



2006 Area Source Emissions Inventory Methodology

610 – RESIDENTIAL NATURAL GAS COMBUSTION

I. Purpose

This document describes the Area Source Methodology used to estimate emissions carbon dioxide (CO₂), nitrogen oxides (NO_x), fine particulate matter less than 10 microns (PM₁₀), volatile organic compounds (VOC), and sulfur oxides (SO_x) from the combustion of natural gas within the residential sector in the San Joaquin Valley Air Basin. An area source is a collection of similar emission units within a geographic area (ie., a County). Area sources collectively represent individual sources that are small and numerous, and that have not been inventoried as specific point, mobile, or biogenic sources. The California Air Resources Board (CARB) has grouped these individual sources with other like sources into area source categories. These source categories are grouped in such a way that they can be estimated collectively using one methodology.

II. Applicability

The emission calculations from this Area Source Methodology apply to facilities that are identified by the following Category of Emission Source (CES) codes and Reconciliation Emission Inventory Codes (REIC):

Table 1. Emission inventory codes.

CES	REIC	Description
54569	610-606-0110-0000	Residential Fuel Combustion - Natural Gas - Space Heating
54577	610-608-0110-0000	Residential Fuel Combustion - Natural Gas - Water Heating
54585	610-610-0110-0000	Residential Fuel Combustion - Natural Gas - Cooking
47191	610-995-0110-0000	Residential Fuel Combustion - Natural Gas - Other

III. Point Source Reconciliation

Emissions from the area source inventory and point source inventory are reconciled against each other to prevent double counting. This is done using relationships created by the California Air Resources Board (ARB) between the area source REIC and the point sources' Standard Industry Classification (SIC) code and emissions process Source Category Code (SCC) combinations. The area sources in this methodology are not represented within our point source inventory so reconciliation is not necessary.

IV. Methodology Description

This methodology is a top down estimation of emissions from the combustion of natural gas by the residential sector within the San Joaquin Valley. Residential natural gas deliveries for each county within the District are obtained from the California Energy Commission (CEC), then apportioned into the following four end use categories: 1) space heating, 2) water heating, 3) cooking, and 4) unspecified. The unspecified category includes natural gas consumption from appliances such as clothes dryers, barbecues, and water heaters used for pools, spas and hot tubs. To estimate area source emissions, the end use process rates were multiplied by emission factors.

V. Activity Data

Consumption. The amount of natural gas consumed in the residential sector for each county in the San Joaquin Valley in 2006 was obtained from the CEC and is presented in the table below:

Table 2. Residential natural gas deliveries reported by the CEC in 2006

County	Million Therms Reported	MMSCF Calculated	Percent of Total Deliveries
Fresno	111	11,100	24.0%
Kern	96	9,600	20.8%
Kings	15	1,500	3.2%
Madera	8	800	1.7%
Merced	26	2,600	5.6%
San Joaquin	89	8,900	19.3%
Stanislaus	66	6,600	14.3%
Tulare	51	5,100	11.0%
Total	462	46,200	100.0%

Categorization. Using the data from the 2004 KEMA-XENERGY report entitled "California Statewide Residential Appliance Saturation Study," consumption was apportioned into four end use categories as presented in the table below:

Table 3. Residential end use of natural gas.

Category	Consumption (%)
Space heating	44%
Water heating	44%
Cooking	7%
Other	5%

VI. Emission Factors

NO_x, CO, SO_x, VOC and PM emission factors for residential natural gas combustion were obtained from EPA’s AP-42 Chapter 1 Section 4 (1998). At this time, each category uses the emission factors for uncontrolled residential furnaces.

Table 4. Industrial natural gas combustion emission factors.

Combustion process	Emissions (pounds per million cubic feet)				
	NO _x	CO	SO _x	VOC	PM
Space heating	94	40	0.6	5.5	7.6
Water heating	94	40	0.6	5.5	7.6
Cooking	94	40	0.6	5.5	7.6
Other	94	40	0.6	5.5	7.6

VII. Emissions Calculations

A. Assumptions

1. Natural gas deliveries are accurately reported by the California Energy Commission.
2. KEMA-XENERGY study of the end-use consumption of natural gas within the residential sector accurately describes consumption within the District.
3. The AP-42 emission factors selected are representative.

B. