

Draft
Bay Area Air Quality Management District
Greenhouse Gas Model User's Manual



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Introduction

The Bay Area Air Quality Management District's (BAAQMD's) Greenhouse Gas Model (BGM) is an Excel spreadsheet program that allows users to estimate operational greenhouse gas (GHG) emissions from land development projects. BGM does not estimate GHG's generated during construction. To run BGM, users must have either Excel 2007 or Excel 2003 installed on their computer.

BGM reads URBEMIS2007 project files to generate a portion of a project's GHG emission estimates. To run BGM, the user must also have URBEMIS2007, version 9.2.4, installed on their computer. URBEMIS2007 can be downloaded from <http://www.urbemis.com>. The user must have created an URBEMIS project file that can be read by BGM. URBEMIS2007 project files use the extension: .urb924.

Users should have at least a rudimentary knowledge of both URBEMIS and Excel to run BGM.

This User's Manual is organized into two separate sections. The first section describes how to install and run BGM. The second section describes how BGM calculates GHG emissions.

Section 1. How to Install and Run BGM

Installation

BGM has been developed to be used with Excel 2003 and Excel 2007. To install BGM, download the installation file from the BAAQMD's website. Double click on the installation file to initiate installation. The BGM spreadsheet automatically installs the BGM spreadsheet at: C:\Program Files\URBEMIS\BGM Greenhouse Gas Calculator\BGM_Template.xls.

Running BGM

Once installed, BGM places an icon on the desktop:



Clicking on this icon starts BGM and places you on BGM's Help tab, which is shown in Figure 1.

Help

Bay Area Air Quality Management District Greenhouse Gas Model (BGM) Version: 1.1.3 Beta

Step 1: Enable Macros

Macros must be enabled for this model to operate correctly. The method for enabling macros for this spreadsheet differs depending on the security settings in Excel.

Step 2: Open an Urbemis Project File, or Refresh Urbemis Data

The Greenhouse Gas Calculator depends on the data and results from an Urbemis project file. Up to two URBEMIS files can be specified: a project file and (optionally) a baseline file. To open a file, or to refresh the data in this spreadsheet after an URBEMIS project file has been modified, go to the Settings tab by clicking on the Open an URBEMIS Project File link to the right. Select the URBEMIS file(s) that you want to import and hit the refresh data button. Please make sure that the Emfac Database Location is correct before clicking either of the Refresh buttons.

Step 3: Data Entry Options

The bright yellow areas on each tab represent data entry locations, if applicable to your project. In some cases, there are optional data inputs (shown in peach). Some tabs, such as transportation and area sources, do not require any data input, as results are imported directly from URBEMIS. Certain other tabs - electricity & natural gas, water & wastewater, and solid waste - require some minor amount of user input, although most of the information used to estimate emissions is imported from URBEMIS. And for certain tabs, - ag, off-road, refrigerants, and carbon sequestration - the user must enter project specific information to obtain emission estimates.

Step 4: View Results

The Results Tab presents a graphical and tabular view of the results of the Greenhouse Gas Calculator. Both a summary and detailed report are included on the Results tab. The user also has the option of selected project specific mitigation on the Mitigation tab and on the Carbon Sequestration tab.

LINKS

[Open an Urbemis Project File](#)

[Summary Results](#)

[Transportation](#)

[Area Source](#)

[Electricity and Natural Gas](#)

[Water and Wastewater](#)

[Solid Waste](#)

[Agriculture](#)



[Off-Road Equipment](#)

[Refrigerants](#)

[Mitigation](#)

[Carbon Sequestration](#)



 Enter data in yellow cells with values applicable to your project
 Enter data in peach cells if you have information specific to your project; these values will be used in place of the default values

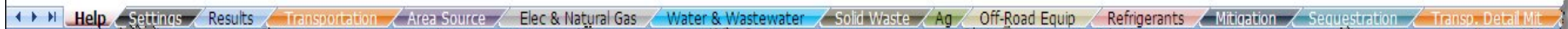


Figure 1. Help Tab

The BGM help tab lists four steps that the user should follow to run BGM. In addition to these four steps, the user should note that BGM contains fifteen tabs listed at the bottom of the spreadsheet:

1. Help
2. Settings
3. Results
4. Transportation
5. Area Source
6. Elec(tric) & Natural Gas
7. Water & Wastewater
8. Solid Waste
9. Ag(riculture)
10. Off Road Equip(ment)
11. Refrigerants
12. Mitigation
13. Sequestration
14. Transp(ortation) Detail Mit(igated)
15. Land Use Detail (not shown in Figure 1).


The use of these tabs is described in Steps 2, 3, and 4 below.

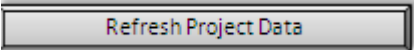
Step 1. Enable Macros

Step 1 requires that the user ensure that their version of Excel has been setup to allow macros. If Excel has been set to not allow macros, then the “Enable All Macros” option should be turned on. Within Excel 2007, macro security is set by going to the Developer Tab within the Ribbon Menu at the top of the screen, and then selecting the Macro Security option. Within Excel 2003, macro security is set by going to the Tools Tab within the Ribbon Menu at the top of the screen, and then selecting the Macro option within the Tools tab.

Step 2. Run an URBEMIS Project File and Refresh URBEMIS Data

Once macros have been turned on, the next step is to load one or more URBEMIS project files. URBEMIS project files are selected within the Settings tab. To load an URBEMIS file, the BGM user should click on the [Open an URBEMIS Project File](#) link shown on the Help tab (which takes you to the Settings tab), or click on the Settings tab found at the bottom of the spreadsheet.

Figure 2 shows the URBEMIS Settings tab. The Settings tab includes seven buttons plus a checkbox. To load an URBEMIS file, click on the top button -  - which allows you to navigate to the URBEMIS project file location.

The second button -  - runs the URBEMIS project file and places the results in the correct locations within BGM.

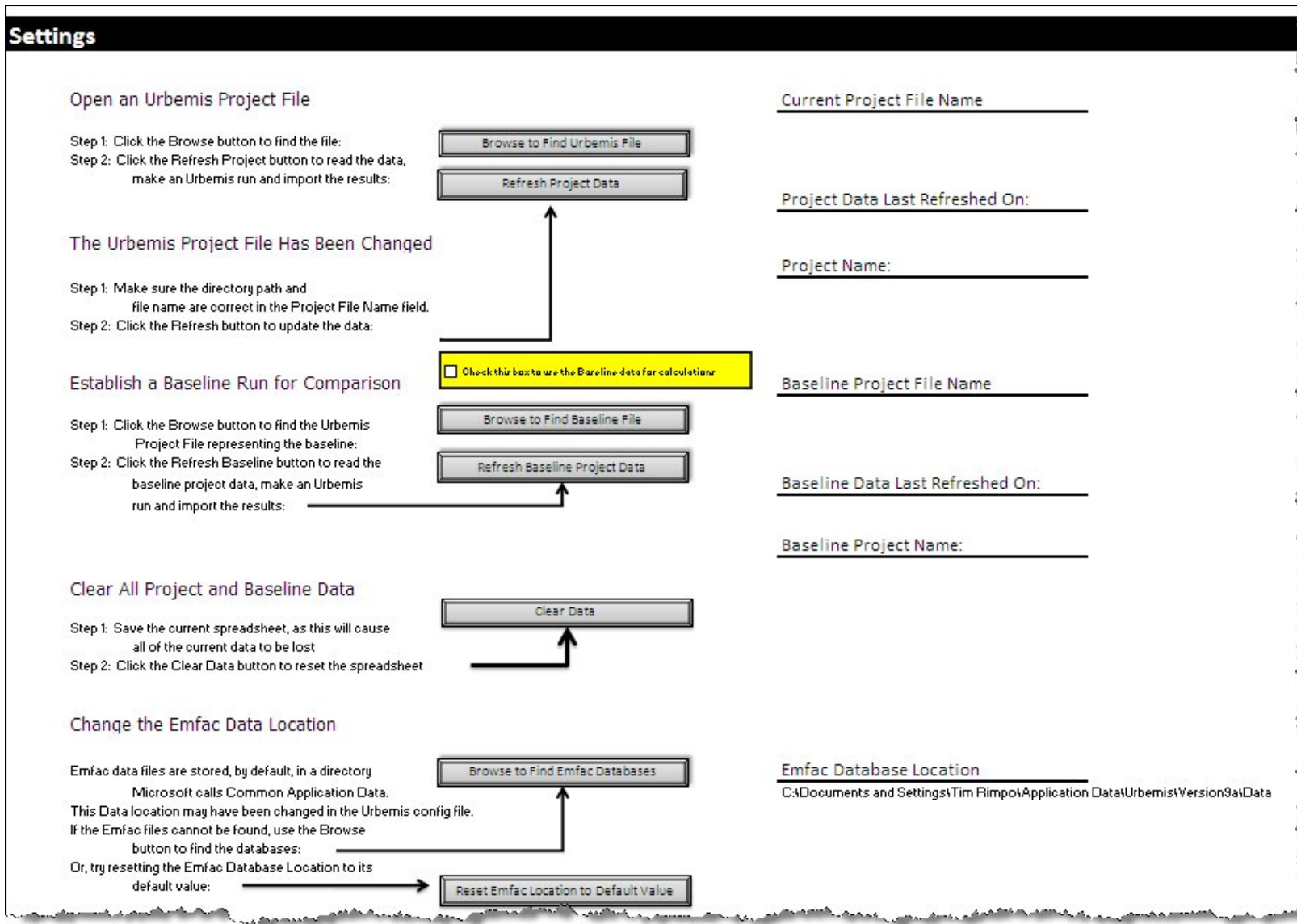
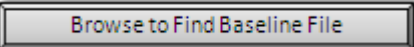

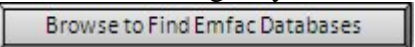


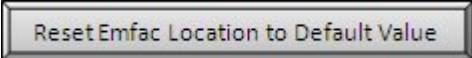
Figure 2. Settings Tab

BGM also allows the user to run an URBEMIS baseline file, though this is optional. To do this, click on the  button to identify the URBEMIS file to be used as the baseline project.

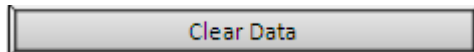
Then, click on the fourth button to place the results of the baseline file into the correct location of BGM. 

The user should note that within the Settings tab there is a checkbox highlighted in yellow. If checked, then BGM will use the Baseline Project file to calculate a project's net emissions increase (project emissions minus baseline emissions). If this checkbox is turned off, BGM will ignore the Baseline data and will only calculate project emissions.

In order for BGM to make the URBEMIS run(s) for the project and baseline, it must know the location of the URBEMIS EMFAC2007 files needed to make those runs. BGM has been setup to look for the EMFAC2007 files in the default location found in the URBEMIS configuration file. If the location of the EMFAC2007 files has been changed, you will need to specify the correct location by clicking on the button: 

The last button  resets BGM to look for the EMFAC2007 files in the default location.

In addition to the six buttons described above, there is a seventh button:



When the Clear Data button is selected, all data entered into the spreadsheet is deleted. This button should be used with caution as any entered data will be removed, including any URBEMIS files that have been selected.

A few notes of caution:

1) BGM requires that the Project file be imported from URBEMIS. Consequently, the operational year specified within the URBEMIS project file becomes the year for which all project emissions are calculated in BGM. You cannot change this year within BGM. To change the project year, you must go back into URBEMIS and change the project year. The same situation holds for the baseline project and year. To change the baseline project year, you must also change it within URBEMIS.

2) If the URBEMIS file that you are importing includes completed "blank" land uses, then the transportation and area source emissions will include the emissions for those blank land uses. However, other areas of BGM that use URBEMIS land uses - the electricity and natural gas tab, the water and wastewater tab, and the solid waste tab – do not import completed blank land use information from URBEMIS. Consequently, the BGM user must go into these three tabs and enter blank land use information. Blank land uses are discussed in detail in the last section of this manual

Step 3. Data Entry Options

Once the URBEMIS file(s) have been imported into BGM, the next step is to enter project data for specific tabs. As mentioned above, BGM contains 15 tabs:

1. Help
2. Settings
3. Results
4. Transportation
5. Area Source
6. Elec(tric) & Natural Gas
7. Waste and Wastewater
8. Solid Waste
9. Ag(riculture)
10. Off Road Equipment
11. Refrigerants
12. Mitigation
13. Sequestration
14. Transp(ortation) Detail Mit(igated)
15. Land Use Detail

These 15 tabs can be grouped into four categories. These include tabs where:

- user input is required to initiate the model (purple, 1 tab),
- no user input is required (yellow, 6 tabs),
- user input is optional and/or minimal (green, 3 tabs), and
- user input is required to generate or mitigate emissions (blue, 5 tabs).

Figure 3 illustrates how the BGM model emission estimates are made.

Bay Area Air Quality Management District Greenhouse Gas Model (BGM)

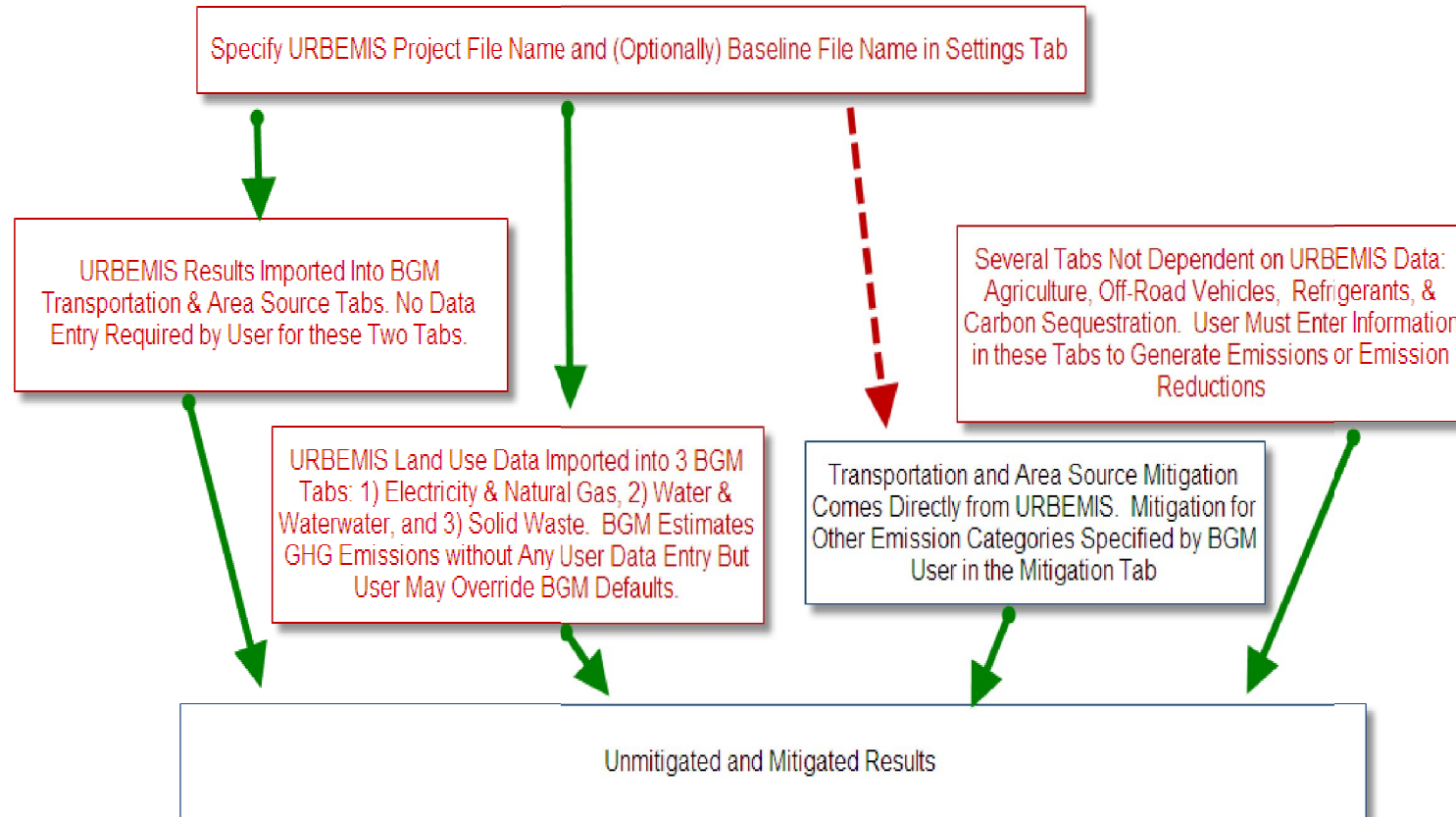


Figure 3. BGM Model Flowchart

Tab Where User Input is Required to Start the Model

Settings Tab

The Settings Tab is used to identify and run the URBEMIS files that are loaded into BGM. Section 2, on page 3 of this manual, describes how to load URBEMIS files within the Settings tab.

Tabs Where No User Input is Required

Help Tab

The Help tab, discussed in Step 1, provides guidance on making a BGM run. The Help tab is shown when the BGM model is started. No user input is directly required on the Help tab, although the user may have to turn on macros if Excel has been set to not allow them to run, as described above in Step 1.

Results Tab

The results tab summarizes the emission results, but no user input or changes can be made within it. BGM produces two types of output: summary and detailed. Step 4 below describes the results tab in more detail.

Transportation and Area Source Tabs

Once you have imported an URBEMIS file into BGM (from within the Settings Tab), BGM uses the URBEMIS results to complete the transportation and area source tabs. The user cannot make any changes to data in either of these tabs. In addition, BGM imports transportation-related assumptions and mitigation detail into two tabs: Transp. Detail Mit. And Land Use Detail. The user cannot directly change information in these tabs. The only way to change information in this tab is to change values in the URBEMIS model, and then refresh the data in the Settings tab, so that the revised URBEMIS data is imported into BGM.

Transp. Detail Mit. And Land Use Detail Tabs

See discussion of these two tabs in the previous paragraph.

Tabs Generating Emissions Where User Input is Optional

Three of the tabs generate emission estimates without any user input (except for importing of URBEMIS files). However, the user should make sure that the information shown in these tabs is accurate for their project. Each of these is discussed separately below.

Electric and Natural Gas

BGM's electricity and natural gas tab estimate GHG emissions in two steps. In the first step, BGM estimates the amount of electricity and natural gas that will be required for a project. To do this, the size of each individual land use for a project is imported from URBEMIS. With that information, BGM estimates the amount of electricity and natural gas that will be used, based on existing energy use information for climate zones 4 and 5. BGM then uses the energy use estimates to calculate GHG emissions.

The BGM user does not need to enter any information to generate GHG emissions associated with electricity and natural gas use. However, the BGM user should check that the correct climate zone is selected for their project (shown as yellow cells on the Electric and Natural Gas

tab and in Figure 4 below). A map of the two BAAQMD climate zones is shown on the electricity and natural gas tab.

In addition to selecting the correct climate zone, the BGM user has the option of overriding the default energy use estimates for each land use. These are identified by the peach colored cells on the worksheet. For example, if an energy demand report has been prepared for a project, the user may want to override the BGM energy use estimates with those included in the energy report. The energy and natural gas tab also includes a button that removes all user override data that has been entered.

Electricity and Natural Gas

Baseline is currently: OFF

Unmitigated Electricity			
	Project	Baseline	Project-Baseline
CO2 metric tons/year CO2:	46,252.824	0.000	
CH4 metric tons/year CH4:	0.385	0.000	
N2O metric tons/year:	0.213	0.000	
CO2e metric tons/year:	46,326.854	0.000	
CO2e metric tons/year:			46,326.85

Unmitigated Natural Gas			
	Project	Baseline	Project-Baseline
CO2 metric tons/year:	11281.38	0.000	
CH4 metric tons/year:	1.06	0.000	
N2O metric tons/year:	0.02	0.000	
CO2e metric tons/year:	11310.30	0.000	
CO2e metric tons/year:			11,310.30

Project Climate Zone Location: Zone 4 Zone 5

User Input Required if Climate Zone is Wrong

PROJECT Residential:

	Number of units (from URBEMIS)	Estimated Electricity Use/Year (kwh/ residence)	Total Residential Electricity Use (mwh /year)	User Override of Residential Electricity Use (mwh/year)
Single Family Residential	333.000	6,047.000	2,013.651	
Multi Family Residential	666.000	3,685.000	2,454.210	

PROJECT Nonresidential:

	Squa (1,000) from URBEMIS	(Megawatt- hours)	Use/Year (Megawatt-hours)	CO2 (metric tons/yr)
Land Use Type				
Day-Care Center	111.00	611.11		223.08

User Should Override Defaults if Project Specific Data Available

Figure 4. Electricity and Natural Gas User Data Entry Options

Water and Wastewater

The Water and Wastewater tab uses a three step process to estimate GHG emissions. Water and wastewater use are estimated based on land use information imported from URBEMIS. Then, electricity use associated with water use and wastewater generated is estimated. Finally, the GHG emissions associated with that electricity use are estimated.

The BGM user does not need to enter any information to generate GHG emissions associated with water and wastewater use. However, the user has the option of overriding the model's estimates of how much water would be required for a project (see Figure 5). This may be necessary if a water demand estimate has been prepared specifically for the project being analyzed.

Water and Wastewater				
Baseline is currently: OFF				
Unmitigated Water and Wastewater				
	Project	Baseline	Project-Baseline	
CO2 metric tons/year:	742.5754	0.0000		
CH4 metric tons/year:	0.0062	0.0000		
N2O metric tons/year:	0.0034	0.0000		
CO2e metric tons/year:	743.7639	0.0000		
CO2e metric tons/year:			743.76	
Clear All User Overrides				
	User Override of Model Estimates (af/yr)	Model Estimate (af/yr)	Total Gallons/year	In Gallons
Baseline Water Demand		201.51	65,673,720	
Project Water Demand		1,337.83	436,000,288	265,96
Net Increase in Water Demand		1,136.32	370,326,568	265,96
PROJECT				
% indoor water use	0.610			
% outdoor water use	0.390			
Total	1.00			
Project Water Demand - Indoor	1439110.51	kwh/year		
Project Water Demand - Outdoor	595140.39	kwh/year		
Total	2034250.90	kwh/year		

Figure 5. Water and Wastewater User Data Entry Options

Solid Waste

The Solid Waste tab generates GHG emissions using a two step process. First, the amount of waste generated for a project is estimated using the land use information imported from URBEMIS. Then, based on the amount of waste generated, BGM estimates GHG emissions.

The BGM user does not need to enter any information to generate GHG emissions associated with solid waste generation. However, the user should check that the correct landfill disposal option is selected: 1) landfilling only 2) landfilling with flaring to burn methane, or 3) landfilling with energy recovery (Figure 6). These three options are shown as yellow cells on the solid waste tab.

Solid Waste

Baseline is currently: OFF

Unmitigated Solid Waste			
	Project	Baseline	Project - Baseline
Truck Haul CO2 (metric tons/year):	150.74	0.00	
Truck Haul CH4 (metric tons/year):	0.0010	0.0000	
Truck Haul CO2e (metric tons/year):	150.76	0.00	
Landfill Offgasing (CO2e metric tons/year):	22,175.63	0.00	
Total Solid Waste (CO2e metric tons/year):	22,326.39	0.00	
Total Solid Waste (CO2e metric tons/year):			22,326.39

Project Landfill disposal option: Select 1 of 3 options
 Landfilling only Landfilling with Flaring to Burn Methane
 Landfilling with Energy Recovery

Clear All User Overrides

Project	Defaults	User Override
Average Round Trip Truck Haul Distance (miles):	40.00	
Solid Waste Truck Capacity (tons):	15.00	
Round Trips/Year:	2,309.96	
Miles per Year:	92,398.45	

	Units	Estimated Solid Waste Generation Rate (tons/residence/year)	Estimated Solid Waste Generation/Year (tons)	User Override of Solid Waste Generated/Year (tons)
PROJECT Residential Land Use (From URBEMIS)				
Single Family Residential	333.00	2.23	743.25	
Multi-Family Residential	666.00	1.17	779.22	
	Square Footage	Estimated Solid Waste Generation	Estimated Solid Waste Generation/Year	User Override of Solid Waste Generated/Year

User Must Select Landfill Option

User Can Override Landfill Default Values

Figure 6. Solid Waste Data Entry Options

In addition to selecting the correct landfill treatment option, the BGM user has the option of overriding some of the default data used by BGM. The default data can be overridden by entering information in the peach tabs. The default values that can be overridden are: 1) truck hauling load size and distance and 2) BGM's estimates of solid waste that would be generated for each land use.

Tabs that Generate No Emissions or Emission Reductions Without User Input

Five of the tabs require that information be entered to either generate emissions - agriculture, off-road equipment, and refrigerants - or to mitigate emissions - sequestration and mitigation. Many projects may not include any agricultural sources, off-road equipment, or refrigeration equipment. For those projects, these tabs may not be relevant to your project and can be ignored.

Ag(riculture)

The agriculture tab can be used to estimate emissions from livestock, from fuel combustion associated with equipment operation, from electricity use, and from fertilizer application. Since there is no information imported from URBEMIS that can be used to estimate agricultural emissions, the user must enter that information. The user must enter the number of animals (if applicable) as shown in Figure 7. If the project includes agricultural fuel use, electricity use, and/or fertilizer application, then those amounts must also be entered, as shown in Figure 8. The cells highlighted in yellow within the ag tab show the locations where data must be entered to generate emissions.

Agriculture

Baseline is currently: OFF

Agriculture			
	Project	Baseline	Project - Baseline
CO2 metric tons/year:	7.730	0.00	
CH ₄ metric tons/year:	102.889	0.00	
N ₂ O metric tons/year:	0.713	0.00	
CO ₂ e metric tons/year:	2,389.34	0.00	
CO ₂ e metric tons/year:			2,389.34

PROJECT Animals	Animals	Enteric Fermentation Methane Emissions (metric tons/year)	Manure Emission Rates (metric tons methane per year)	Manure Emission Rates (metric tons N ₂ O/year)
Beef Cattle	1,200	102.67	0.2216	0.0000
Beef Replacement Heifers		0.00	0.0000	0.0000
Steers		0.00	0.0000	0.0000
Bulls		0.00	0.0000	0.0000
Milk Cows		0.00	0.0000	0.0000
Dry Cows		0.00	0.0000	0.0000
Heifers, 15-24 months		0.00	0.0000	0.0000
Heifers, 7-14 months		0.00	0.0000	0.0000
Heifers, 4-6 months		0.00	0.0000	0.0000
Calves		0.00	0.0000	0.0000
Chickens (fryers)		0.00	0.0000	0.0000
Goats, Hogs, Pigs		0.00	0.0000	0.0000
Sheeps and Lambs		0.00	0.0000	0.0000
Turkeys		0.00	0.0000	0.0000
Totals	1,200	102.67	0.22	0.00

Figure 7. Agricultural Data Entry for Number of Animals

PROJECT Agricultural Equipment	gallons/year	CO2 (metric tons/yr)	CH4 (metric tons/yr)	N2O (metric tons/yr)	CO2e (metric tons/year)
Gasoline	100.00	0.79	0.00	0.00	0.80
Diesel Fuel	250.00	2.28	0.00	0.00	2.30
Propane	200.00	1.15	0.0000	0.0001	1.17
		4.22	0.00	0.00	4.28

PROJECT Stationary Combustion	gallons/year	CO2 (metric tons/yr)	CH4 (metric tons/yr)	N2O (metric tons/yr)	CO2e (metric tons/year)
Gasoline		0.00	0.0000	0.0000	0.00
Diesel Fuel	150.00	1.52	0.0002	0.0000	1.53
Propane		0.00	0.0000	0.0000	0.00
		1.52	0.0002	0.0000	1.53

PROJECT Electricity	kwh/year	CO2 (metric tons/yr)	CH4 (metric tons/yr)	N2O (metric tons/yr)	CO2e (metric tons/year)
Electricity Consumption (kwh/year)	5,000.00	1.9934	0.0000	0.0000	2.00

PROJECT Fertilizer	Tons/year	CO2 (metric tons/yr)	CH4 (metric tons/yr)	N2O (metric tons/yr)	CO2e (metric tons/year)
Fertilizer Used (tons/year)	50.00	0.00	0.00	0.71	220.88

Figure 8. Agricultural Data Entry Areas for Fuel Use, Electricity Use, and Fertilizer Application

Off Road Equipment

Like the agriculture tab, no information is available from URBEMIS that can be used to estimate off-road equipment emissions associated with project operation. (URBEMIS only generates emissions for off-road equipment in its construction phase.) Certain land uses, however, may use off-road equipment during their normal course of operations. For example, an industrial facility may use forklifts and/or generators during the normal course of business activity. For these situations, the off-road equipment tab can be used to estimate emissions. The user will need to enter the annual gallons used per year of diesel, gasoline, and/or propane. This information is entered in the cells highlighted in yellow, as shown in Figure 9.

Off-Road Equipment

Baseline is currently: OFF

	Project			Total
	Gasoline	Diesel Fuel	Propane	
CO2 metric tons/year:	0.0000	0.0000	0.0000	0.00
CH4 metric tons/year:	0.0000	0.0000	0.0000	0.00
N2O metric tons/year:	0.0000	0.0000	0.0000	0.00
CO2e metric tons/year:	0.0000	0.0000	0.0000	0.00
CO2e metric tons/year:				

Off-Road Equipment (typically used in commercial and industrial activities, e.g., forklifts, compressors, etc.) (This does not include landscape maintenance equipment, which is accounted for in the area source calculation.)

PROJECT Fuel Use	Total Gallons Used per Year
Gasoline	
Diesel Fuel	
Propane	

Figure 9. Off-Road Equipment Fuel Use Data Entry

Refrigerants

Certain land uses like grocery stores and some industrial users have large refrigeration systems. Like the agriculture and off-road equipment tabs, BGM will not estimate refrigerant-related GHG emissions unless the user enters project specific information.

The user must enter the amount of refrigerant charge (pounds of refrigerant) required for the project's refrigeration and air conditioning systems (see Figure 10). These areas are highlighted as yellow cells. With that information, and default information on leakage rates, BGM estimates the amount of refrigerant that leaks per year. The user has the option of overriding BGM's estimate of the amount of refrigerant leaked per year by entering an override amount in the cells highlighted in peach. BGM also includes an estimate of the global warming potential of the refrigerants, which it multiplies by the leakage amount to generate estimates of GHG emitted. If the user knows the type of refrigerant that will be used, then the global warming potential (GWP) of that refrigerant should be entered in the User Override of GWP cell(s), also highlighted in peach.

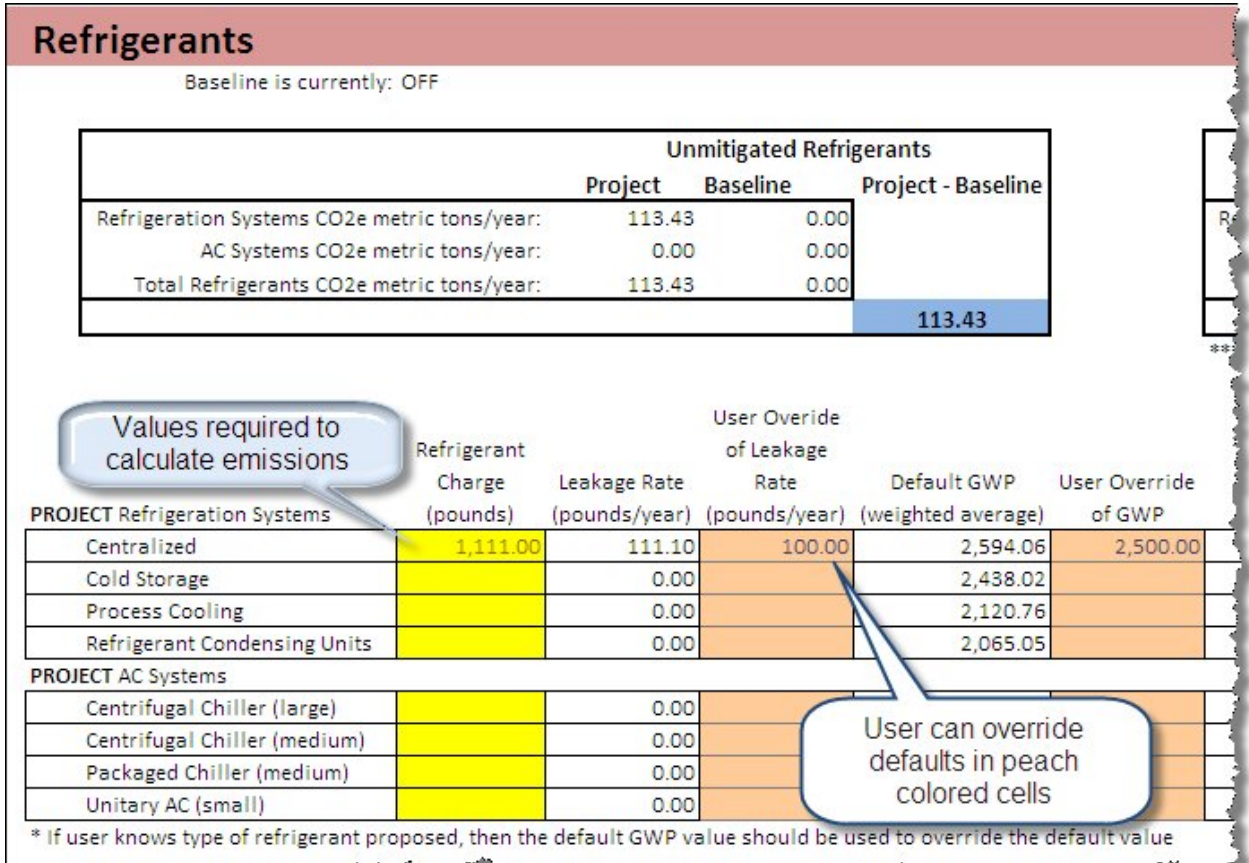


Figure 10. Refrigerant User Data Entry and Override Options

Mitigation

The mitigation tab allows the user to select specific mitigation measures that apply to their project. Each of the mitigation measures listed works in a similar manner. The user turns the measure on by clicking on the check box, and the user has the option of entering mitigation specific information for each measure. Although the mitigated emissions are summarized on the Summary tab, they are also shown in the Mitigation tab so that users can observe the effects of turning various mitigation measures on and off. The various mitigation measures are described below.

Transportation and Area Source Mitigation

Although mitigation can be specified for transportation and area sources, that mitigation must be specified within the URBEMIS model. It cannot be specified from within BGM. Within URBEMIS, if mitigation measures have been specified for transportation and/or area sources, then those mitigated emissions are also imported into BGM when the user selects the URBEMIS input file from within the BGM Settings tab. The list of transportation-related mitigation measures selected within URBEMIS is shown in the Transp(ortation) Detail Mit(igation) tab.

Electricity and Natural Gas Mitigation

Figure 11 shows BGM’s mitigation options for electricity and natural gas. To select a mitigation measure, the user must click on the box to turn it on. In addition, the user should enter the amount of gas reduced (MMBtu/year) and/or electricity reduced (kwh/year) for each measure

selected. One measure, cool roofs/green roofs, allows the user to enter both the annual change in electricity and natural gas use. This is because studies have shown that while cool roofs reduce electricity demand during the summer months, they increase natural gas demand during the winter months.

Electricity & Natural Gas	<input type="checkbox"/>			
	<input type="checkbox"/>	Solar Water Heater	5000	
	<input type="checkbox"/>	Tankless Water Heater	5000	
	<input type="checkbox"/>	Cool Roofs/Green Roofs	5000	2
	<input type="checkbox"/>	Increase Energy Efficiency Beyond Title 24	10	
	<input type="checkbox"/>	Onsite Renewable Energy Systems - Solar	5000	
	<input type="checkbox"/>	Onsite Renewable Energy Systems - Wind	5000	
<input type="checkbox"/>	Onsite Renewable Energy Systems - Other	5000		

Figure 11. Electricity and Natural Gas Mitigation Measures

Water and Wastewater Mitigation

Figure 5 shows the two mitigation measures that apply to water and wastewater. The user has the option of turning these two options on and changing the % of water use reduction for each measure. As is evident by Figure 12, the drought tolerant landscaping measure only reduces outdoor water use, while low flush toilets only reduce indoor water use.

Water and Wastewater	<input type="checkbox"/>	Drought Tolerant Landscaping	10
	<input type="checkbox"/>	Low Flush Toilets	2

Figure 12. Water and Wastewater Mitigation

Solid Waste Mitigation

Currently, BGM only includes one mitigation measure for solid waste (Figure 13). That measure reduces the amount of solid waste generated by a project. To apply this measure, the user must click the check box to turn it on and enter the percentage reduction that applies.

Solid Waste			Solid Waste Reduction %
	<input type="checkbox"/>	Reduce Solid Waste by the Following Percentage	10

Figure 13. Solid Waste Mitigation

Agriculture and Off-Road Mitigation

For the agricultural and off-road categories, BGM does not currently include any mitigation measures.

Refrigerants Mitigation

For the refrigerants category, BGM only includes one mitigation measure (Figure 14). This measure would replace the use of CFCs and HCFCs with ammonia, which results in a 100% reduction.

Refrigerants			% Reduction
	<input type="checkbox"/>	Use Ammonia Instead of CFCs or HCFCs	100

Figure 14. Refrigerant Mitigation

Offsets Mitigation

One final mitigation measure is included in BGM: Purchase Emission Offsets/Credits. To use this measure, the user must click the check box and specify the metric tons of carbon dioxide equivalent (CO₂e) per year that will be offset (see Figure 15).

Offsets / Credits			Metric Tons CO ₂ e/Year
	<input type="checkbox"/>	Purchase Emission Offsets / Credits	5000

Figure 15. Offsets/Credit Mitigation Option

Step 4. View Results

The results tab includes both a summary and a detailed results section.

The summary section shows unmitigated minus baseline emissions (CO₂e/year) and mitigated minus baseline emissions in table and graphical format, as shown in Figure 16. This graph allows the user to quickly see which emission categories contribute the most to GHG emissions. The graph also shows how efficient the various mitigation measures are at reducing GHG emissions.

The results tab also includes a detailed section that shows emissions for each emission category. Three tables are listed, unmitigated, mitigated, and baseline conditions. For each of these tables, carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O) and CO₂e emissions are listed. Also, for the mitigation emissions, each mitigation measure that has been selected is shown below the mitigated results table.

Summary Results

Project Name: alameda

Project and Baseline Years: 2040 N/A

Results	Unmitigated Project-Baseline CO2e (metric tons/year)	Mitigated Project-Baseline CO2e (metric tons/year)
Transportation:	172,750.72	80,318.41
Area Source:	531.73	531.73
Electricity:	46,326.85	46,326.85
Natural Gas:	11,310.30	11,310.30
Water & Wastewater:	743.76	743.76
Solid Waste:	22,326.39	22,326.39
Agriculture:	0.00	0.00
Off-Road Equipment:	0.00	0.00
Refrigerants:	113.43	113.43
Sequestration:	N/A	0.00
Purchase of Offsets:	N/A	0.00
Total:	254,103.18	161,670.88

Baseline is currently: OFF

Baseline Project Name:

Go to Settings Tab to Turn On Baseline

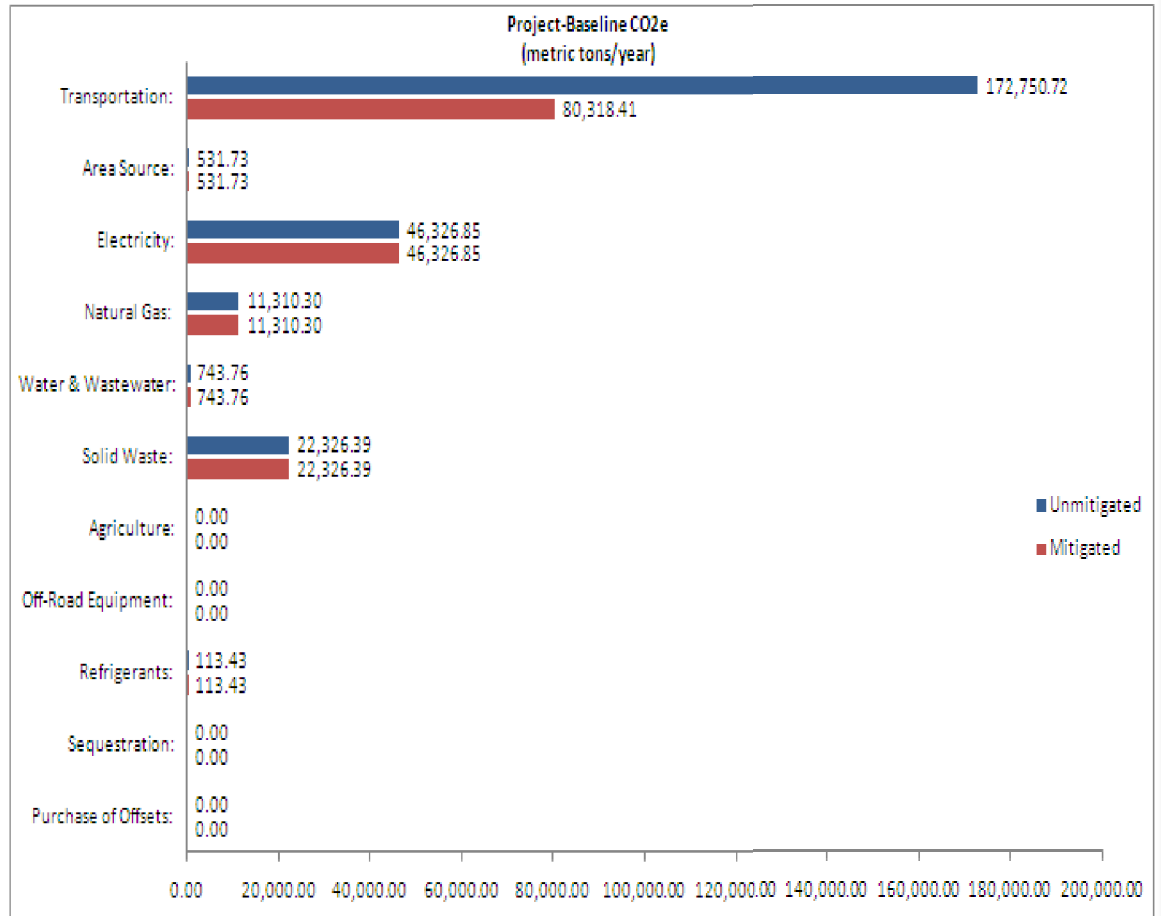


Figure 16. Summary Results

Section 2. How BGM Estimates GHG Emissions

Section 1 describes what the BGM user needs to do to generate GHG emissions using the BGM model. Section 2 describes how BGM generates those emissions. A separate discussion is included for each BGM tab that is used to estimate or mitigate emissions.

