is comprised of the main document plus Appendices A through H. Table H-4 contains a list of the changes that were made to reflect the updates contained in CalEEMod version 2022.1, relative to the prior version of CalEEMod (version 2020.4.0). Please note that several of the appendices have been renumbered.

Table H-1. General Comparison of CalEEMod 2022.1 with Previous CalEEMod (Version 2020.4.0)

Function or Feature	CalEEMod 2022.1	CalEEMod Version 2020.4.0
Accessing the program	Web-based program accessed directly through a browser at http://www.caleemod.com.	Downloadable program that required user installation.
Navigating the interface (i.e., key features)	• Top Bar located in the top right-hand corner of the interface has options to create a new model run, open a saved model run, or delete a prior run. • Next/back buttons are the same as CalEEMod 2020.4.0. • Side Navigation Bar located on the left-hand side of the interface to navigate across non-sequential screens. • Tabular View and Data List View display values for variables in two different viewing modes, depending on user preference.	• "Home" on the Menu Bar has options to create a new model run, open a saved model run, save the model run, or exit the program. • Next button in lower right corner of interface to move between sequential screens. • Menu Bar located at the top of the interface to quickly navigate across non-sequential screens. • Data Grid where values for variables defined across the top of the grid are to be filled in with data.
Creating a model run	• Option 1: From the **Home** screen, click the "New Project" button. • Option 2: Click the Top Bar and click the "New Project" button. • Option 3: From the **Home** screen, click the **Map** component on the Side Navigation Bar.	• Option 1: Each time the program is opened, the Project Characteristics screen defaulted to a new model run. • Option 2: If the program was already open, users click "Home" on the Menu Bar, and then "New Project."
Saving a model run	Progress on a model run is automatically saved because projects are automatically cached.	To not lose progress on a model run before closing the program, users click "Home" on the Menu Bar, then "Save" or "Save as" to download an .xls input file of the model run.
Opening a saved model run (cached or local file)	Users click the Top Bar and then click the project's name.	Users click "Home" on the Menu Bar, then "Open Project" to upload the previously saved .xls input file of the model run.
Downloading a model run	Users click the Top Bar, select the desired model run by checking the box to the left of the project name, and click the down arrow icon to download a .json input file of the model run.	Same as saving a model run (see above).

<table>
<tr><th>Function or Feature</th><th>CalEEMod 2022.1</th><th>CalEEMod Version 2020.4.0</th></tr>
<tr><td>Uploading a model run (i.e., accessing a non-cached or non-local model run)</td><td>Provide the .json input file to the intended recipient. Recipient opens caleemod.com on their computer.
Option 1: Click the Top Bar and click the up arrow icon to upload the .json input file of the model run.
Option 2: From the Home screen, click the “Upload Project” button.</td><td>Same as opening a saved model run (see above).</td></tr>
<tr><td>Deleting a model run</td><td>Click the Top Bar, select the desired model run by checking the box to the left of the project name, and click the trash can icon.</td><td>User clicks “Home” on the Menu Bar, then “New Project,” then “OK.”</td></tr>
<tr><td>Exiting the program</td><td>Less applicable. Simply close the tab in your browser.</td><td>Option 1: Click “Home” on the Menu Bar, then “Exit.”
Option 2: Click the “X” icon in the top-right corner of the program.</td></tr>
<tr><td>Troubleshooting the program (i.e., technical issues associated with downloading, installing, and running the model).</td><td>Send an email to caleemod@airquality.org.</td><td>Sent an email to CalEEMod_TechSupport@trinityconsultants.com.</td></tr>
</table>

Table H-2. Comparison of Data Fields in CalEEMod 2022.1 with Previous CalEEMod (Version 2020.4.0)

CalEEMod Version 2022.1 Data Field or Button	CalEEMod Version 2020.4.0 Data Field or Button	Comparison
Home		
New Project	New Project	Described above in Table H-1.
Upload Project	Open Project	Described above in Table H-1.
Start a New Project		
Project Name	Project Name	Not updated
Land Use Scale	-	New
Land Use Type	n/a (defined in the Land Use screen)	Updated
Land Use Subtype	n/a (defined in the Land Use screen)	Updated
Define Project Center Point		
All	-	All new.
Map		
All	-	All new.
Project Detail (formerly Project Characteristics)		
Project Name	Project Name	Not updated
Automatic Updates to Default Values	Cascade Defaults and Default button	Updated
Lead Agency	-	New
Quantify emissions for [ ]	-	New
Locational Context	Land Use Setting from Mitigation screen	Updated
Analysis Level for Defaults	-	New
County	Project Location	Not updated

CalEEMod Version 2022.1 Data Field or Button	CalEEMod Version 2020.4.0 Data Field or Button	Comparison
Air District	Project Location	Updated
Air Basin	Project Location	Not updated
Windspeed	Windspeed	Updated
Precipitation days per year	Precipitation Frequency	Updated
CEC California Electricity Demand Forecast Zone	CEC Forecasting Climate Zone	Updated
TAZ	-	New
Start of Construction	Start of Construction	Not updated
Operational Year	Operational Year	Not updated
-	CEC Forecasting Climate Zone Look-up button	Removed (EDFZ automatically identified based on user identified location)
-	Apply EMFAC Off-Model Adjustment Factors for Gasoline Light Duty Vehicle to Account for the SAFE Vehicle Rule	Removed (emission factors account for SAFE Rule)
Utility Information		
Electric Utility	Select Utility Company from Project Characteristics screen	Updated
Operations GHG Emission Factors (electricity)	-	New
Gas Utility	-	New
CO_2 Intensity Factor	CO_2 Intensity Factor from Project Characteristics screen	Updated
CH_4 Intensity Factor	CH_4 Intensity Factor from Project Characteristics screen	Updated

CalEEMod Version 2022.1 Data Field or Button	CalEEMod Version 2020.4.0 Data Field or Button	Comparison
N_2O Intensity Factor	N_2O Intensity Factor from Project Characteristics screen	Updated
Pollutants		
Total Organic Gases (TOG)	-	New
Reactive Organic Gases (ROG)	Reactive Organic Gases (ROG) from Project Characteristics screen	Not updated
Carbon Monoxide (CO)	Carbon Monoxide (CO) from Project Characteristics screen	Not updated
Sulfur Dioxide (SO_2)	Sulfur Dioxide (SO_2) from Project Characteristics screen	Not updated
Particulate Matter 10 Exhaust (PM10 Ex)	Particulate Matter 10um (PM10) from Project Characteristics screen	Not updated
Particulate Matter 2.5 Exhaust (PM2.5 Ex)	Particulate Matter 2.5um (PM2.5) from Project Characteristics screen	Not updated
Particulate Matter 10 Dust (PM10 Dust)	Fugitive 10 um (PM10) from Project Characteristics screen	Not updated
Particulate Matter 2.5 Dust (PM2.5 Dust)	Fugitive 2.5 um (PM2.5 Dust) from Project Characteristics screen	Not updated
Particulate Matter 10 Total (PM10 Total)	-	New
Particulate Matter 2.5 Total (PM2.5 Total)	-	New
Biogenic Carbon Dioxide (CO_2)	Biogenic Carbon Dioxide (CO_2) from Project Characteristics screen	Not updated
Non-Biogenic Carbon Dioxide (CO_2)	Non-Biogenic Carbon Dioxide (CO_2) from Project Characteristics screen	Not updated
Carbon Dioxide (CO_2)	Carbon Dioxide (CO_2) from Project Characteristics screen	Not updated

CalEEMod Version 2022.1 Data Field or Button	CalEEMod Version 2020.4.0 Data Field or Button	Comparison
Methane (CH_4)	Methane (CH_4) from Project Characteristics screen	Not updated
Nitrous Oxide (N_2O)	Nitrous Oxide (N_2O) from Project Characteristics screen	Not updated
Refrigerants (CO_2e)	-	New
CO_2 Equivalent GHGs (CO_2e)	CO_2 Equivalent GHGs (CO_2e) from Project Characteristics screen	Not updated
Construction Thresholds - Daily	-	New
Construction Thresholds - Quarterly	-	New
Construction Thresholds - Annual	-	New
Operations Thresholds - Daily	-	New
Operations Thresholds - Quarterly	-	New
Operations Thresholds - Annual	-	New
Land Use		
Type	Land Use Type	Updated
Subtype	Land Use Subtype	Updated
Unit	Unit Amount	Updated
Size	Size Metric	Updated
Lot Acreage	Lot Acreage	Updated
Building Square Feet	Square Feet	Updated
Landscape Area	-	New
Special Landscape Area	-	New

CalEEMod Version 2022.1 Data Field or Button	CalEEMod Version 2020.4.0 Data Field or Button	Comparison
Recreational Building Area	Recreational Swimming Pool Building Square Feet	Not Updated
Population	Population	Updated
Description	-	New
Predominant Soil/Site Soil Type	-	New
Construction Phases		
Enable Auto-Scheduler	n/a (automatic)	Updated
Phase Name - Vertical Construction	Phase Name	Not updated
Phase Type - Vertical Construction	Phase Type	Not updated
Start Date - Vertical Construction	Start Date	Not updated
End Date - Vertical Construction	End Date	Not updated
Days/Week - Vertical Construction	Days/Week	Updated
Work Days per Phase - Vertical Construction	Total Days	Not updated
Phase Description - Vertical Construction	Phase Description	Not updated
Linear Land Use Type Construction Workdays	-	New
Phase Name - Linear Construction	-	New
Phase Type - Linear Construction	-	New
Start Date - Linear Construction	-	New
End Date - Linear Construction	-	New
Days/Week - Linear Construction	-	New

CalEEMod Version 2022.1 Data Field or Button	CalEEMod Version 2020.4.0 Data Field or Button	Comparison
Work Days per Phase - Linear Construction	-	New
Phase Description - Linear Construction	-	New
Off-Road Equipment		
Equipment Type	Equipment Type	Not updated
Fuel Type	-	New
Engine Tier	-	New
Number/Day	Unit Amount	Not updated
Hours/Day	Hours/Day	Not updated
Horsepower	HorsePower (HP)	Updated
Load Factor	Load Factor	Updated
Off-Road Equipment Emission Factors		
All fields	-	New
Dust from Material Movement		
Water Exposed Area	-	New
Frequency	-	New
PM10 % Reduction	-	New
PM2.5 % Reduction	-	New
Phase Type	Phase Name	Updated
Material Imported	Material Imported	Not updated
Material Exported	Material Exported	Not updated
Size Metric	Size Metric	Not updated

CalEEMod Version 2022.1 Data Field or Button	CalEEMod Version 2020.4.0 Data Field or Button	Comparison
Material Import/Export Phased?	Material Import/Export Phased?	Not updated
Mean Vehicle Speed	Mean Vehicle Speed	Not updated
Total Acres Graded	Total Acres Graded	Not updated
Material Moisture Content Bulldozing	Material Moisture Content Bulldozing	Not updated
Material Moisture Content Truck Loading	Material Moisture Content Truck Loading	Not updated
Material Silt Content	Material Silt Content	Not updated
Demolition		
Water Demolished Area	-	New
Frequency	-	New
PM10 % Reduction	-	New
PM2.5 % Reduction	-	New
Phase Name	Phase Name	Updated
Phase Type	-	New
Size Metric	Size Metric	Not updated
Unit Amount	Unit Amount	Not updated
Trips and VMT		
Worker and Vendor Trip Length Data Source	-	New
One-Way Trips/day - Worker	# Trips Worker	Not updated
Trip Length - Worker	Trip Length Worker	Updated
Vehicle Class - Worker	Vehicle Class Worker	Updated
One-Way Trips/day - Vendor	# Trips Vendor	Not updated

CalEEMod Version 2022.1 Data Field or Button	CalEEMod Version 2020.4.0 Data Field or Button	Comparison
Trip Length - Vendor	Trip Length Vendor	Updated
Vehicle Class - Vendor	Vehicle Class Vendor	Not updated
One-Way Trips/day - Hauling	# Trips Hauling	Not updated
Trip Length - Hauling	TripLength Hauling	Not updated
Vehicle Class - Hauling	Vehicle Class Hauling	Not updated
One-Way Trips/day - Onsite truck	-	New
Trip Length - Onsite truck	-	New
Vehicle Class - Onsite truck	-	New
On-Road Fugitive Dust		
Control Strategy	-	New
Strategy Active - Water unpaved roads twice daily	-	New
Strategy Active - Apply dust suppressants to unpaved roads	-	New
Strategy Active - Limit vehicle speeds on unpaved roads to 25 mph	-	New
Strategy Active - Sweep paved roads once per month	-	New
PM2.5 % Reduction	-	New
PM10 % Reduction	-	New
Phase Name	Phase Name	Not updated
% Pave Worker	% Pave Worker	Not updated

