



Greenhouse Gas and Climate Change Impact Analysis



Sacramento Metropolitan Air Quality
Management District Workshop
April 20, 2009
9 AM- 4 PM



Unit 3 GHG Quantification and Tools

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April 20, 2009

Greenhouse Gas Quantification Tools and Methods

- In general, no one stop-shop tool available for all projects
- Quantification will often rely on a combination of established models, protocols, boutique tools/models, and other customized approaches to form a comprehensive analysis
- Quantification utilizes tools that are meant to predict future year emissions and inventory current emissions
 - Must ensure your analysis takes into account these disparate features
- Most tools/models will evaluate CO₂, CH₄, and N₂O emissions

Greenhouse Gas Sources

- The tool/methodology used will depend on project emission sources
- Common emission sources
 - Construction sources (direct)
 - Mobile sources (direct)
 - Electricity and fuel use (indirect)
 - Waste emissions (indirect)

Greenhouse Gas Sources

- Construction activities
 - Often associated with most types of projects
 - Can be its own project
 - Mainly direct emissions, can include indirect emissions
 - Operation of construction equipment

- Don't fall into trap of thinking a project will only result in construction emissions
 - A project may only result in direct construction emissions, but may have indirect operational emissions (e.g., transmission line project, construction of well or pump station)

Greenhouse Gas Sources

- Operational emissions
 - Emission types and sources can vary from project to project
 - Consist of both direct and indirect emissions

 - Direct
 1. On-road mobile source emissions
 2. Maintenance/landscaping activities
 3. On-site processes

 - Indirect
 1. Electricity and fuel use for power and heating
 2. Water supply/waste water treatment

Greenhouse Gas Sources

- Life-cycle
 - Indirect emissions inherent to the manufacture and shipment of a product
 - Often difficult to characterize due to issue of drawing a boundary around scope of emission sources
 - Source vs. end-user
 - Attorney General comment letter to SJVAPCD states:
 - “CEQA does not require independent research to trace back to its source every single material...but there is no reason that existing, readily available information about lifecycle emissions should not be included in the CEQA analysis.”
 - Lead agencies should identify appropriate scope of life-cycle analyses for projects

Greenhouse Gas Sources

- Recommendations
 - Use established protocols and models
 - Quantify all reasonable activity
 - Don't quantify speculative emissions, but list them
 - Update analysis as methods evolve

Greenhouse Gas Quantification Tools

- Traditional Models
 - URBEMIS2007 (Rimpo & Associates)
 - Calculates emissions for land use and construction projects
 - EMFAC2007 (California Air Resources Board)
 - Calculates emission factors from motor vehicles
 - CT-EMFAC (California Department of Transportation)
 - Calculates emission factors from motor vehicles
 - OFFROAD2007 (California Air Resources Board)
 - Calculates emission factors from off-road vehicles
 - Road Construction Emissions Model (SMAQMD)
 - Calculates construction emissions for roadway projects

Greenhouse Gas Quantification Tools

- Other Traditional Models (not Commonly Used in California)
 - MOBILE 6.2 (U.S. Environmental Protection Agency)
 - Calculates emission factors from motor vehicles
 - NONROAD 2007 (U.S. Environmental Protection Agency)
 - Calculates emission factors from off-road vehicles
 - MOVES – currently in draft form (U.S. Environmental Protection Agency)
 - Calculates emission factors from motor vehicles

Greenhouse Gas Quantification Tools

- Protocols
 - California Climate Action Registry General Reporting Protocol, Version 3.1
 - Local government inventory protocol for California The Climate Registry
 - General Reporting Protocol, Version 1.1
 - Local government inventory protocol
 - ARB/ICLEI/CCAR/Climate Registry Local Government Operations Protocol
 - Local government inventory protocol for government operations
 - U.S. EPA Methodology from Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007
 - Methodology for U.S. GHG inventory

Greenhouse Gas Quantification Tools

- Protocols (continued)
 - IPCC Guidance for National Greenhouse Gas Inventories
 - Guidance from IPCC for conducting inventories
 - World Business Council for Sustainable Development/World Resources Institute Greenhouse Gas Protocol
 - Inventory protocols/tools for a variety of sources
 - Local Community Protocol (in progress, expected Summer 2009)
 - Inventory protocol for community operations

Greenhouse Gas Quantification Tools

- Inventory Models
 - Clean Air and Climate Protection (ICLEI - Local Governments for Sustainability)
 - Inventory tool for local governments
 - Software for Cities (Torrie-Smith Associates)
 - Inventory tool for local governments

- Land Use/Scenario Planning
 - INDEX (Criterion Planners)
 - Sustainable Communities Model (CTG)
 - I-PLACE³S (CA/OR/WASH state energy offices)

Greenhouse Gas Quantification Tools

- Other Resources
 - EIA databases for energy
 - CEC Info
 - Land GEM, ARB landfill – landfill gas
 - U.S. Environmental Protection Agency AP-42 Emission Factors

Greenhouse Gas Quantification Tools

- Traditional Models vs. Protocols
 - Traditional models typically forecast emissions that will occur in the future
 - Often take into account emission trends for future years
 - Protocols typically evaluate emissions that are currently occurring or have occurred in the past
 - No accounting for emission trends for future years

Traditional Models Available for Projects

- Land use project
 - URBEMIS2007
- Construction project
 - URBEMIS2007
- Roadway/transportation project
 - EMFAC2007/CT-EMFAC
 - Road Construction Emissions Model
- Most projects will use URBEMIS2007, EMFAC2007/CT-EMFAC, and other protocols to provide a comprehensive analysis

URBEMIS2007

- URBEMIS2007 calculates emissions associated with land use and construction projects
 - Calculates emissions in pounds per day or tons/year
 - Not metric tons per year
- Evaluates the **CO₂** emissions from the following sources:
 - Construction
 - On-road mobile sources (vehicles resulting from projects)
 - Area source emissions
 - Natural gas from heating
 - Landscaping
 - Hearth emissions

URBEMIS2007 - Limitations



- Limited to land use projects, will not calculate emissions for:
 - Stationary sources
 - Linear infrastructure
 - Roadway projects/
 - Agricultural sources
 - Non-construction off-road sources (i.e., aircraft, boats, rail, OHV, etc.)
 - Dispersion modeling or estimating ambient concentrations
- URBEMIS2007 does not calculate electricity emissions!!
 - May be included in future updates to URBEMIS
- URBEMIS2007 does not calculate other GHG emissions (i.e., CH₄ or N₂O)
 - CH₄ may be included in future updates to URBEMIS

