



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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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

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

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>

Available Protocols

- California Climate Action Registry General Reporting Protocol, Version 3.1
 - Local government inventory protocol for California
 - <http://www.climateregistry.org/tools/protocols/general-reporting-protocol.html>

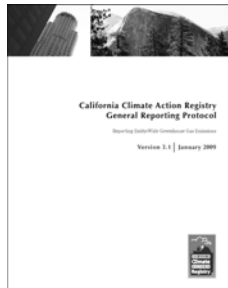


Table C-1 Carbon Dioxide Emission Factors for Stationary Combustion (continued)

Fuel Type	Carbon Content (MWh/ton)	Heat Content (Btu/ton)	Fractional Oxidized	CO ₂ Emission Factor (kg CO ₂ /MWh)	CO ₂ Emission Factor (kg CO ₂ /MMBtu)
Petroleum Products (liquid)	19.34	4,320	1.00	7.56	46.83
Petroleum Residue	19.37	4,428	1.00	9.18	71.03
Petroleum Coke	27.05	6,024	1.00	14.03	103.12
Solid Coal	19.18	4,400	1.00	9.17	64.31
Special Naphtha	19.86	5,260	1.00	9.18	72.82
Unrefined Oil	20.33	5,623	1.00	10.34	76.74
Waste	19.89	5,027	1.00	9.58	72.81
Non-Fossil Fuel (Solid)	kg C / MWh (solid fuel)	MMBtu / (solid fuel)		kg CO ₂ / (solid fuel)	kg CO ₂ / MWh (solid fuel)
Wood and Wood Waste (12% moisture content)	20.00	15.38	1.00	3.76, 3.0	43.87
Wood Fuel (Solid)	kg C / MWh (solid fuel)	Btu / (solid fuel)		kg CO ₂ / (solid fuel)	kg CO ₂ / MWh (solid fuel)
Biogas*	18.20	502.50	1.00	varies	52.07

*The CO₂ emissions from burning wood, wood waste and biogas are calculated separately and should not be included as a fossil stationary emission as part of inventory. The only fossil CO₂ emissions are from the biogas production process. The biogas production process is a fossil stationary emission and should be included as a fossil stationary emission in the biogas production process. The biogas production process is a fossil stationary emission and should be included as a fossil stationary emission in the biogas production process. The biogas production process is a fossil stationary emission and should be included as a fossil stationary emission in the biogas production process.

Available Protocols

- The Climate Registry General Reporting Protocol, Version 1.1
 - Local government inventory protocol
 - <http://www.theclimateregistry.org/resources/protocols/general-reporting-protocol.php>

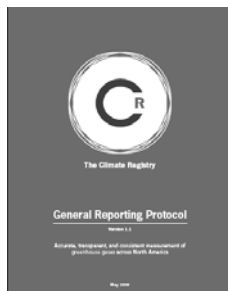


Table 13.6 Default CH₄ and N₂O Emission Factors for Non-Highway Vehicles

Vehicle Type / Fuel Type	CH ₄ (g / gallon fuel)	N ₂ O (g / gallon fuel)
Motor and Boats		
Gasoline, Petrol, Gas	0.25	0.03
Gasoline, Fuel	0.26	0.04
Gasoline, Fuel	0.22	0.04
Marine Engines		
Gasoline, Fuel	0.26	0.05
Refrigerant Equipment		
Refrigerant	0.22	1.08
Refrigerant	0.26	1.04
Combustion		
Gasoline, Fuel	0.22	0.05
Gasoline, Fuel	0.26	0.04
Other Non-Highway		
Refrigerant, Equipment	0.22	0.05
Other Refrigerator	0.22	0.05
Other Small Utility	0.22	0.05
Other Large Utility	0.22	0.05
Other Large Utility (Green)	0.26	0.05
Other		
Jet Fuel	0.31	0.07
Aviation Gasoline	0.31	0.07

NOTE: SOURCE: U.S. EPA OFFICE OF AIR QUALITY PLANNING AND STANDARDS (2007) BASED ON U.S. EPA INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS: 1990-2006 (2007), TABLE 3.6, TABLE A-20.

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>



Table A-162: Calculated National Emission Factors for Cattle by Animal Type (kg GH₄/head/year)

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	51	56	60	60	60	60	58	58	58	58
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).

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 FEEDSTOCK 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 dairy cattle and swine operations. ^e Other cattle, swine and birds are usually managed in a mixed and depend on systems in region.	Cattle-Cows	40	50	55	58	60	65	68	70	72	74	76	78	80	82	84	86	100	110	112
	Cattle-Cows	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Market Swine	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	20


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)

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/>



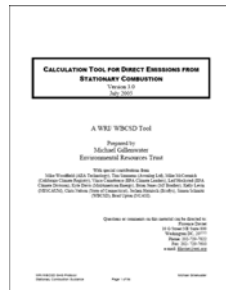
Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories

TABLE 2.10
REVISION TWO 2 EMISSION FACTORS FOR FERTILISER AND MANURE FROM ON-FARM GAS EMISSIONS
(kg CO₂e/ha/yr)

Country	Sub-Category	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	
	Sealing	6.4E-05	4.8E-07	0	kg per number of producing and non-producing wells	
	Shoring	2.2E-03 to 2.9E-03	9.5E-05	0	kg per 10 ³ m ³ gas production	
Gas Production	Flaring ^b	1.1E-05	1.8E-05	2.1E-08	kg per 10 ³ m ³ gas production	
		Flaring	1.8E-04 to 1.0E-04	2.7E-05	0	kg per 10 ³ m ³ gas receipt
	Flare Gas Flare	Flaring	1.3E-05	2.1E-05	2.5E-08	kg per 10 ³ m ³ gas receipt
		Flaring	2.1E-04 to 2.1E-04	2.8E-05	0	kg per 10 ³ m ³ gas receipt
	Flare Gas Flare	Flaring	2.9E-05	4.8E-05	1.6E-08	kg per 10 ³ m ³ gas receipt
		Flaring	0	7.1E-02	0	kg per 10 ³ m ³ gas receipt
	Deep-well Sealed-in Wells	Flaring	1.0E-05	5.8E-07	0	kg per 10 ³ m ³ gas receipt
		Flaring	6.2E-06	9.7E-04	1.2E-08	kg per 10 ³ m ³ gas receipt
		Flaring	2.1E-03 to 2.9E-03	1.0E-05	0	kg per year well production of hydrocarbon gas/liquid
		Flaring	1.8E-03 to 1.2E-03	8.1E-06	0	kg per year well production of hydrocarbon gas/liquid
Gas Flaring & Drilling	Flaring	1.8E-03 to 1.2E-03	8.1E-06	0	kg per year well production of hydrocarbon gas/liquid	
	Flaring	1.8E-03 to 1.2E-03	8.1E-06	0	kg per year well production of hydrocarbon gas/liquid	
Storage	Flaring	4.1E-04 to 4.1E-04	0	0	kg per year well production of hydrocarbon gas/liquid	
	Flaring	4.1E-04 to 4.1E-04	0	0	kg per year well production of hydrocarbon gas/liquid	

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>



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

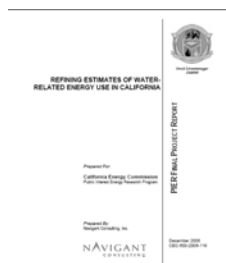


Table 7. Recommended revised water-energy proxies

	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

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>