CalEEMod Version 2022.1 Data Field or Button	CalEEMod Version 2020.4.0 Data Field or Button	Comparison
% Pave Vendor	% Pave Vendor	Not updated
% Pave Hauling	% Pave Hauling	Not updated
% Pave Onsite Truck	-	New
Road Silt Loading	Road Silt Loading	Not updated
Material Silt Content	Material Silt Content	Not updated
Material Moisture Content	Material Moisture Content	Not updated
Average Vehicle Weight	Average Vehicle Weight	Not updated
Mean Vehicle Speed	Mean Vehicle Speed	Not updated
Architectural Coatings		
Phase Name	Phase Name	Updated
Phase Type	-	New
Residential Interior VOC	Residential Interior VOC	Updated
Non Residential Interior VOC	Non Residential Interior VOC	Updated
Residential Exterior VOC	Residential Exterior VOC	Updated
Non Residential Exterior VOC	Non Residential Exterior VOC	Updated
VOC for Parking Paint/Linear Paint	VOC for Parking Lot Paint	Updated
Residential Interior Area	Residential Interior Area	Not updated
Non Residential Interior Area	Non Residential Interior Area	Not updated
Residential Exterior Area	Residential Exterior Area	Not updated
Non Residential Exterior Area	Non Residential Exterior Area	Not updated

CalEEMod Version 2022.1 Data Field or Button	CalEEMod Version 2020.4.0 Data Field or Button	Comparison
Parking/Linear Area	Parking Area	Not updated
Paved Area		
All fields	-	New
Electricity		
All fields	-	New
Vehicle Data – Default (formerly Vehicle Trips)		
VMT Estimation Source	-	New
Land Use Subtype	Land Use SubType	n/a (defined in the Land Use screen)
Size	Size Metric	n/a (defined in the Land Use screen)
Weekday Trip Rate	WkDy Trip Rate	Not updated
Saturday Trip Rate	Sat Trip Rate	Not updated
Sunday Trip Rate	Sun Trip Rate	Not updated
Res H-W Trip Length	Res H-W Trip Length	Updated
Res H-S Trip Length	Res H-S Trip Length	Updated
Res H-O Trip Length	Res H-O Trip Length	Updated
Non Res H-W Trip Length	-	New
Non Res W-O Trip Length	-	New
Non Res O-O Trip Length	-	New
Weekday Primary Trip	Primary Trip	Updated
Weekday Divert Trip	Divert Trip	Updated
Weekday Pass-By Trip	Pass-By Trip	Updated

CalEEMod Version 2022.1 Data Field or Button	CalEEMod Version 2020.4.0 Data Field or Button	Comparison
Saturday Primary Trip	-	New
Saturday Divert Trip	-	New
Saturday Pass-By Trip	-	New
Sunday Primary Trip	-	New
Sunday Divert Trip	-	New
Sunday Pass-By Trip	-	New
Res H-W Trip	Res H-W Trip	Updated
Res H-S Trip	Res H-S Trip	Updated
Res H-O Trip	Res H-O Trip	Updated
Non Res H-W Trip	-	New
Non Res W-O Trip	-	New
Non Res O-O Trip	-	New
-	Non Res C-C Trip Length	Removed
-	Non Res C-W Trip Length	Removed
-	Non Res C-NW Trip Length	Removed
-	Non Res C-C Trip	Removed
-	Non Res C-W Trip	Removed
-	Non Res C-NW Trip	Removed
Vehicle Data - Manual		
All fields	-	New
Fleet Mix		

CalEEMod Version 2022.1 Data Field or Button	CalEEMod Version 2020.4.0 Data Field or Button	Comparison
Land Use Subtype	Land Use SubType	n/a (defined in the Land Use screen)
Season	-	New
LDA through MH	LDA through MH	Updated
Vehicle Emission Factors (formerly Vehicle Emissions – Annual/Summer/Winter)		
Operational Year	-	New
TOG through N_2O	TOG through N_2O	Updated
Road Dust		
CARB Unmitigated Unpaved Road Statewide Emission Inventory Method	CARB Unmitigated Unpaved Road Statewide Emission Inventory Method	Not updated
% Paved	% Pave	Not updated
Road Silt Loading	Road Silt Loading	Not updated
Material Silt Content	Material Silt Content	Not updated
Material Moisture Content	Material Moisture Content	Not updated
Average Vehicle Weight	Average Vehicle Weight	Not updated
Mean Vehicle Speed	Mean Vehicle Speed	Not updated
Hearths		
Land Use Subtype	Residential Land Use SubType	n/a (defined in the Land Use screen)
# Wood	# Wood	Updated
# Gas	# Gas	Updated
# Propane	# Propane	Updated
# Electric	-	New