URBEMIS2007

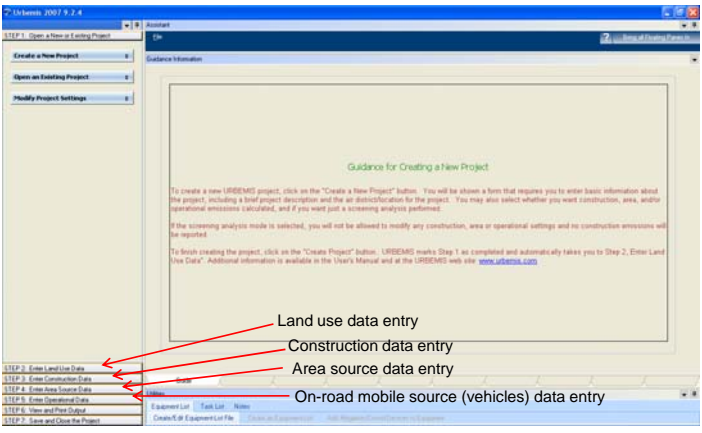
- Utilizes EMFAC2007 and OFFROAD2007 emission rate data to calculate emissions
- Uses default values that can be overridden with more project specific values
 - Construction equipment horsepower, load factor, hours per day
 - Land use daily trip generation rates and average trip lengths to calculate vehicle miles traveled (VMT)
- Larger projects with multiple phases may result in inaccurate emissions due to conservative URBEMIS default values

URBEMIS2007 – Mobile Sources



- Key data needed to calculate on-road emissions
 - Types of land uses (e.g., single family residential, retail, etc.)
 - Number of land use units
 - Trip generation data by land use
 - From project traffic study
 - Project acreage
- Useful data to have
 - Average vehicle speed
 - Project trip length

URBEMIS2007 - Main screen



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URBEMIS2007 – Mobile Sources

- Land use input screen
 - Includes various standard types of land uses
 - URBEMIS will calculate daily trip rates based on
 - Land use type
 - Number of units for each land use
 - Size of land use
 - Trip generation rates from 7th Edition of Institute of Transportation Engineers Trip Generation document (2003)

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URBEMIS2007 – Mobile Sources Land use screens

Land Use Type	Land Area	Trip Rate	Other Columns
...

Number of land use units

Land Use Type	Land Area	Trip Rate	Other Columns
...

Daily trip generation rate

Land Use Type	Land Area	Trip Rate	Other Columns
...

Land Use Type	Land Area	Trip Rate	Other Columns
...

URBEMIS2007 – Mobile Sources

- Operational trip characteristic screen
 - Fleet characteristics and year being analyzed
 - Emissions vary by vehicle type and vehicle year
 - Vehicle speeds
 - Emissions vary by speed
 - Trip lengths
 - Trip length and trip generation rates used to calculate VMT

Equation 1: $\# \text{ trips} \times \# \text{ miles} = \text{VMT}$

- Vehicle speed data used to determine emission rates used to calculate emissions
 - URBEMIS applies EMFAC2007 emission rates (grams/mile) to VMT

Equation 2: $\text{emission rate} \times \text{VMT} = \text{emissions}$

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URBEMIS2007 – Mobile Sources

Operational trip characteristic screens

Year analyzed Vehicle speeds Trip lengths

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URBEMIS2007 – Mobile Sources

Output screens

CO₂ emissions by land use

Calculated VMT by land use

Operational (mobile) output

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4/11/2009 6:12:16 PM

URBEMIS 2007 Version 9.2.4
Detailed Report for Annual Operational Uninvestigated Emissions (Transit)

File Name: C:\urbemis\2007\9.2.4 Files_SMAQMD Example\ur24
Project Name: Large Project Example
Project Location: California State-wide
Default Vehicle Emissions Based on: Vehicle - Emissions2007 v2.3 Nov 1 2006
On-Road Vehicle Emissions Based on: OFFROAD2007

Land Use Type	Average	Trip Rate	Unit Type	No. Units	Total Trips	Total VMT
Single family housing	500.00	9.57	dwelling units	1,500.00	14,355.00	122,732.94
Apartments low rise	15.62	6.00	dwelling units	250.00	1,725.00	14,743.23
Apartments high rise	10.00	4.72	dwelling units	1,400.00	6,608.00	56,456.42
Retirement community	40.00	3.71	dwelling units	200.00	742.00	6,343.88
Daycare center		79.28	1000 sq ft	25.00	1,982.20	11,821.63
Elementary school		14.49	1000 sq ft	40.00	579.60	4,858.29
Restaurant (all)		14.03	1000 sq ft	25.00	350.75	2,819.72
Freight/express superstore		49.21	1000 sq ft	70.00	4,445.20	36,160.44
Strip mall		42.94	1000 sq ft	100.00	4,294.00	31,745.04
Office park		11.42	1000 sq ft	50.00	571.00	4,768.12
TOTALS (company investigated)					33,271.05	275,688.25

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Analysis Year: 2008 Season: Annual
Enter Year: Emissions2007 v2.3 Nov 1 2006

OPERATIONAL EMISSION ESTIMATES (Annual Tons Per Year - Uninvestigated)

Species	ROG	NOx	CO	SO2	PM10	PM2.5	CO2
Single family housing	27.38	45.62	339.91	0.22	38.80	7.62	21,859.21
Apartments low rise	3.46	4.88	42.72	0.03	4.96	0.92	2,822.22
Apartments high rise	13.03	16.70	150.01	0.10	17.88	3.51	9,956.30
Retirement community	1.81	2.16	17.62	0.01	2.91	0.39	1,119.33
Daycare center	2.50	3.93	31.85	0.02	3.74	0.73	2,099.14
Elementary school	1.90	1.89	19.97	0.01	1.46	0.39	769.89
Restaurant (all)	0.58	0.87	7.08	0.00	0.83	0.16	496.94
Freight/express superstore	3.87	6.04	49.82	0.03	6.76	1.13	3,178.78
Strip mall	6.76	10.50	84.89	0.05	10.33	1.87	5,542.28
Office park	1.07	1.58	13.16	0.01	1.91	0.30	842.58
TOTALS (company investigated)	62.88	90.77	750.98	0.44	88.62	17.51	48,217.70

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URBEMIS2007 – Area Sources

- URBEMIS will calculate the following area sources:
 - Natural gas from heating
 - Landscaping
 - Hearth emissions

- Generally will use default URBEMIS values
 - Update if project/site specific data is available

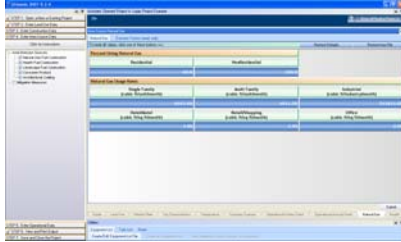
URBEMIS2007 – Area Sources Hearth Inputs

The image displays four screenshots of the URBEMIS2007 software interface, arranged in a 2x2 grid. Each screenshot shows a different part of the software's data entry and calculation process for area sources.

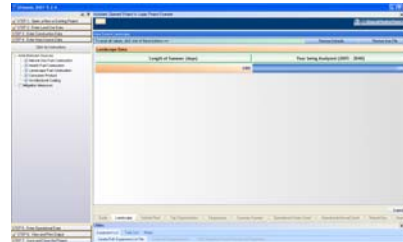
- Top Left:** Shows a summary table with columns for 'Roads', 'Roads', 'Natural Gas', 'Landscaping', and 'Total'. The table is currently empty.
- Top Right:** Shows a detailed input screen for 'Hearth Emissions'. It includes a table with columns for 'Area', 'Type', 'Fuel', 'Emission Factor', and 'Emissions'. The table contains several rows of data.
- Bottom Left:** Shows a detailed input screen for 'Natural Gas Heating'. It includes a table with columns for 'Area', 'Type', 'Fuel', 'Emission Factor', and 'Emissions'. The table contains several rows of data.
- Bottom Right:** Shows a detailed input screen for 'Landscaping'. It includes a table with columns for 'Area', 'Type', 'Fuel', 'Emission Factor', and 'Emissions'. The table contains several rows of data.

URBEMIS2007 – Area Sources

Natural gas
consumption screen

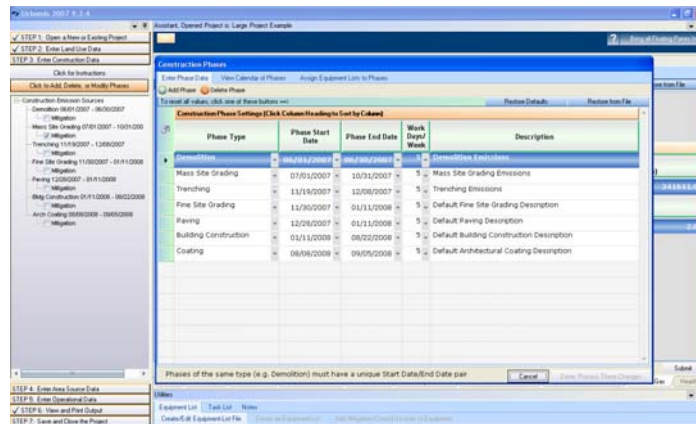


Landscape and year
analyzed screen



URBEMIS2007 – Construction

- URBEMIS will calculate construction emissions from a variety of construction activities



URBEMIS2007 – Construction

- User can specify construction duration and equipment information to override URBEMIS default values

Default values that can be overridden

Equipment Type	Horsepower	Load Factor*	%/Day
Asphalt Pavers	60,000	0.400	0.0
Air Compressors	100.00	0.400	0.0
Bulk/Drill Pipe	200.00	0.700	0.0
Cement and Mortar Mixers	100.00	0.300	0.0
Concrete/Industrial Saws	15.00	0.700	0.0
Cranes	300.00	0.400	0.0
Crawler Tractors	245.00	0.400	0.0
Crushing/Screening Equip	140.00	0.300	0.0
Dumpsters/Trailers	100.00	0.300	0.0
Excavators	100.00	0.370	0.0
Forklifts	245.00	0.200	0.0
Generator Sets	500.00	0.740	0.0
Graders	174.00	0.300	0.0
Off Highway Tractors	245.00	0.300	0.0
Other Equipment	470.00	0.370	0.0
Other/Unidentified Equipment	500.00	0.300	0.0

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URBEMIS2007 – Key Data

- Key data needed to calculate construction emissions
 - Schedule of each construction phase
 - Construction equipment used for each phase of construction
 - Equipment horsepower, load factor, hours per day
- Useful data to have
 - Number of workers/worker trips
 - Number of construction vendor/delivery trips
 - Amount of imported/exported soil
- If no project-specific data is available, default URBEMIS2007 data can be used

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EMFAC2007



File Run Help

California Air Resources Board

Emfac2007 V2.3 Nov 1 2006

Select from the File menu to edit input data, or select from the Run menu to run a case.

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EMFAC2007 – Overview

- EMFAC2007 is often used to help calculate emissions from roadway/transportation projects
- EMFAC2007 calculates emission factors from on-road motor vehicles by vehicle classification
 - Does not calculate total emissions
 - Calculates emission rates that are then applied to vehicle activity data (VMT) to calculate total emissions
 - Grams per trip
 - Grams per mile
- Calculates **CO₂** and **CH₄** emission rates
- On-road mobile source emissions in URBEMIS2007 are calculated using EMFAC2007 emission rate data

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EMFAC2007 – Inputs




EMFAC2007 will calculate emission factors based on:


- Geographic area
- Calendar year
- Season/month
- Temperature
- Humidity
- Speed



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EMFAC2007 – Output

Title : Sacramento County Subarea January Ctr 2011 Default Title
 Version : Emfac2007 V2.3 Nov 1 2006
 Run Date : 4/12/2009 17:29:29
 Setn Year : 2011 - all model years in the range 1967 to 2011 selected
 Season : January
 Area : Sacramento

Year: 2011 - Model Years 1967 to 2011 inclusive -- January
 Emfac2007 Emission Factors: V2.3 Nov 1 2006

County Average Sacramento		County Average	
Table 1:00 Running Exhaust Emissions (grams/mile)			
Pollutant Name:	Methane	Temperature	Relative Humidity:
Speed MPH	LDA	LOT	MDT
5	0.069	0.074	0.088
10	0.069	0.074	0.088
15	0.04	0.046	0.056
20	0.032	0.038	0.046
25	0.026	0.031	0.039
30	0.022	0.027	0.035
35	0.02	0.024	0.031
40	0.018	0.022	0.029
45	0.017	0.021	0.027
50	0.017	0.021	0.027
55	0.016	0.021	0.027
60	0.016	0.021	0.027
65	0.021	0.026	0.032

Pollutant Name: Carbon Dioxide		Temperature		Relative Humidity:	
Speed MPH	LDA	LOT	MDT	MDT	MDT
5	949.18	1171.971	1691.187	2664.442	2599.07
10	717.4	897.8	1249.224	2235.971	2200.492
15	562.764	697.567	985.248	1911.826	1967.48
20	459.31	568.919	778.956	1658.859	1623.602
25	387.239	481.585	655.229	1595.6	1573.428
30	339.642	423.023	571.845	1525.975	1482.495
35	309.171	385.554	512.509	1479.37	1469.44
40	282.064	364.51	484.12	1435.37	1432.041
45	266.377	357.49	465.003	1411.682	1407.137
50	251.402	353.871	460.016	1401.817	1404.111
55	247.73	353.76	452.929	1404.897	1404.153
60	247.268	420.103	574.684	1423.687	1400.607
65	249.654	477.15	651.171	1460.167	1700.54

EMFAC will calculate emission rate data (grams per mile/trip) by vehicle type and speed for each pollutant

This data is then applied to vehicle activity data to calculate overall emissions

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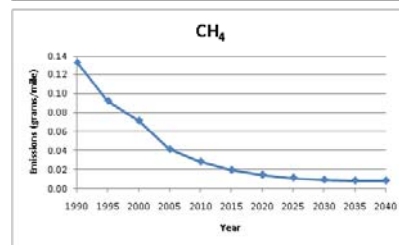
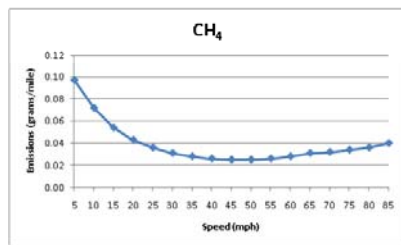
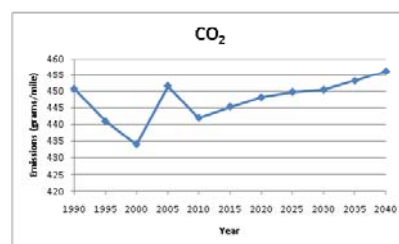
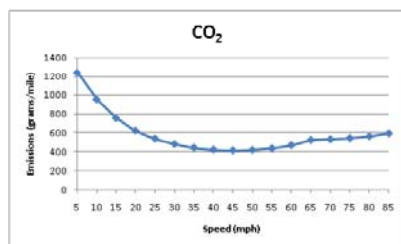
EMFAC2007 – Key Data

- Key data needed to calculate on-road mobile source emissions from EMFAC2007:
 - Year being evaluated
 - Regional temperature/humidity
 - Speeds being evaluated (from traffic study)
 - Vehicle activity data
 - This data is not used for EMFAC2007, but is used to calculate emissions from the EMFAC2007 output

EMFAC2007 – Emissions Trends

Emission rates by speed

Emission rates by year



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CT-EMFAC

CT-EMFAC Version 2.6 May 29, 2008

Help

Title | Emission Factors | Emission Calculations

CT-EMFAC

UC Davis-Caltrans Air Quality Project
[http://AQP.engr.ucdavis.edu /](http://AQP.engr.ucdavis.edu/)
Task Orders No. 61 and 67

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Prepared in response to

A request to create a transportation project-level emissions analysis tool based on the California Air Resources Board EMFAC2007 emissions model.

GO TO.....

Emission Factors | Emission Calculations

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CT-EMFAC – Overview

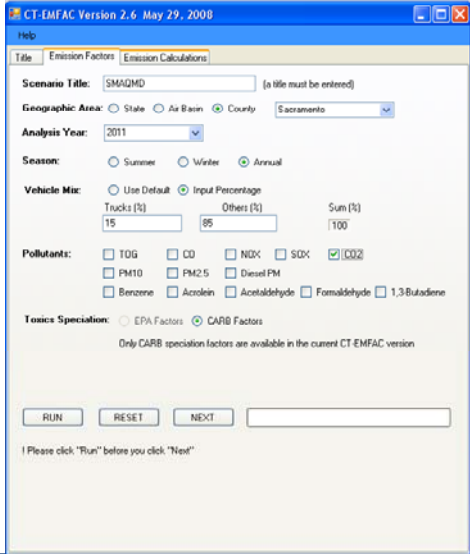
- CT-EMFAC is used to calculate emissions from roadway/transportation projects
- CT-EMFAC contains database of EMFAC2007 emission rate data that is applied to user-input vehicle activity data
- Unlike EMFAC2007, CT-EMFAC will calculate total emissions, rather than just an emission rate
- CT-EMFAC calculates **CO₂** emissions

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CT-EMFAC – Inputs




CT-EMFAC will query its EMFAC2007 emissions database based on the following user-defined inputs:

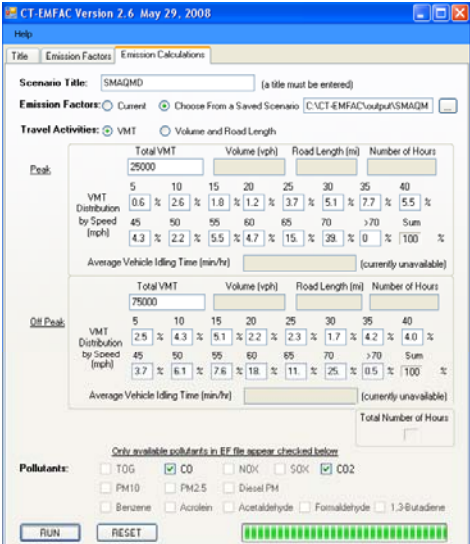
- Geographic area
- Calendar year
- Season
- Fleet mix

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CT-EMFAC – Inputs



- Using the emission factor data identified from the user-defined inputs, CT-EMFAC will calculate emissions based on vehicle activity and speed distribution data input by the user
- Vehicle activity data is input as either 1) VMT or 2) roadway volume and length and number of hours to calculate VMT
 - Typically VMT data is input directly
 - This data is from traffic study
- VMT speed distribution is from traffic study

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CT-EMFAC – Output

Vehicle activity and speed bin data summary

Title : SMAQMD
 Version : CT-EMFAC 2.4
 Run Date : 12 April 2009 06:22 PM
 Run Year : 2011
 Season : Annual
 Temperature : 65F
 Relative Humidity : 96%
 Area : Sacramento County

Peak User Input: Total VMT: 25000, Volume (vph): 5-10-15-20-25-30-35-40-45-50-55-60-65-70-75, Road Length(mi): 0.6-2.6-3.9-5.2-2.7-5.1-7.7-5.5-4.9-2.3-5.5-4.7-15.8-22.9, Number of Hours:

Offpeak User Input: Total VMT: 75000, Volume (vph): 5-10-15-20-25-30-35-40-45-50-55-60-65-70-75, Road Length(mi): 2.5-4.2-5.1-2.2-2.2-1.7-4.2-4.0-3.7-5-7.6-10.5-11.7-25.8-0.5, Number of Hours:


Running Exhaust Emissions (grams)
 Pollutant Name : CO2
 speed(mph) Emission Factor(grams/mile) VMT by Speed VMT-Speed Distribution (%) Emissions by Speed


speed(mph)	Emission Factor(grams/mile)	VMT by Speed	VMT-Speed Distribution (%)	Emissions by Speed
5	1180.024007	2,025.00	2.03	2,389,548.614175
10	899.259049	2,875.00	2.89	2,480,870.241625
15	710.126494	4,075.00	4.25	2,938,650.511950
20	559.388176	1,950.00	1.95	1,197,509.499200
25	500.092710	2,650.00	2.66	1,329,182.768500
30	444.052376	2,850.00	2.85	1,262,852.858500
35	407.977460	2,075.00	2.08	2,079,488.609500
40	387.475957	4,275.00	4.28	1,659,607.313775
45	369.241059	2,920.00	2.93	1,069,914.126800
50	355.528568	5,125.00	5.12	1,828,602.161000
55	404.012563	7,075.00	7.08	2,859,410.105225
60	427.864600	15,050.00	15.05	6,424,358.794000
65	491.453840	12,725.00	12.73	6,256,258.134000
70	491.453840	29,025.00	29.02	14,469,582.521375
75	509.256626	275.00	0.28	1,401,971.238500
Total		100,000.00	100.00	50,072,280.510675

Total Emissions
 Pollutant Name Total Emissions (grams) Total Emissions (Kilograms) Total Emissions (US Tons)
 CO2 50,072,280.510675 50,072.280511 55.189241171

END

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CT-EMFAC – Key Data

- Key data needed to calculate on-road mobile source emissions from CT-EMFAC:
 - Year being evaluated
 - Fleet mix (from traffic study)
 - Vehicle activity data (from traffic study)
 - This is typically VMT data. If VMT data is unavailable, VMT can be calculated using:
 - Roadway vehicles per hour
 - Roadway length in miles
 - Number of hours for peak and off-peak periods
 - Speed bin distribution (from traffic study)

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OFFROAD2007



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OFFROAD2007 – Overview

- OFFROAD2007 is not a calculation tool.
- OFFROAD2007 is an inventory tool that estimates the population, activity, and emissions from the various types of off-road equipment
 - Agricultural
 - Airport/port
 - Construction
 - Lawn and garden
 - Offroad recreation,
- OFFROAD2007 provides **CO₂**, **CH₂**, and **N₂O** emissions

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OFFROAD2007 – Overview

- OFFROAD2007 output data can be modified to provide emission factor data for various equipment types
 - Emission factors are a function of horsepower and usage
 - Expressed in grams per horsepower-hour
- Emission factor data from OFFROAD2007 can be applied to off-road equipment to calculate overall emissions
- Emission factors from OFFROAD2007 are included in URBEMIS2007 and the Road Construction Emissions Model
- OFFROAD2007 is not often used; primarily for projects with atypical off-road equipment

Road Construction Emissions Model

Road Construction Emissions Model
Data Entry Worksheet

Version 6.3.1

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Note: Required data input sections have a yellow background.
Optional data input sections have a blue background. Only areas with a yellow or blue background can be modified. Program defaults have a white background.
The user is required to enter information in cells C10 through C26.

Road Type

Project Name: _____

Construction Start Year: _____
Enter a Year between 2008 and 2026 (inclusive) WARNING: Start Year must be between 2008 and 2026 (inclusive)

Project Type: _____
Please note: Select either 1, 2, or 3

Project Construction Time (months): _____
Equipment Selection Type: Enter 1, 2, or 3 1. New Road Construction
2. Road Widening
3. Bridge/Overpass Construction

Project Length (miles): _____
Please note: Select either 1, 2, or 3 1. Sand Gravel
2. Unstabilized Rock-Earth
3. Stabilized Rock

Total Project Area (acres): _____

Maximum Area Disturbed/Day (acres): _____

Water Trucks Used? (Yes/No): _____
1. Yes 2. No You must enter a 1 or 2

Soil Imported (yof/day): _____

Soil Exported (yof/day): _____

Average Truck Capacity (yof (assume 20 if unknown)): _____

To begin a new project, click the button to clear data previously entered. This button will only work if you opted not to disable macros when loading this spreadsheet.

Road Construction Emissions Model – Overview

- Spreadsheet model used to calculate construction emissions from roadway/transportation projects
- Contains database of EMFAC2007 and OFFROAD2007 emission rate data that is applied to user-input data
- Calculates CO₂ emissions

Road Construction Emissions Model – Inputs

Off-Road Equipment Emissions		
Grubbing/Land Clearing	Default Number of Vehicles Program-estimate	Type
		Aerial Lifts
		Air Compressors
		Bore/Drill Rigs
		Cement and Mortar Mixers
		Concrete/Industrial Gaws
		Cranes
		Crushing/Proc. Equipment
		Excavators
		Forklifts
		Generator Sets
		Graders
		Off-Highway Tractors
		Off-Highway Trucks
		Other Construction Equipment
		Other General Industrial Equipment
		Other Material Handling Equipment
		Pavers
		Paving Equipment
		Pallet Compactors
		Pressure Washers
		Pumps
		Rollers
		Rough Terrain Forklifts
		Rubber Tired Dozers
		Rubber Tired Loaders
		Scrapers
		Signal Boards
		Skid Steer Loaders
		Surfacing Equipment
		Swepers/Scrubbers
		Tractors/Loaders/Backhoes
		Trenchers
		Welders

The RCEM will provide estimates if equipment types based on information provided by user

- Default values should be overridden if project-specific data is available

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Road Construction Emissions Model – Inputs

Default values that can be overridden

Construction Periods		User Override of Construction Months	Program Calculated Months
Grubbing/Land Clearing			1.00
Grading/Excavation			7.00
Drainage/Utilities/Sub-Grade			4.00
Paving			2.00
Total		0.00	16.00

User Input	User Override of Soil Hauling Defaults	Default Values
Minimum Trip		30
Round Trip/Day		25
Vehicle miles traveled/Day (calculated)		631

Worker Commute Emissions		User Override of Worker Commute Default Values	Default Values
Miles one-way trip			20
One-way trip/day			3
No. of employees: Grubbing/Land Clearing			6
No. of employees: Grading/Excavation			14
No. of employees: Drainage/Utilities/Sub-Grade			10
No. of employees: Paving			20

Water Truck Emissions		User Override of Default # Water Trucks	Program Estimate of Number of Water Trucks	User Override of Miles Traveled/Day	Default Values Miles Traveled/Day
Grubbing/Land Clearing - Exhaust			5		200
Grading/Excavation - Exhaust			5		200
Drainage/Utilities/Sub-Grade			3		120

Fugitive Dust		User Override of Max Average Emissions/Day	Default
Fugitive Dust - Grubbing/Land Clearing			25
Fugitive Dust - Grading/Excavation			25
Fugitive Dust - Drainage/Utilities/Sub-Grade			25

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Road Construction Emissions Model – Inputs

More default values that can be overridden

Equipment	Default Values Horsepower	Default Values Load Factor	Default Values Hour/day
Aerial Lifts	60	0.46	6
Air Compressors	106	0.48	6
Bore/Drill Rigs	291	0.75	6
Cement and Mortar Mixers	10	0.56	6
Concrete/Industrial Cams	19	0.73	6
Cranes	399	0.43	6
Crushing/Proc. Equipment	142	0.78	6
Excavators	168	0.67	6
Forklifts	145	0.30	6
Generator Sets	549	0.74	6
Graders	174	0.61	6
Off-Highway Tractors	267	0.65	6
Off-Highway Trucks	479	0.67	6
Other Construction Equipment	75	0.62	6
Other General Industrial Equipment	238	0.51	6
Other Material Handling Equipment	191	0.69	6
Pavers	100	0.62	6
Paving Equipment	104	0.53	6
Plate Compactors	9	0.43	6
Pressure Washers	1	0.60	6
Pumps	63	0.74	6
Rollers	95	0.56	6
Rough Terrain Forklifts	93	0.60	6
Rubber Tired Dozers	357	0.59	6
Rubber Tired Loaders	137	0.54	6
Scrapers	313	0.72	6
Signal Boards	20	0.78	6
Skid Steer Loaders	44	0.65	6
Surfacing Equipment	362	0.45	6
Sweepers/Scrubbers	61	0.68	6
Tractors/Loaders/Backhoes	108	0.55	6
Trenchers	63	0.75	6
Welders	45	0.45	6

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Road Construction Emissions Model – Output

- The RCEM will provide CO₂ emissions for each of the default construction phases