Transportation Tab

Within the transportation tab, BGM imports transportation emissions in tons of CO₂ per year as estimated by URBEMIS (see Figure 17).

Conversion from English to Metric

BGM first converts the URBEMIS value to metric tons CO₂ per year by multiplying by 2000 lbs/ton / 2204 lbs/metric ton.

Transportation			
Baseline is Currently: OFF			
Unmitigated Transportation	Target Year:	2040	2012
		Project	Baseline
Operational Emissions from URBEMIS (CO2 tons/year)		268,845.14	0.00
Metric Ton Adjustment (CO2 metric tons/year)		243,961.11	0.00
Pavley Regulation Adjustment (CO2 metric tons/year):		182,347.98	0.00
US EPA Adjustment (CO2e metric tons/year):		191,945.24	0.00
Low Carbon Fuels Rule Adjustment (CO2e metric tons/year)		172,750.72	0.00
Total (CO2e metric tons/year):			172,750.72

Figure 17. Transportation Emission Screen

Pavley Regulation Adjustment

In the next step, BGM adjusts transportation emissions to account for the Pavley regulations. The Pavley regulations reduce GHG emissions in light duty autos and trucks, and medium duty trucks from 2009 through 2016. Consequently, the Pavley emission reductions are only applied to a percentage of the total vehicle fleet. They do not affect other vehicles, such as heavy duty vehicles, buses, and motorcycles.

Table 1 shows the emission reduction percentages applied to light duty autos (LDA), light duty trucks (LDT1 and LDT2) and medium duty vehicles (MDV) by year applied.

Table 1. Pavley Percentage GHG Reductions by Year and Vehicle Class

Year	% CO₂ Reduction - LDA	% CO₂ Reduction - LDT1	% CO₂ Reduction - LDT2	% CO₂ Reduction MDV
2009	0.00%	0.00%	0.07%	0.08%
2010	0.35%	0.25%	0.45%	0.48%
2011	1.75%	1.34%	1.31%	1.29%
2012	4.07%	3.27%	2.60%	2.44%
2013	6.31%	5.26%	3.88%	3.61%
2014	8.48%	7.26%	5.17%	4.83%
2015	10.74%	9.38%	6.54%	6.17%
2016	12.96%	11.56%	7.94%	7.54%
2017	15.03%	13.58%	9.27%	8.88%
2018	16.94%	15.43%	10.54%	10.16%
2019	18.72%	17.13%	11.74%	11.40%
2020	20.37%	18.69%	12.89%	12.59%
2025	26.87%	24.86%	17.60%	17.42%
2030	30.60%	28.71%	20.63%	20.47%
2035	32.38%	31.17%	22.43%	22.29%
2040	33.27%	32.61%	23.60%	23.53%

The information in Table 1 was estimated using the Pavley 1-LCFS post-processor developed by the California Air Resources Board (2010). To run the post-processor, separate EMFAC2007 Burden runs were made for the BAAQMD for the years 2009-2020,2025,2030,2035, and 2040. Each of these years was then read by the Pavley 1-LCFC post-processor to obtain weekday CO₂ emissions for each of the four vehicle classes in Table 1.

Table 2 shows the post-processor results for 2010. The Pavley regulations would reduce 2010 BAAQMD CO₂ emissions by 0.35% for LDA, by 0.25% for LDT1, by 0.45% for LDT2, and by 0.48% for MDV. Calculations similar to those shown in Table 2 were made for each year included in the BGM. The BGM spreadsheet assumes that the percentage reductions as calculated for the entire BAAQMD would be the same for individual projects. This may not be the case if the user has changed the default fleet mix within URBEMIS. Consequently, the user should use caution if the default fleet mix has been changed within the URBEMIS model.

Table 2. Pavley Post-Processor Results for the BAAQMD in 2010

Vehicle Category	Weekday CO₂ Emissions from EMFAC (tons/day)	% CO₂ Emissions	Weekday CO₂ Emission Reduction from Pavley I (tons/day)	Annual CO₂ Emissions after adopting Pavley I & LCFS (MMT CO₂/year)	% CO₂ Emission Reduction from Pavley
LDA	39,805.91	41.72%	139.41	12.49	0.35%
LDT1	11,818.53	12.39%	29.80	3.71	0.25%
LDT2	18,646.46	19.54%	84.12	5.84	0.45%
MDV	9,165.16	9.61%	44.24	2.87	0.48%
Total	79,436.06	83.26%	297.57	24.91	0.37%
All other Cat	15,973.94	16.74%	0.00		0.00%
Grand Total	95,410.00	100.00%	297.57		0.31%

Source: California Air Resources Board, 2010

CO₂ to CO₂e Conversion

After the Pavley calculations have been made, BGM converts CO₂ emissions into CO₂e emissions to account for the U.S. EPA finding that GHG emissions from other pollutants – CH₄, N₂O, and refrigerants from leaking air conditions – account for 5% of total GHGs from vehicles, after each pollutant’s global warming potential has been taken into account (U.S. Environmental Protection Agency, 2005).

Low Carbon Fuels Rule Conversion

Finally, BGM adjusts transportation emissions to account for the Low Carbon Fuels Rule (LCFR). LCFR applies to all vehicles. Table 3 shows the emission reduction percentages applied as a result of the LCFR.

Table 3. Low Carbon Fuel Rule Percentage GHG Reductions

Year	% CO₂e Reduction Gasoline and Diesel Fuel
2010	0.00
2011	0.25
2012	0.50
2013	1.00
2014	1.50
2015	2.50
2016	3.50
2017	5.00
2018	6.50
2019	8.00
2020 - 2040	10.00
Source: California Air Resources Board, 2009a	

Area Source Tab

Area source emissions use as a starting point the area source emissions for hearths and landscape maintenance equipment as calculated by URBEMIS2007, version 9.2.4. The hearth and landscape maintenance CO₂ emissions (English tons per year) are imported from URBEMIS into the Area Source tab and converted to metric tons in the first line (see Figure 18).

The consumer product and architectural coatings categories in URBEMIS do not include any GHG emissions and, consequently, are not imported into BGM. Although the area source component of URBEMIS estimates natural gas-related CO₂ emissions, those emissions are not imported into BGM. Instead, natural gas related- CO₂ emissions are calculated in the Electricity and Natural Gas tab as explained in the following section.

Once BGM has imported hearth and landscape maintenance equipment, two additional calculations are made, both for hearth emissions. First, BGM estimates N₂O emissions associated with wood burning fireplaces and natural gas fireplaces (U.S. EPA, 1998, U.S. EPA, 1996a.) NO₂ emission factors are not available for wood burning stoves.

Then, CH₄ emissions are estimated for wood burning stoves and natural gas fireplaces (U.S. EPA 1998 and U.S. EPA 1996b). CH₄ emission factors are not available for wood burning fireplaces

Area Source			
Baseline is currently: OFF			
Unmitigated Area Source			Project-Baseline
	Project	Baseline	
Landscaping Emissions from URBEMIS (CO2 metric tons/year):	13.648	0.000	
Hearth Emissions from URBEMIS (CO2 metric tons/year):	479.347	0.000	
Wood Burning Fireplaces (N2O metric tons/year):	0.005	0.000	
Natural Gas Fireplaces (N2O metric tons/year):	0.003	0.000	
Wood Burning Stoves (CH4 metric tons/year):	1.722	0.000	
Natural Gas Fireplaces (CH4 metric tons/year):	0.004	0.000	
Total (CO2e metric tons/year):	531.732	0.000	
Total (CO2e metric tons/year):			531.732

Figure 18. Area Source Emissions

Electricity & Natural Gas Tab

In the electricity/natural gas tab, GHG emissions are calculated using a two step process. First, BGM estimates the amount of electricity and natural gas for each land use. If the user has a better estimate of electricity and/or natural gas use, then BGM's estimates can be overridden.

Once the user is satisfied with the electricity and natural gas values, GHG emissions associated with that energy use are calculated.

Step 1 – Estimate Electricity and Natural Gas Use

BGM imports project specific information directly from URBEMIS, specifically the size of each land use: number of single family and multi-family units and the square footage of non-residential land uses.

Within this tab, the user must enter the climate zone in which the project is located. Figure 19 shows that the BAAQMD is located within climate zones 4 and 5.

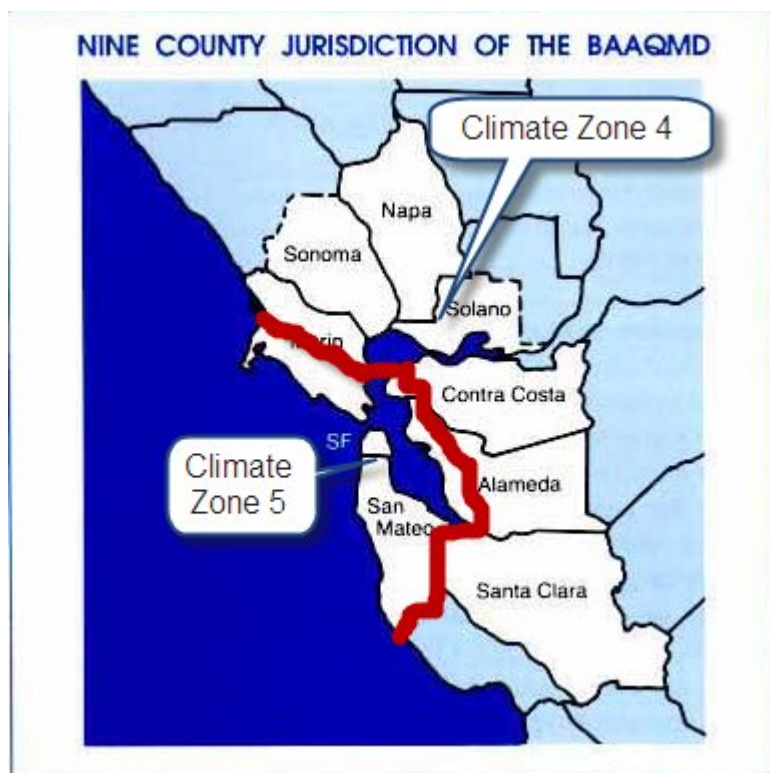


Figure 19. Climate Zones within the California Commercial End-Use Survey

Electricity and Natural Gas Use - Residential

BGM estimates average residential electricity and natural gas use based on the California Residential Appliance Saturation Study. The results of this study were used to estimate energy use for the average single family and multi-family residence. The data was sufficient to estimate average electricity use for the two housing types for the two climate zones (Table 4). However, for natural gas use, separate use estimates were not available for the two climate zones.

Electricity and Natural Gas Use – Non-Residential

To estimate non-residential electricity and natural gas use, BGM uses the California Commercial End-Use Survey, published by the California Energy Commission (2006). The survey contains natural gas (and electricity) consumption data by major utility and climate zone, and by commercial end use.

Table 4. Average Residential Electricity Use by Climate Zone

	Single Family Residential	Multi-Family Residential
Electricity Use – Climate Zone 4	7415 kwh/year	4434 kwh/year
Electricity Use – Climate Zone 5	6047 kwh/year	3685 kwh/year
Natural Gas Use – Climate Zones 4 and 5	49.6 MMBtu/year	22.5 MMBtu/year

The California Commercial End-Use Survey includes an online database that allows the user to estimate average natural gas and electricity use for any of California’s 15 climatic zones, and for any of several building types within each zone. Using this database, BGM estimates average natural gas and electricity use data for individual climate zones, and for individual land uses within each climate zone. Table 5 shows the electricity and natural gas usage rates by land use and climate zone as derived from the California Commercial End-Use Survey.

Table 5. Electricity and Natural Gas Usage Rates by Land Use and Climate Zone

	Climate Zone 4 Summary		Climate Zone 5 Summary	
	Electric (kwh/sf)	Natural Gas (kBtu/sf)	Electric (kwh/sf)	Natural Gas (kBtu/sf)
All Commercial	13.6	29.49	13.2	31.7
Small Office (<30,000 sf)	17.4	9.7	14.5	30.0
Large Office (>= 30,000 sf)	23.5	26.4	15.2	23.3
Restaurant	36.0	212.5	31.4	171.1
Retail	12.8	3.0	12.6	5.5
Food Store	44.3	25.8	40.3	41.4
Refrigerated Warehouse	10.1	3.9	24.9	18.7
Unrefrigerated Warehouse	4.3	4.4	4.6	1.7
School	6.7	22.7	5.5	19.6
College	9.8	27.5	12.7	41.8
Health	23.0	118.7	18.4	110.7
Lodging	9.3	47.0	10.0	39.1
Miscellaneous	9.8	29.7	9.0	27.2
All Offices	21.3	20.5	15.1	24.3
All Warehouses	5.8	4.3	7.7	4.3

BGM uses this CEC database to estimate natural gas use for each land use type within URBEMIS. The one problem with this approach is that the land use types in URBEMIS do not

perfectly match those in the CEC database. The CEC database includes the following fifteen land uses:

1. All Commercial
2. Small Office (<30,000 sf)
3. Large Office (>=30,000 sf)
4. Restaurant
5. Retail
6. Food Store
7. Refrigerated Warehouse
8. Unrefrigerated Warehouse
9. School
10. College
11. Health
12. Lodging
13. Miscellaneous
14. All Offices
15. All Warehouses

In contrast, URBEMIS contains 43 non-residential land uses. Table 6 shows the CEC database categories that BGM uses to estimate electricity and natural gas use for each land use.

Table 6. CEC Database Category Used to Estimate Energy Use for Each URBEMIS Non-Residential Land Use

URBEMIS Land Use	CEC Commercial Use Category Used to Estimate BGM Electricity and Natural Gas Use
Day-Care Center	School
Elementary School	School
Junior High School	School
High School	School
Junior College	College
University/College	College
Library	Small Office
Place of Worship	Miscellaneous
City Park	Miscellaneous
Racquet Club	Retail
Racquetball/Health	Retail
Quality Restaurant	Restaurant
High Turnover/Sit-Down Restaurant	Restaurant
Fast Food w/Drive Through	Restaurant
Fast Food w/o Drive Through	Restaurant

Hotel	Lodging
Motel	Lodging
Free-Standing Discount Store	Retail
Free-Standing Discount Superstore	Retail
Discount Club	Retail
Regional Shopping Center	Retail
Electronic Superstore	Retail
Home Improvement Superstore	Retail
Strip Mall	Retail
Hardware/Paint Store	Retail
Supermarket	Food Store
Convenience Market	Food Store
Convenience Market w/gas pumps	Food Store
Gasoline Service Station	Retail
Bank w/Drive Through	Small Office
General Office Building	Large Office
Office Park	Large Office
Government Office Building	Large Office
Government Civic Center	Large Office
Pharmacy w/Drive Through	Retail
Pharmacy w/o Drive Through	Retail
Medical Office Building	Health
Hospital	Health
Warehouse	All Warehouses
General Light Industry	All Warehouses
General Heavy Industry	All Warehouses
Industrial Park	All Warehouses
Manufacturing	All Warehouses

The BGM user has the option of overriding BGM's estimate of electricity and natural gas use.

Step 2 – Estimate GHG Emissions Based on Electricity and Natural Gas Use

Once electricity and natural gas use has been estimated, BGM estimates GHG emissions using CO₂, CH₄, and N₂O emission factors. BGM uses California electricity and natural gas GHG emission factors as reported in the California Climate Action Registry's General Reporting Protocol, version 2.2 (2009). The resulting emissions are then converted to CO₂e.

Water Use Tab

BGM estimates GHG emissions associated with water use in a three step process.

Step 1- Estimate Water Use

In the first step, BGM estimates the amount of water that a project would use and allocates this between indoor and outdoor use.

To estimate water use, URBEMIS land use information is imported into the water use tab. For single family and multi-family residential units, water use is estimated by multiplying the number of residential units by the average persons per unit and by the average gallons consumed per capita. The average persons per unit can be modified by the user. Water use estimates are summarized in Table 7. The project year is used to identify the correct water use values

For non-residential land uses, the information in Table 7 is also used to estimate water use, except that the square footage must be converted to number of employees. Table 8 shows the values used to convert building square footage into the number of employees. Table 8 also shows the URBEMIS land uses that were assumed to match the employee per square foot values. BGM allows the user to overwrite the square footage per employee.

Table 7. Water Use Estimates with the San Francisco Area

Year	Single Family (gallons a day/ capita)	Multi-family (gallons a day/ capita)	Non-Res (gallons a day/ employee)
2001	108.00	75.00	86.00
2002	107.79	74.72	85.97
2003	107.59	74.45	85.93
2004	107.38	74.17	85.90
2005	107.17	73.90	85.86
2006	106.97	73.62	85.83
2007	106.76	73.34	85.79
2008	106.55	73.07	85.76
2009	106.34	72.79	85.72
2010	106.14	72.52	85.69
2011	105.93	72.24	85.66
2012	105.72	71.97	85.62
2013	105.52	71.69	85.59
2014	105.31	71.41	85.55
2015	105.10	71.14	85.52
2016	104.90	70.86	85.48
2017	104.69	70.59	85.45
2018	104.48	70.31	85.41

2019	104.28	70.03	85.38
2020	104.07	69.76	85.34
2021	103.86	69.48	85.31
2022	103.66	69.21	85.28
2023	103.45	68.93	85.24
2024	103.24	68.66	85.21
2025	103.03	68.38	85.17
2026	102.83	68.10	85.14
2027	102.62	67.83	85.10
2028	102.41	67.55	85.07
2029	102.21	67.28	85.03
2030	102.00	67.00	85.00
Source: URS Corporation and Maddeaus Water Management, 2004.			

Table 8. Land Use Types and Square Feet per Employee

Land Use Type	Square Feet per Employee	URBEMIS Land Use
Warehouse	1,700.00	Warehouse, General Light Industry, General Heavy Industry, Industrial Park, Manufacturing
Public Assembly	1,300.00	City Park
Lodging	1,300.00	Hotel, Motel
Food Sales	1,000.00	Supermarket, Convenience Market, Convenience Market w/Gas Pumps
Retail and Service	900.00	Racquetball Club, Racquetball/Health, Free-Standing Discount Store, Free-Standing Discount Superstore, Discount Club, Regional Shopping Center, Electronic Superstore, Home Improvement Superstore, Strip Mall, Bank w/Drive Through, Pharmacy w/Drive Through, Pharmacy w/o Drive Through
Education	766.00	Day Care Center, Elementary School, Junior High, High School, Junior College, University/College/Library
Food Service	600.00	Quality Restaurant/High Turnover Sit-Down Restaurant, Fast Food w/Drive Through, Fast Food w/o Drive Through
Other	550.00	Place of Worship, Gasoline Service Station
Health Care	500.00	Medical Office Building, Hospital
Office	400.00	General Office Building, Office Park, Government Office Building, Government Civic Center
Source: Energy Information Administration, 1995.		

Once BGM estimates water use, the user has the option of overriding those water use estimates. Then, using the water use estimates, BGM estimates the amount of indoor versus outdoor water use using the percentages shown in Table 9.

Table 9. Indoor versus Outdoor Water use Percentages

Indoor vs. Outdoor Water Use			
Year	Indoor	Outdoor	Total
2001-2005	0.64	0.36	1.00
2006-2015	0.63	0.37	1.00
2016-2025	0.62	0.38	1.00
2026-2030	0.61	0.39	1.00

Source: URS and Maddaus Water Management, 2004

Step 2. Estimate Electricity Demand Resulting from Water Use

Once water use has been entered, BGM estimates the electricity demand associated with that use. The emission rates applied to water use are based on a report prepared for the California Energy Commission (Navigant, 2006). Table 10 summarizes the electricity associated with water use. For BGM, the Northern California water energy values are used.