CalEEMod Version 2022.1 Data Field or Button	CalEEMod Version 2020.4.0 Data Field or Button	Comparison
# Without Fireplace	# No Fireplace	Updated
Hours/Day	Hours/Day	Updated
Days/Year	Days/Year	Updated
Wood Mass	Wood Mass	Updated
# Conventional	# Conventional	Updated
# Catalytic	# Catalytic	Updated
# Non-Catalytic	# Non-Catalytic	Updated
# Pellet	# Pellet	Updated
Days/Year	Days/Year	Updated
Wood Mass	Wood Mass	Updated
Consumer Products		
General Category Emission Factor	General Category Emission Factor	Not updated
City Park/Golf Course, Pesticides/Fertilizers Emission Factor	City Park/Golf Course, Pesticides/Fertilizers Emission Factor	Updated
Parking Degreaser Emission Factor	Parking Degreaser Emission Factor	Updated
Architectural Coatings		
Reapplication Rate Per Year	Reapplication Rate	Not updated
Residential Interior VOC Content	Residential Interior VOC Emission Factor	Updated
Non Residential Interior VOC Content	Non Residential Interior VOC Emission Factor	Updated
Residential Exterior VOC Content	Residential Exterior VOC Emission Factor	Updated

CalEEMod Version 2022.1 Data Field or Button	CalEEMod Version 2020.4.0 Data Field or Button	Comparison
Non Residential Exterior VOC Content	Non Residential Exterior VOC Emission Factor	Updated
Parking Paint VOC Content	Parking VOC Emission Factor	Updated
Residential Interior Coated Area	Residential Interior Square Footage	Not updated
Non Residential Interior Coated Area	Non Residential Interior Square Footage	Not updated
Residential Exterior Coated Area	Residential Exterior Square Footage	Not updated
Non Residential Exterior Coated Area	Non Residential Exterior Square Footage	Not updated
Parking Coated Area	Parking Square Footage	Updated
Landscape Equipment – Default		
Snow Days	Snow Days	Updated
Summer Days	Summer Days	Updated
Landscape Equipment – Manual		
All fields	-	New
Energy Use - Default and Manual		
Land Use Subtype	Land Use SubType	n/a (defined in the Land Use screen)
Total Electricity	-	New
Total Natural Gas	-	New
Title 24 Electricity	-	New
Title 24 Natural Gas	-	New
Non Title 24 Electricity	-	New
Non Title 24 Natural Gas	-	New

CalEEMod Version 2022.1 Data Field or Button	CalEEMod Version 2020.4.0 Data Field or Button	Comparison
-	Title 24 Electricity Energy Intensity	Removed
-	Title 24 Natural Gas Energy Intensity	Removed
-	Lighting Energy Intensity	Removed
-	Non-Title 24 Electricity Energy Intensity	Removed
-	Non-Title 24 Natural Gas Energy Intensity	Removed
Water and Wastewater		
Land Use Subtype	Land Use SubType	n/a (defined in the Land Use screen)
Indoor Water Use	Indoor Water Use	Updated
Include Precipitation	-	New
Outdoor Water use	Outdoor Water use	Updated
Electricity Intensity Factor to Supply	Electricity Intensity Factor to Supply	Updated
Electricity Intensity Factor to Treat	Electricity Intensity Factor to Treat	Updated
Electricity Intensity Factor to Distribute	Electricity Intensity Factor to Distribute	Updated
Electricity Intensity Factor for Wastewater Treatment	Electricity Intensity Factor for Wastewater Treatment	Updated
% of Wastewater Treated by Septic Tank	Septic Tank	Not updated
% of Wastewater Treated by Aerobic	Aerobic	Not updated
% of Wastewater Treated by Facultative Lagoons	Facultative Lagoons	Not updated
% of Wastewater Solids Treated by Anaerobic Digester with Combustion of Digester Gas	Anaerobic Digester with Combustion of Digester Gas	Not updated

CalEEMod Version 2022.1 Data Field or Button	CalEEMod Version 2020.4.0 Data Field or Button	Comparison
% of Wastewater Solids Treated by Anaerobic Digestion with Cogeneration from Combustion of Digester Gas	Anaerobic Digestion with Cogeneration from Combustion of Digester Gas	Not updated
-	Size Metric	Removed
Solid Waste		
Land Use Subtype	Land Use SubType	n/a (defined in the Land Use screen)
Unit	-	New
Size	Size Metric	Not updated
Solid Waste Generation Rate	Solid Waste Generation Rate	Updated
Landfill No Gas Capture	Landfill No Gas Capture	Not updated
Landfill Capture Gas Flare	Landfill Capture Gas Flare	Not updated
Landfill Capture Gas Energy Recovery	Landfill Capture Gas Energy Recovery	Not updated
Refrigerants		
All fields	-	New
Off-Road Equipment		
Equipment Type	Equipment Type	Not updated
Fuel Type	Fuel Type	Updated
Engine Tier	-	New
# per Day	Number of Equipment	Not updated
Hours/Day	Hours/Day	Not updated
Days/Year	Days/Year	Not updated

CalEEMod Version 2022.1 Data Field or Button	CalEEMod Version 2020.4.0 Data Field or Button	Comparison
Horsepower	HorsePower (HP)	Updated
Load Factor	Load Factor	Updated
-	Equipment Description	Removed
Off-Road Equipment Emission Factors		
All fields	-	New
Emergency Generators and Fire Pumps		
Equipment Type	Equipment Type	Not updated
Fuel Type	Fuel Type	Updated
# per Day	Number of Equipment	Not updated
Hours/Day	Hours/Day	Not updated
Hours/Year	Hours/Year	Not updated
Horsepower	HorsePower (HP)	Not updated
Load Factor	Load Factor	Not updated
Description	Equipment Description	Not updated
Generators/Pump Emission Factors (formerly Generators / Fire Pumps EF)		
TOG to N_2O	TOG to CH_4	Updated
Process Boilers		
Boiler	Equipment Type	Not updated
Count	Number of Equipment	Not updated
Fuel Type	Fuel Type	Not updated
Boiler Rating	Boiler Rating	Not updated

CalEEMod Version 2022.1 Data Field or Button	CalEEMod Version 2020.4.0 Data Field or Button	Comparison
Daily Heat Input	Daily Heat Input	Not updated
Annual Heat Input	Annual Heat Input	Not updated
Boilers Emission Factors (formerly Boilers EF)		
TOG to N_2O	TOG to CH_4	Updated
User Defined		
Equipment Type	Equipment Type	Not Updated
Fuel Type(s)	Fuel Type(s)	Not Updated
Emission Factor Pollutants (all)	TOG through CH_4	Not Updated
Land Use Change		
Soil Carbon Accumulation - Vegetation Land Use Type	Vegetation Land use Type	Updated
Soil Carbon Accumulation - Vegetation Soil	Vegetation Land Use Subtype	Updated
Soil Carbon Accumulation - CO_2 Accumulation	-	New
Soil Carbon Accumulation - Initial Acres	Initial Acres	Not Updated
Soil Carbon Accumulation - Final Acres	Final Acres	Not Updated
Above and Belowground Biomass Carbon Accumulation - Cover Type	-	New
Above and Belowground Biomass Carbon Accumulation - CO_2 Accumulation	-	New
Above and Belowground Biomass Carbon Accumulation - Initial Acres	Initial Acres	Not Updated

CalEEMod Version 2022.1 Data Field or Button	CalEEMod Version 2020.4.0 Data Field or Button	Comparison
Above and Belowground Biomass Carbon Accumulation - Final Acres	Final Acres	Not Updated
-	Annual CO_2 accumulation per acre	Removed
Sequestration		
Operations Lifetime	-	New
Removed Trees - Species	Broad Species Class	Updated
Removed Trees - Number	Number of New Trees	Not Updated
Removed Trees - CO_2 Avoided through PM2.5 Removed	-	New
Added Trees - Species	Broad Species Class	Updated
Added Trees - Number	Number of New Trees	Not Updated
Added Trees - CO_2 Avoided through PM2.5 Removed	-	New
-	Annual CO_2 accumulation per tree	Removed
Climate Risk		
All fields	-	New
Emission Reduction (formerly Mitigation)		
Described below in Table H-3.	Described below in Table H-3.	Described below in Table H-3.
Climate Risk Reduction		
All fields	-	New
Health & Equity		
All fields	-	New