Road Construction Emissions Model, Version 6.3.1

Emission Estimates for -> SMAQMD										
Project Phases (Project Units)	ROD (lb/day)	CO (lb/day)	NOx (lb/day)	PM10 (lb/day)	Exhaust PM10 (lb/day)	Fugitive Dust PM10 (lb/day)	Total PM2.5 (lb/day)	Exhaust PM2.5 (lb/day)	Fugitive Dust PM2.5 (lb/day)	CO2 (lb/day)
Grubbing/Land Clearing	35.2	122.4	216.7	242.3	15.3	232.0	87.2	8.4	47.8	21,152.1
Grading/Excavation	33.8	107.2	228.4	242.3	12.3	232.0	85.0	11.2	47.8	20,507.7
Drainage/Utilities/Sub-Grade	22.6	79.7	129.7	238.0	8.0	232.0	86.2	7.4	47.8	12,840.0
Paving	21.6	72.0	151.5	8.0	8.0	-	8.2	8.2	-	9,797.8
Minimum (lb/day)	33.8	107.2	228.4	242.3	12.3	232.0	85.0	11.2	47.8	20,507.7
Total (lb/day) (nonconstruction project)	6.1	21.7	32.9	36.3	1.9	35.4	8.9	1.7	7.2	3,487.7

Notes: Project Start Year => 2011
 Project Length (months) => 16
 Total Project Area (acres) => 48
 Maximum Area Disturbed (Day) (acres) => 23
 Total Soil Impacted/Exposed (m²/day) => 658
 PM10 and PM2.5 estimates assume 50% control of fugitive dust from watering and associated dust control measures if a minimum number of water trucks are specified.
 Total PM10 emissions shown in column F are the sum of exhaust and fugitive dust emissions shown in columns H and I. Total PM2.5 emissions shown in Column J are the sum of exhaust and fugitive dust emissions shown in columns K and L.

Emission Estimates for -> SMAQMD										
Project Phases (Project Units)	ROD (lb/day)	CO (lb/day)	NOx (lb/day)	PM10 (lb/day)	Exhaust PM10 (lb/day)	Fugitive Dust PM10 (lb/day)	Total PM2.5 (lb/day)	Exhaust PM2.5 (lb/day)	Fugitive Dust PM2.5 (lb/day)	CO2 (lb/day)
Grubbing/Land Clearing	13.7	86.8	88.0	108.2	4.7	104.6	26.0	4.3	21.7	9,844.9
Grading/Excavation	16.3	71.4	122.6	115.1	6.6	104.6	26.8	6.1	21.7	10,939.9
Drainage/Utilities/Sub-Grade	10.3	36.2	88.9	108.2	3.7	104.6	26.1	3.3	21.7	6,836.4
Paving	8.9	32.7	48.9	4.1	4.1	-	3.7	3.7	-	4,453.6
Minimum (lb/day)	16.3	71.4	122.6	115.1	6.6	104.6	26.8	6.1	21.7	10,939.9
Total (lb/day) (nonconstruction project)	4.6	19.6	29.9	32.9	1.7	31.2	8.0	1.6	6.6	3,145.3

Notes: Project Start Year => 2011
 Project Length (months) => 16
 Total Project Area (acres) => 18
 Maximum Area Disturbed (Day) (acres) => 9
 Total Soil Impacted/Exposed (m²/day) => 427
 PM10 and PM2.5 estimates assume 50% control of fugitive dust from watering and associated dust control measures if a minimum number of water trucks are specified.
 Total PM10 emissions shown in column F are the sum of exhaust and fugitive dust emissions shown in columns H and I. Total PM2.5 emissions shown in Column J are the sum of exhaust and fugitive dust emissions shown in columns K and L.

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Greenhouse Gas Quantification Tools

- Available at:
 - URBEMIS2007 (Rimpo & Associates)
 - <http://www.urbemis.com/>
 - EMFAC2007 (California Air Resources Board)
 - www.arb.ca.gov/msei/onroad/latest_version.htm
 - CT-EMFAC (California Department of Transportation)
 - <http://www.dot.ca.gov/hq/env/air/pages/ctemfac.htm>
 - OFFROAD2007 (California Air Resources Board)
 - www.arb.ca.gov/msei/offroad/offroad.htm
 - Road Construction Emissions Model (SMAQMD)
 - <http://www.airquality.org/ceqa/RoadConstructionModelVer6.3-1.xls>

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Protocols

- Protocols and other tools should also be used to augment analyses using traditional models
 - Indirect emissions
 - Electricity and fuel use for power and heating
 - Water supply/waste water treatment
 - Other GHGs not evaluated by models
 - N₂O and CH₄
 - URBEMIS2007
 - Road Construction Emissions Model
 - CT-EMFAC
 - N₂O
 - EMFAC2007

Protocols

- Electricity emissions
 - Calculated from anticipated electricity consumption and electricity GHG emission factors
 - Some Utility-specific CO₂ emission factors can be obtained from the California Climate Action Registry Reporting Online Tool (CARROT)
 - Regional CO₂, CH₄, and N₂O emission factors from electricity generation can be found in California Climate Action Registry General Reporting Protocol, Version 3.1
- Water supply/treatment emissions
 - Calculated from anticipated water supply/treatment data, electricity consumption data, and electricity GHG emission factors
 - Energy data for Water supply/treatment from California Energy Commission
 - Utility-specific CO₂ electricity emission factors
 - California Climate Action Registry General Reporting Protocol, Version 3.1 electricity emission factors

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Energy Emissions

- CCAR CARROT Reporting tool for electricity generation

2007 Annual Entity Emissions: Electric Power Generation/Electric Utility Sector

Sacramento Municipal Utility District
6201 S St.
Sacramento, CA, 95817
www.smutd.org

Reporting Year: 2007
Direct Baseline Year:
Indirect Baseline Year:
Reporting Scope: CA and US
Reporting Boundaries:
Reporting Protocols: General Reporting Protocol Version 3.0 (April 2008)
Power/Utility Reporting Protocol Version 1.0 (April 2005)

Legend:
Blue = required
Green = required
Orange = optional

SMUD CO₂ emission rate

Contact: Okasha Berthelony
Title: Project Manager
Telephone: (916) 725-6885
Email: okasha@smutd.org
Industry Type: Power Generation
Entity NAICS Code: 2211 Electric Power Generation, Transmission and Distribution
Entity NAICS Code: 2211 Electric Power Generation, Transmission and Distribution
Entity Description: The Sacramento Municipal Utility District is the nation's sixth largest publicly owned electric utility in terms of customers served. SMUD generates, transmits, and distributes electric power within a 900 square mile service area in and around the greater Sacramento, California. SMUD owns and operates 1707 MW of central generation resources located in the California Counties of Sacramento, El Dorado and Sutter. SMUD's electrical generation is comprised of 956 MW of natural gas fired fossil generation, cogeneration, and peaking resources, 688 MW of hydroelectric, 105 MW of cogeneration, and 124.4 MW of solar photovoltaic generation. SMUD owns and operates a 70-mile natural gas transmission pipeline serving the cogeneration and fossil generation facilities. SMUD has equity shares in the Ineos Natural Gas Production Plant in New Mexico and in a Northern California transmission line known as the California Oregon Transmission Project or the Transmission Association of Northern California.

Do you deliver power to an end-user/retail customer? (Enter yes or no) **yes**

EMISSIONS EFFICIENCY METRICS

Electricity Delivered: **914.31 lbs CO₂/MWh delivered (includes CO₂ from owned and purchased generation)**

Net Generation: 718.58 lbs CO₂/MWh net owned generation (fossil, geothermal, hydroelectric, nuclear, solar, etc.)