Step 3. Estimate GHG Emissions Associated with Electricity Demand

Once electricity use associated with indoor and outdoor uses have been estimated, BGM estimates the GHGs associated with that electricity use using the same GHG emission factors as described in the Electricity and Natural Gas discussion.

Table 10. Energy Use Associated with Water and Wastewater Consumption

	Indoor Uses		Outdoor Uses	
	Northern California kWh/MG	Southern California kWh/MG	Northern California kWh/MG	Southern California kWh/MG
Water Supply and Conveyance	2,117	9,727	2,117	9,727
Water Treatment	111	111	111	111
Water Distribution	1,272	1,272	1,272	1,272
Wastewater Treatment	1,911	1,911	0	0
Regional Total	5,411	13,022	3,500	11,111

Solid Waste Tab

For solid waste, BGM uses the U.S. EPA WARM model emission factors to estimate GHG emissions.

BGM uses a two step process. In the first step, BGM estimates the amount of solid waste that the project will generate. In the second step, BGM estimates the GHG emissions associated with that solid waste. Each step is described below.

Step 1 – Estimate Solid Waste Generation

BGM estimates solid waste generation using the land use types and sizes for a project as imported from URBEMIS. BGM includes information on the tons of solid waste generated per single family and multi-family residence and per square foot of non-residential land use. For single family units, solid waste generation was based on a disposal rate of 0.42 tons per resident per year times an average of 2.94 residents per unit. For multi-family units, the solid waste generation was based on an estimate of 0.46 tons per residential unit per year (CalRecycle, 2010a).

For non-residential land uses, BGM uses the solid waste generation rates shown in Table 11.

The user has the option of overriding BGM's estimates of solid waste generation.

Table 11. Non-Residential Solid Waste Generation Rates

PROJECT Nonresidential Land Use (From URBEMIS)	Estimated Solid Waste Generation Rate (tons/sf/yr)	Source:
Day-Care Center; Elementary School, Junior High School, High School, Junior College, University/College, Library, Place of Worship	0.0013	CalRecycle, 2010j
City Park	0.0000	No available source
Racquet Club, Racquetball/Health	0.0057	CalRecycle, 2010k
Quality Restaurant, High Turnover/Sit-Down Restaurant, Fast Food w/Drive Through, Fast Food w/o Drive Through	0.0009	CalRecycle, 2010i
Hotel, Motel	0.0108	CalRecycle, 2010h
Free-Standing Discount Store, Free-Standing Discount Superstore, Discount Club, Regional Shopping Center, Electronic Superstore, Home Improvement Superstore	0.0046	CalRecycle, 2010e
Strip Mall, Hardware/Paint Store, Convenience Market, Convenience Market w/gas pumps, Gasoline Service Station, Pharmacy w/Drive Through, Pharmacy w/o Drive Through	0.0024	CalRecycle, 2010g
Supermarket	0.0057	CalRecycle, 2010e
Bank w/Drive Through, General Office Building, Office Park, Government Office Building, Government Civic Center	0.0108	CalRecycle, 2010f
Medical Office Building, Hospital	0.0108	CalRecycle, 2010d.
Warehouse, Manufacturing	0.0026	CalRecycle, 2010b
General Light Industry, General Heavy Industry, Industrial Park	0.0011	CalRecycle, 2010c

BGM uses a project’s solid waste generation to estimate the amount of truck hauling needed to dispose of this waste in a landfill. BGM estimates the amount of truck hauling required based on the amount of waste generated per year, the average round trip haul distance, and the truck hauling capacity. The user has the option of overriding the round trip haul distance and truck hauling capacity. Using either the BGM default or user override values, BGM estimates the total truck vehicle miles traveled (VMT) per year for the project.

Step 2. Estimate Solid Waste GHG Emissions

The solid waste GHG emissions include two components: truck hauling emissions and emissions resulting from the decomposition of solid waste.

Truck Hauling Emission Estimates

Truck hauling emissions use the VMT estimates described in Step 1 and multiply them by EMFAC2007 emission rates for heavy heavy-duty trucks. An EMFAC2007 modeling run was

used to estimate CO₂ and CH₄ emissions in grams per mile for trucks traveling at an average speed of 35 mph. Truck emissions also account for the Low Carbon Fuels Rule (California Air Resources Board, .

Solid Waste Decomposition Emission Estimates

BGM uses the U.S. EPA WARM Model emission rates for mixed solid waste decomposition. Those rates equal 3.1 metric tons of CO₂e per short ton of solid waste that is landfilled, assuming no recovery, 0.64 tons CO₂e per short ton, assuming landfilled waste with flaring, and 0.3 tons CO₂e per short ton, assuming landfilled waste with energy recovery (U.S. EPA, 2009a).

Agriculture Tab

The agriculture tab allows users to enter information that BGM uses to generate GHG estimates. If no information is entered, then agricultural emissions are assumed to equal zero GHGs.

The ag tab allows users to estimate:

- enteric and manure emissions from livestock,
- fuel emissions associated with mobile source and stationary equipment,
- electricity emissions, and
- emissions associated with fertilizer application.

Livestock Emissions

To estimate livestock emissions, the BGM user must enter the number of animals in each of the categories as shown in Table 12. With the livestock numbers, and enteric and manure emission factors, BGM estimates the enteric emissions and manure-related emissions associated with livestock. Table 13 shows the enteric and manure emission factors used.

Table 12. Livestock Data Entry Form

PROJECT Animals	Number of Animals	Enteric Fermentation Methane Emissions (metric tons/year)	Manure Emission Rates (metric tons methane per year)	Manure Emission Rates (metric tons N ₂ O /year)
Beef Cattle	11.00	0.94	0.02	0.00
Beef Replacement Heifers		0.00	0.00	0.00
Steers		0.00	0.00	0.00
Bulls		0.00	0.00	0.00
Milk Cows		0.00	0.00	0.00
Dry Cows		0.00	0.00	0.00
Heifers, 15-24 months		0.00	0.00	0.00
Heifers, 7-14 months		0.00	0.00	0.00
Heifers, 4-6 months		0.00	0.00	0.00
Calves		0.00	0.00	0.00
Chickens (fryers)		0.00	0.00	0.00

PROJECT Animals	Number of Animals	Enteric Fermentation Methane Emissions (metric tons/year)	Manure Emission Rates (metric tons methane per year)	Manure Emission Rates (metric tons N₂O /year)
Goats, Hogs, Pigs		0.00	0.00	0.00
Sheep and Lambs	0.00	0.00	0.00	0.00
Turkeys	0.00	0.00	0.00	0.00
Totals	11.00	0.94	0.02	0.00

Table 13. Enteric Fermentation and Manure Emission Rates

Animal Type	Enteric Fermentation Emission Rates (metric tons CH₄/head/yr)	Manure Emission Rates (metric tons CH₄/head/yr)	Manure Emission Rates (metric tons N₂O /head/yr)
Beef Cattle	0.085556	0.002158	0.000000
Beef Replacement Heifers	0.066208	0.001914	0.000000
Steers	0.033349	0.001470	0.000000
Bulls	0.053000	0.002793	0.000000
Milk Cows	0.116520	0.164125	0.000738
Dry Cows	0.116520	0.165125	0.000738
Heifers, 15-24 months	0.067047	0.002210	0.001620
Heifers, 7-14 months	0.042376	0.002210	0.001620
Heifers, 4-6 months	0.042376	0.002210	0.001620
Calves	0.042376	0.002210	0.001620
Chickens (fryers)	0.000000	0.000018	0.000002
Goats, Hogs, Pigs	0.001500	0.028228	0.000141
Sheep and Lambs	0.008000	0.000781	0.000002
Turkeys	0.000000	0.000086	0.000010

Agricultural and Stationary Equipment

The ag tab also allows users to estimate the amount of agricultural equipment emissions and stationary equipment emissions associated with their project. To estimate emissions for these two categories, the user must enter the gallons of diesel fuel, gasoline, and propane that will be burned per year. With that information, BGM uses emission factors developed by the California Climate Action Registry (2009) to estimate metric tons of CO₂e emitted per year. Similarly, for BGM to estimate electricity-related GHG emissions, the user must enter the amount of electricity consumed per year. BGM uses electricity related emission factors developed by the California Climate Action Registry (2009) to estimate metric tons of CO₂e emitted per year.

The gasoline and diesel fuel use estimates assume the Low Carbon Fuel Standard will apply to these fuels.

Fertilizer Emissions

Finally, to estimate the amount of fertilizer (N₂O) emissions emitted per year, the user must enter the tons of fertilizer applied annually.

Off-Road Equipment Tab

Certain types of commercial and industrial land uses may use off-road equipment during their normal course of operations. Equipment such as fork lifts, generators, pumps, or compressors are commonly used in certain industries. The off-road equipment tab allows the user to quickly estimate GHG emission from off-road equipment.

User input is required to estimate off-road equipment emissions. The user must enter into BGM the annual fuel use – gasoline, diesel, and/or propane - for all off-road equipment. With that information, BGM estimates the GHG emissions using emission factors developed by the California Climate Action Registry (2009), now called the Climate Registry.

BGM estimates GHG emissions using fuel use, and adjusts the resulting emissions to account for the LCFS. The LCFS applies to gasoline and diesel combustion, but not to propane.

Refrigerants Tab

Many types of commercial and industrial land uses require refrigeration or air conditioning (A/C) equipment as part of their normal course of operations. These systems require refrigerants to operate. In most cases, these refrigerants have a high GWP. Refrigerant leaks can contribute to a project's GHG emissions.

BGM calculates GHG emissions by first multiplying refrigerant charge by the annual leakage rate. The resulting annual refrigerant leakage is then multiplied by the refrigerant's GWP to estimate CO₂e.

BGM does not attempt to guesstimate the amount of refrigerant charge for a project. Consequently, the user must enter information on refrigerant charge, otherwise BGM will not estimate GHG emissions for the refrigerant category. The user must enter the quantity of refrigerant charge in the correct category or categories of the eight categories listed. These eight categories include four refrigeration system categories – centralized, cold storage, process cooling, and refrigerant condensing units – and four AC system categories – centrifugal chiller (large), centrifugal chiller (medium), packaged chiller (medium), and unitary AC (small).

BGM assumes default leakage rates for each of these eight categories. Those leakage rates are based on the California Air Resources Board's Refrigerant Management Program rule, slated to take effect on January 2011. The leakage rates can be found in the California Air Resources Board's Appendix B. California Facilities and Greenhouse Gas Emissions Inventory – High-Global Warming Potential Stationary Source Refrigerant Management Program (California Air

Resources Board, 2008). The user can override the total leakage per year. The leakage rates found in the ARB staff report are summarized in Table 14.

Table 14. Refrigerant Leakage Rates Associated with ARB’s Proposed Refrigerant Management Program Rule

Refrigeration Systems		Default Leak Rate (%)	
		Centralized (large and medium)	10.00
	Cold Storage (large and medium)	10.00	
	Process Cooling (medium)	7.00	
	Refrigerant Condensing Units (small)	5.00	
AC Systems			
		Centrifugal Chiller (large)	2.00
		Centrifugal Chiller (medium)	1.00
		Packaged Chiller (medium)	3.50
	Unitary AC (small)	5.00	

BGM also includes default GWP estimates for each of the eight system categories (see Table 15). Those default values are averages for each category taken from Table 5 of the California Air Resources Board staff report (2008). The ARB report shows how refrigerant use is estimated to change between 2010 and 2020. This change is reflected in the default GWP estimated by BGM. Changing the year of the analysis also changes the GWP used by BGM. If the user knows the refrigerant that will be used however, they have the option of overriding the default GWP used by BGM.

Table 15. Weighted Global Warming Potential by Type of Refrigerant

Refrigerant Distribution	Refrigerant Type	Global Warming Potential	2010
Centralized Systems		GWP	% of Total
	HCFC-22	1,500	42.20
	R-404A	3,260	39.70
	R-507	3,300	18.10
	Weighted GWP		2,524.52
Cold Storage			
	CFC-12	8,100	2.00
	HCFC-22	1,500	56.60
	R-404A	3,260	26.20
	R-502	4,500	6.60
	R-507	3,300	8.60
	Weighted GWP		2,445.92

Refrigerant Distribution	Refrigerant Type	Global Warming Potential	2010
Process Cooling			
	CFC-11	3,800	1.00
	CFC-12	8,100	15.60
	HCFC-22	1,500	22.00
	HCFC-123	90	23.30
	HFC-134A	1,300	33.30
	R-401A	970	0.40
	R-404a	3,260	2.70
	R-410A	1,725	0.90
	R-507	3,300	0.90
	Weighted GWP		2,222.60
Refrigerated Condensing Units			
	CFC-12	8,100	2.20
	HCFC-22	1,500	30.40
	HFC-134a	1,300	40.40
	R-404a	3,260	19.00
	R-507	3,300	8.00
	Weighted GWP		2,042.80
Chillers			
	CFC-11	3,800	2.60
	CFC-12	8,100	0.90
	HCFC-22	1,500	73.80
	HCFC-123	90	6.80
	CFC-114	9,300	0.10
	HFC-134A	1,300	14.10
	HFC-236fa	6,300	0.40
	R-407a	1,526	1.00
	R-410a	1,725	0.10
	R-500	6,010	0.20
	Weighted GWP		1,531.63
Unitary AC			
	HCFC-22	1,500	78.40
	HFC-134a	1,300	0.10
	R-407a	1,526	0.30
	R-410a	1,725	21.20
	Weighted GWP		1,547.58
Source: California Air Resources Board, 2008			

Mitigation Tab

Figure 20 shows the individual mitigation measures that can currently be set within BGM. Carbon sequestration, also considered to be a mitigation measure, is described separately in the next section. Within the mitigation tab, the user can turn each measure on or off, and has the option of specifying the amount of mitigation.

Mitigation Category				
Electricity & Natural Gas	Check=On	Mitigation Options	MMBtu/year Reduced	
	<input type="checkbox"/>	Solar Water Heater	5000	
	<input type="checkbox"/>	Tankless Water Heater	5000	
			kwh/year reduced	MMBtu/year Increased
	<input type="checkbox"/>	Cool Roofs/Green Roofs	5000	2
			% Increase In Energy Efficiency	
	<input type="checkbox"/>	Increase Energy Efficiency Beyond Title 24	10	
			kwh/year generated	
Water and Wastewater	<input type="checkbox"/>	Drought Tolerant Landscaping	10	
			% Reduction Indoor Use	
<input type="checkbox"/>	Low Flush Toilets	2		
Solid Waste	<input type="checkbox"/>	Reduce Solid Waste by the Following Percentage	10	
Refrigerants	<input type="checkbox"/>	Use Ammonia or CFCs or HCFCs	50	
Offsets / Credits	<input type="checkbox"/>	Purchase Emission Offsets / Credits	5000	

Figure 20. Individual Mitigation Measures within BGM

For example, the user can select solar water heaters, and can edit the amount of million Btu/year of natural gas that would be avoided or reduced. For each of the electricity and natural gas mitigation measures, the user must enter the amount of natural gas or electricity that would be reduced. The user should also note that the cool roofs/green roofs mitigation reduces electricity in the summer months, but increases natural gas consumption during the winter (Levinson, R. et. al. 2005). Consequently, the user should enter two values for this mitigation measure.

The mitigation tab also includes a measure to reduce energy efficiency by a percentage beyond Title 24. For example, by specifying that a building will be ten percent more efficient than Title 24, emissions of electricity and natural gas are assumed to be reduced by ten percent from uncontrolled rates, assuming no additional electricity or natural gas has been specified.

Carbon Sequestration Tab

For carbon sequestration associated with tree plantings, a separate tab has been created. In this tab, the user is required to enter the number of trees that will be planted in six separate categories: fast, medium and slow growing hardwood trees and fast, medium, and slow growing conifer trees. The user must enter the number of trees planted in the year in which they are to be planted. With that information, BGM estimates the amount of CO₂ sequestered annually and cumulatively.

The carbon sequestration estimates are based entirely on the carbon sequestration worksheet developed by the U.S. Department of Energy (2009). This workbook estimates carbon sequestered by individual ("open grown") trees planted at a "standard" age, defined as typical, nursery-raised trees, sold in a 15-gallon container or balled and burlapped. The carbon sequestration calculations account for tree survival rates and the differences in sequestration rates by tree type.

Results Tab

The results tab includes both Summary and Detailed Results sections.

Summary Results

The Summary Results section shows, for each emission category, the unmitigated minus baseline and mitigated minus baseline CO₂e emissions. The user has the option of turning baseline emissions on or off on the Settings tab. Two categories – sequestration and purchase of offsets – are not included in the unmitigated calculations but are included and itemized separately for the mitigation estimates.

The Summary Results section also includes a bar chart that shows unmitigated minus baseline and mitigated minus baseline emissions for each category.

Detailed Results

The detailed results show CO₂, CH₄, N₂O, and metric tons CO₂e for the unmitigated, mitigated, and baseline scenarios. In addition, any mitigation measures that have been selected are listed in the detailed results section. The only exception is that transportation mitigation is listed in a separate tab: Transp. Detail Mit.

Global Warming Potential

BGM assumes a global warming potential (GWP) of 1 for CO₂, 21 for carbon dioxide, and 310 for nitrous oxides (California Climate Action Registry, 2009). These are the GWPs used by the IPCC in their second assessment report (IPCC, 1996). For refrigerants, the actual GWP potential of the refrigerant is used, except in cases where a weighted average of refrigerant GWPs is used instead.

Global warming potentials were developed by the Intergovernmental Panel on Climate Change (IPCC) to quantify the globally averaged relative radiative forcing effects of a given GHG, using carbon dioxide as the reference gas. In 1996, the IPCC published a set of GWPs for the most commonly measured greenhouse gases in its Second Assessment Report (SAR). In 2001, the IPCC published its Third Assessment Report (TAR), which adjusted the GWPs to reflect new information on atmospheric lifetimes and an improved calculation of the radiative forcing of carbon dioxide. However, SAR GWPs are still used by international convention and the U.S. to maintain the value of the carbon dioxide “currency“. Consequently, the BGM model also uses the SAR convention for calculation CO₂e.

Blank Land Uses

Within URBEMIS, users enter information for their project on the land use tabs, such as the number of residences and/or square footage of non-residential uses. Occasionally, a project’s specific land use type is not listed on the URBEMIS land use tabs. In these circumstances, users have the option of entering one or more land uses into URBEMIS’ designated blank land use tab.

If the URBEMIS file that you are importing into BGM includes completed “blank” land uses, then the imported transportation and area source emissions will include the emissions for the blank land uses. However, other areas of BGM that use URBEMIS land use data - the electricity and natural gas tab, the water and wastewater tab, and the solid waste tab – do not import completed blank land use information from URBEMIS. Consequently, the BGM user must go into these three tabs and enter blank land use information.

Figure 21 shows a portion of the blank land use data entry form located on the electricity and natural gas tab. For each blank land use, the user must enter a land use name, and the annual amount of electricity and natural gas that will be used. The resulting emissions are then incorporated into the project totals.

User Provided Blank Land Use Data: Project Data					
Land Use Name	Electricity Use/Year (MWH/Year)	Natural Gas Use/Year (MM Btu/Year)	Electricity CO2 (metric tons/yr)	Electricity CH4 (metric tons/yr)	Ele
Movie Theatre	350.00	220.00	127.76	0.00106	
			0.00	0.00000	
			0.00	0.00000	
			0.00	0.00000	
			0.00	0.00000	

Figure 21. Electricity and Natural Gas Blank Land Use Data Entry

Figure 22 shows a portion of the blank land use data entry form on the water and wastewater tab. The user must enter the land use name and its annual water consumption. BGM then estimates CO₂e emissions for the blank land use, which are then incorporated into total project emissions.

User Provided Blank Land Use Data: Project Data	
Land Use Name	Projected Water Use (gallons/yr)
Movie Theatre	190,000.00

Figure 22. Water and Wastewater Blank Land Use Data Entry

Figure 23 shows a portion of the blank land use data entry form on the solid waste tab. The user enters the land use name and the amount of solid waste that will be generated annually. BGM then estimates CO₂e for this land use and incorporates those emissions into the project total.

User Provided Blank Land Use Data: Project Data		
Land Use Name	Solid Waste Generation/Year (tons)	CO ₂ e (metric tons/year)
Movie Theatre	50.00	32.00
		0.00
		0.00
		0.00
		0.00

Figure 23. Solid Waste Blank Land Use Data Entry

BGM requires the user to enter electricity and natural gas use, water use, and solid waste generation for each identified blank land use. The user must also note that if they are using a baseline project, any blank land uses for it must also be entered.

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