CalEEMod Version 2022.1 Data Field or Button	CalEEMod Version 2020.4.0 Data Field or Button	Comparison
Results		
All fields	-	New
Report (formerly Reporting)		
Summary Report	Summary Report	Updated
Quarterly Report	Embedded in other reports	Updated
Detailed Report	Annual, Summer, and Winter	Updated
Custom Report	-	New
Download PDF	Export PDF	Updated
Download CSV	Export Excel	Updated
Downloaded Excel	Export Excel	Updated
-	Export Word	Removed
-	Recalculate All Emissions and Run Report	n/a (automatic)
Help (from CalEEMod Version 2020.4.0)		
-	Help on the Current Page button	Removed
-	About… button	Removed

- = N/A or not updated

Table H-3. Comparison of Emission Reduction Measures in CalEEMod 2022.1 with Previous CalEEMod (Version 2020.4.0)

CalEEMod Version 2022.1 Measure	CalEEMod Version 2020.4.0 Measure	Comparison
Construction		
C-1-A	C-1	Updated
C-1-B	C-1	Not updated
C-3	-	New measure
C-5	C-1	Updated
C-6	C-1	Not updated
C-7	Unnumbered but named "Oxidation Catalyst (%Reduction)"	Not updated
C-8	-	New measure
C-9	Unnumbered but named "Soil Stabilizer for Unpaved Roads"	Not updated
C-10-A	Unnumbered but named "Water Exposed Surfaces"	Updated
C-10-B	-	New measure
C-10-C	-	New measure
C-11	Unnumbered but named "Unpaved Road Mitigation"	Updated
C-12	Unnumbered but named "Clean Paved Road"	Updated
C-13	-	New measure
-	Unnumbered but named "Replace Ground Cover of Area Disturbed"	Removed measure (wind erosion is not a quantified source)
Transportation		
T-1	LUT-1	Updated
T-2	LUT-3	Updated
T-3	-	New Measure
T-4	LUT-6	Updated
T-5	TRT-1, TRT-2	Updated
T-6	TRT-1, TRT-2	Updated
T-7	TRT-7	Updated

CalEEMod Version 2022.1 Measure	CalEEMod Version 2020.4.0 Measure	Comparison
T-8	TRT-3	Updated
T-9	TRT-4	Updated
T-10	-	New measure
T-12	TRT-14	Updated
T-13	TRT-15	Updated
T-15	PDT-1	Updated
T-16	PDT-2	Updated
T-17	LUT-9	Updated
T-18	SDT-1	Updated
T-19-A	-	New measure
T-19-B	-	New measure
T-20	-	New measure
T-21-A	-	New measure
T-21-B	SDT-3	Updated
T-22-A	-	New measure
T-22-B	-	New measure
T-22-C	-	New measure
T-23	-	New measure
T-24	PDT-3	Updated
T-25	TST-3	Updated
T-27	-	New measure
T-29	TRT-4	Updated
-	TRT-13	Removed (now qualitative or supporting)
-	TRT-6	Removed (now qualitative or supporting)
-	TRT-11	Removed (now qualitative or supporting)
-	LUT-4	Removed (now qualitative or supporting)
-	LUT-5	Removed (now qualitative or supporting)

CalEEMod Version 2022.1 Measure	CalEEMod Version 2020.4.0 Measure	Comparison
-	SDT-2	Removed (now qualitative or supporting)
-	TST-1	Removed (now qualitative or supporting)
-	TST-4	Removed (now qualitative or supporting)
Energy		
E-1	BE-1	Updated
E-2	BE-4	Updated
E-4	-	New measure
E-5	-	New measure
E-6	-	New measure
E-10-A	AE-1, AE-2, AE-3	Updated
E-10-B	AE-1, AE-2, AE-3	Updated
E-10-C	AE-1, AE-2, AE-3	Updated
E-11	-	New measure
E-12-A	-	New measure
E-12-B	-	New measure
E-13	-	New measure
E-15	-	New measure
E-16	-	New measure
E-17	-	New measure
-	LE-1	Removed (now qualitative or supporting)
Water		
W-1	WSW-1	Updated
W-2	WSW-2	Updated
W-3	-	New measure
W-4	WUW-1	Updated
W-5	WUW-3, WUW-4	Updated
W-6	WUW-5	Updated