Net Fossil Generation: 499.23 lbs CO₂/MWh net owned fossil generation only

Note: Efficiency metrics are calculated using CO₂ emissions from stationary combustion for purposes of electricity generation. CO₂ emissions from biogenic sources are not included in the Electricity Delivered metric; however MWh from biogenic and all other generation sources are included. Geothermal generation CO₂ emissions and MWh are included in Net Generation metric but not Net Fossil Generation metric. Combustion sources related to any non-electricity generating natural gas operations are not included.

Comments:

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Energy Emissions

- CCAR General Protocol

California Climate Action Registry
General Reporting Protocol
Version 3.1 | January 2009

Emission Factors for Electricity Use

Table C.2 Carbon Dioxide, Methane and Nitrous Oxide Electricity Emission Factors by eGRID Subregion

eGRID Subregion Acronym	eGRID Subregion Name	CO ₂ (lbs/MWh)	CH ₄ (lbs/MWh)	N ₂ O (lbs/MWh)
AKGD	ASCC Alaska Grid	1,232.36	0.0256	0.0065
AKMS	ASCC Miscellaneous	498.86	0.0208	0.0041
AZNM	WECC Southwest	1,311.05	0.0175	0.0179
CAMX	WECC California	724.12	0.0206	0.0081

CCAR's protocol can be used to calculate CH₄ and N₂O emissions from energy usage

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Other sources

- Protocols can be used to evaluate emissions from stationary fuel combustion

Table C-7 Carbon Dioxide Emission Factors for Stationary Combustion

Fuel Type	Carbon Content	Heat Content	Fraction of Carbon	CO ₂ Emission Factor	CO ₂ Emission Factor
	kg C/GJ	MWh/GJ		kg CO ₂ /GJ	kg CO ₂ /MWh
Coal and Coke					
Anthracite	26.26	12.68	1.00	46.77	103.66
Bituminous	25.45	12.03	1.00	43.62	97.86
Sub-bituminous	24.45	11.25	1.00	40.62	91.46
Oil					
Residual/C Commercial	20.22	12.03	1.00	33.97 (3)	76.33
Residual/C Light	20.22	12.03	1.00	33.97 (3)	76.33
Other Industrial	25.23	12.03	1.00	42.84	96.56
Electric Power	25.26	12.03	1.00	42.87	96.61
Gas					
Propane	18.24	6.80	1.00	31.62	71.67
Butane	18.24	6.80	1.00	31.62	71.67
Ferrous Production					
Iron	kg C/GJ	Btu/GJ	kg C/GJ	kg CO ₂ /GJ	kg CO ₂ /MWh
Electricity	19.42	11.02	1.00	40.06	90.66
Aluminum Production					
Aluminum	19.42	11.02	1.00	40.06	90.66
Other					
Other	19.42	11.02	1.00	40.06	90.66

Table C-8 Methane and Nitrogen Oxide Emission Factors for Stationary Combustion for Petroleum Products by Fuel Type and Grade

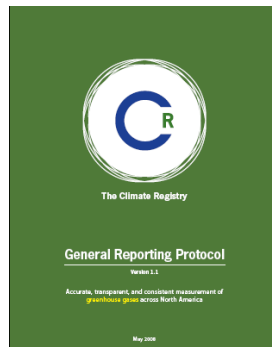
Fuel Type/End-use Sector	CH ₄ (kg/gallon)	N ₂ O (kg/gallon)
Gasoline	0.0013	0.0001
Jet Fuel	0.0013	0.0001
Aviation Turbine Fuel	0.0013	0.0001
Lighter Fuel Oil (LFO)	0.0013	0.0001
Medium Fuel Oil (MFO)	0.0013	0.0001
Residual Fuel Oil (RFO)	0.0013	0.0001
Propane	0.0013	0.0001
Butane	0.0013	0.0001
Commercial/Industrial		
Gasoline	0.0013	0.0001
Jet Fuel	0.0013	0.0001
Aviation Turbine Fuel	0.0013	0.0001
Lighter Fuel Oil (LFO)	0.0013	0.0001
Medium Fuel Oil (MFO)	0.0013	0.0001
Residual Fuel Oil (RFO)	0.0013	0.0001
Propane	0.0013	0.0001
Butane	0.0013	0.0001
Manufacturing/Construction		
Gasoline	0.0013	0.0001
Jet Fuel	0.0013	0.0001
Aviation Turbine Fuel	0.0013	0.0001
Lighter Fuel Oil (LFO)	0.0013	0.0001
Medium Fuel Oil (MFO)	0.0013	0.0001
Residual Fuel Oil (RFO)	0.0013	0.0001
Propane	0.0013	0.0001
Butane	0.0013	0.0001
Electric Power		
Gasoline	0.0013	0.0001
Jet Fuel	0.0013	0.0001
Aviation Turbine Fuel	0.0013	0.0001
Lighter Fuel Oil (LFO)	0.0013	0.0001
Medium Fuel Oil (MFO)	0.0013	0.0001
Residual Fuel Oil (RFO)	0.0013	0.0001
Propane	0.0013	0.0001
Butane	0.0013	0.0001

Table C-9 Methane and Nitrogen Oxide Emission Factors for Stationary Combustion by Fuel Type and Grade

Fuel Type/End-use Sector	CH ₄ (kg/MWh)	N ₂ O (kg/MWh)
Gasoline	0.0013	0.0001
Jet Fuel	0.0013	0.0001
Aviation Turbine Fuel	0.0013	0.0001
Lighter Fuel Oil (LFO)	0.0013	0.0001
Medium Fuel Oil (MFO)	0.0013	0.0001
Residual Fuel Oil (RFO)	0.0013	0.0001
Propane	0.0013	0.0001
Butane	0.0013	0.0001
Commercial/Industrial		
Gasoline	0.0013	0.0001
Jet Fuel	0.0013	0.0001
Aviation Turbine Fuel	0.0013	0.0001
Lighter Fuel Oil (LFO)	0.0013	0.0001
Medium Fuel Oil (MFO)	0.0013	0.0001
Residual Fuel Oil (RFO)	0.0013	0.0001
Propane	0.0013	0.0001
Butane	0.0013	0.0001
Manufacturing/Construction		
Gasoline	0.0013	0.0001
Jet Fuel	0.0013	0.0001
Aviation Turbine Fuel	0.0013	0.0001
Lighter Fuel Oil (LFO)	0.0013	0.0001
Medium Fuel Oil (MFO)	0.0013	0.0001
Residual Fuel Oil (RFO)	0.0013	0.0001
Propane	0.0013	0.0001
Butane	0.0013	0.0001
Electric Power		
Gasoline	0.0013	0.0001
Jet Fuel	0.0013	0.0001
Aviation Turbine Fuel	0.0013	0.0001
Lighter Fuel Oil (LFO)	0.0013	0.0001
Medium Fuel Oil (MFO)	0.0013	0.0001
Residual Fuel Oil (RFO)	0.0013	0.0001
Propane	0.0013	0.0001
Butane	0.0013	0.0001