CalEEMod Version 2022.1 Measure	CalEEMod Version 2020.4.0 Measure	Comparison
W-7	WUW-2	Updated
Waste		
S-1/S-2	SW-1	Not updated
Refrigerants		
R-1	-	New measure
R-2	-	New measure
R-3	-	New measure
R-4	-	New measure
R-5	-	New measure
R-6	-	New measure
Natural Lands		
N-1	-	New measure
N-2	-	New measure
Area Source		
AS-1	Unnumbered but named "Use Low VOC Cleaning Supplies."	Not updated
AS-2	Unnumbered but named "Use Low VOC Paint."	Not updated
E-14	Unnumbered but named "Only Natural Gas Hearth" and "No Hearth."	Updated
LL-1	A-1	Updated
Miscellaneous		
M-1	-	New measure
M-2	-	New measure
M-3	-	New measure

Table H-4. Comparison of User Guides for CalEEMod 2022.1 and CalEEMod Version 2020.4.0

Document	Changes Reflected in the User Guide for CalEEMod Version 2022.1
User Guide	1. The organizational structure of the user's guide was revised to match and reflect the modules and screens of CalEEMod version 2022.1. 2. Section 1, *Introduction*, was updated to reflect the expanded purpose and functionalities of CalEEMod. A figure was added to illustrate the architecture of CalEEMod and hierarchy among the sections, modules, screens, and sub-screens 3. Section 2, *Accessing CalEEMod*, was condensed to explain that installation is no longer relevant to the web-based tool. 4. Edits were made through Section 3, *Using CalEEMod*, and Section 4, *Detailed Program Components, Modules, Submodules, and Screens*, to reflect the new features, content, presentation, terminology, and quantification methods for CalEEMod Version 2022.1. This includes addition of the **Map** component, **Climate Risk** module, **Results** component. 5. The section on mitigation measures was updated to provide guidance on using the new **Measures** module, which includes emission reduction, climate risk reduction, and health and equity measures. 6. A complete references section was added to the user's guide (see Section 5, *References*).
Appendix A – Glossary *(previously Appendix B)*	The appendix has been expanded to include additional terms and concepts relevant to CalEEMod Version 2022.1, including those related to climate change and health and equity.
Appendix B – Acronym List (*previously Appendix C*)	The appendix has been expanded to define additional acronyms relevant to CalEEMod Version 2022.1, including those related to climate change and health and equity.
Appendix C – Emission Calculation Details for CalEEMod *(previously Appendix A)*	1. The organizational structure of the appendix was revised to match and reflect the modules and screens of CalEEMod Version 2022.1. 2. Section 1, *Overview*, was updated to reference additional appendices users should consult for further information related to emission quantification. A figure was also added to illustrate the CalEEMod modules, screens, and sub-screens addressed by the appendix. 3. Edits were made throughout the appendix to reflect the revised methods and data sources for CalEEMod Version 2022.1. Key methodological updates are described in the tables above. 4. New sections were added to address new model content related to emissions quantification. 5. An expanded description and example of how CalEEMod quantifies maximum daily and annual construction emissions has been added to the appendix. 6. Additional information was added for emission reduction measures to describe the revised calculation approach and new feature (e.g., filtering by co-benefits).

Document	Changes Reflected in the User Guide for CalEEMod Version 2022.1
	7. A complete references section was added to the appendix (see Section 8, *References*).
Appendix D – Technical Source Documentation for Emissions Calculations (*previously Appendix E*)	Discrete sections of this appendix have been updated, specifically Appendix D4, *Degreaser, Fertilizer/Pesticide Use Analysis*, and Appendix D5, *Analysis of Building Energy Use Data*. Appendix D11, *Additional Construction Defaults*, was added.
Appendix E – Support Documentation for Climate Change Analyses	This is a new appendix that was added to describe the technical method underlying the **Climate Risk** module and associated risk reduction analyses.
Appendix F – Support Documentation for Health and Equity Association Scoring	This is a new appendix that was added to describe the technical method underlying the health and equity measure prioritization analysis and **Health and Equity Evaluation Scorecard**.
Appendix G – Default Data Tables (previously Appendix D)	This appendix has been updated to reflect the revised defaults and underlying model assumptions. Additional tables were added for the new climate and health and equity analyses.
Appendix H – Comparison to CalEEMod Version 2020.4.0	This is a new appendix that was added to highlight updates included in CalEEMod Version 2022.1 and the associated User Guide, relative to the prior version (Version 2020.4.0).