Sector Specific Sources

- Many other protocols are available to evaluate other sources

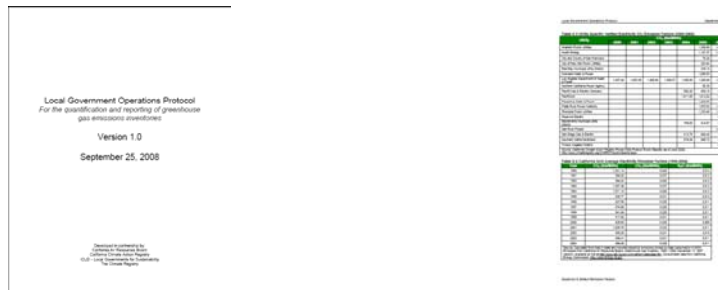


California
Climate Action Registry

Cement Reporting Protocol

Available Protocols

- ARB/ICLEI/CCAR/Climate Registry Local Government Operations Protocol
 - Local government inventory protocol for government operations
 - www.arb.ca.gov/cc/protocols/localgov/localgov.htm



Available Protocols

- U.S. EPA Methodology from Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007
 - Methodology for U.S. GHG inventory
 - <http://www.epa.gov/climatechange/emissions/usinventoryreport.html>

Cattle Type	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007
Dairy										
Cows	130	130	130	129	131	132	132	135	136	137
Replacements 7-11 months	46	46	45	45	45	45	45	45	45	45
Replacements 12-23 months	69	69	69	69	69	69	69	69	69	69
Beef										
Bulls	53	53	53	53	53	53	53	53	53	53
Cows	89	92	91	91	91	93	93	94	94	94
Replacements 7-11 months	24	21	21	21	21	24	24	24	24	24
Replacements 12-23 months	63	66	66	66	66	68	68	68	68	68
Other Stockers	55	56	58	58	58	58	57	58	57	57
Heifer Stockers	11	16	60	60	60	60	68	68	68	68
Feedlot Cattle	39	34	33	33	33	33	32	32	32	32

Note: To convert to a daily emission factor, the yearly emission factor can be divided by 365.25 (the average number of days in a year).

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Available Protocols

- IPCC Guidelines for National Greenhouse Gas Inventories
 - Guidance from IPCC for conducting inventories
 - <http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html>

2006 IPCC Guidelines for National Greenhouse Gas Inventories
Volume 1
General Guidance and Reporting

TABLE 3.3.4
METHANE MANAGEMENT METHANOL EMISSION FACTORS BY TEMPERATURE FOR CATTLE, SWINE, AND BIRDS^a
(kg CH₄/head^b/day^c)

Regional characteristics	Livestock species	CH ₄ emission factors by average annual temperature (°C) ^d															
		Cool						Warm									
North America: Liquid-based systems; no manure feed; no direct urine and manure storage. ^e Other parts of the world: manure is usually managed in a solid and deposited in manure or manure pits.	Cattle-Cows	40	50	55	58	60	65	68	70	74	76	80	82	85	88	90	95
	Other Cattle	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Other Swine	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18

TABLE 3.5.3
DEFAULT WATER-BORNE NAVIGATION CH₄ AND N₂O EMISSION FACTORS

	CH ₄ (kg/TJ)	N ₂ O (kg/TJ)
Ocean-going Ships *	7 ± 50%	2 +140% -40%

*Default values derived for diesel engines using heavy fuel oil.
Source: Lloyd's Register (1995) and EC (2002)

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Available Protocols

- IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories
 - Guidance from IPCC complimenting IPCC GHG inventory guidance
 - <http://www.ipcc-nggip.iges.or.jp/public/gp/english/>

Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories

TABLE 2.10
RECOMMENDED FACTORS FOR ESTIMATING EMISSIONS FROM ON-LAND GAS DEPOSITIONS
(SOURCE: 2006 IPCC GOOD PRACTICE GUIDANCE)

Country	Sub-Category	Default emission factor ^a			Units of Measure
		CH ₄	CO ₂	N ₂ O	
Wells	Drilling	4.9E-07	2.9E-08	0	kg per number of wells drilled
	Testing	1.7E-04	5.7E-05	6.8E-08	kg per number of wells drilled
	Severing	6.4E-05	4.8E-07	0	kg per number of producing and non-producing wells
Gas Production	All	2.2E-03 to 2.9E-03	9.5E-05	0	kg per 10 ⁹ m ³ gas production
	Flaring ^b	1.1E-05	1.8E-05	2.1E-08	kg per 10 ⁹ m ³ gas production
	Flare Gas	1.8E-04 to 1.0E-04	2.7E-05	0	kg per 10 ⁹ m ³ gas receipt
Gas Processing	Flaring	1.3E-05	2.1E-05	2.5E-08	kg per 10 ⁹ m ³ gas receipt
	Flare Gas	2.1E-04 to 2.9E-05	2.9E-05	0	kg per 10 ⁹ m ³ gas receipt
	Flaring	2.9E-05	4.8E-05	1.6E-08	kg per 10 ⁹ m ³ gas receipt
Deep-well Sequestration Sites	Flaring	0	7.1E-02	0	kg per 10 ⁹ m ³ gas receipt
	Flaring	1.0E-05	5.8E-07	0	kg per 10 ⁹ m ³ gas receipt
	Flaring	6.2E-06	9.7E-04	1.2E-08	kg per 10 ⁹ m ³ gas receipt
Gas Flaring & Drilling	Flaring ^b	2.1E-03 to 2.9E-03	1.0E-05	0	kg per year and per km of transmission pipeline
	Testing ^c	1.8E-03 to 1.2E-03	8.1E-06	0	kg per year and per km of transmission pipeline
	Drilling	4.1E-04 to 4.0E-04	0	0	kg per year and per 10 ⁹ m ³ gas withdrawal


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Available Protocols

- World Business Council for Sustainable Development/World Resources Institute Greenhouse Gas Protocol
 - Inventory protocols/tools for a variety of sources
 - <http://www.ghgprotocol.org/calculation-tools/all-tools>



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Available Protocols

- California Energy Commission Refining Estimates of Water-Related Energy Use in California
 - Provides general electricity use data associated with water use
 - http://www.energy.ca.gov/pier/project_reports/CEC-500-2006-118.html

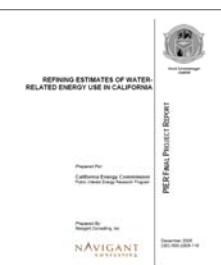


Table 7. Recommended revised water-energy proxies

	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

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Useful Tools/Websites

- California's climate change portal website:
<http://www.climatechange.ca.gov/>
- OPR's proposed CEQA Guideline amendments for greenhouse gas emissions plus list of over 900 documents with GHG discussion: www.opr.ca.gov
- CARB: Scoping Plan, meetings, webcasts:
<http://www.arb.ca.gov/cc/cc.htm>
- Attorney General's list of comment letters and FAQ:
<http://ag.ca.gov/globalwarming/ceqa.php>
- CAPCOA: <http://www.capcoa.org/climatechange/>
- SMAQMD's Climate Change:
<http://www.airquality.org/climatechange/index.html>

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**Climate Change Update:
Messages From the Ice**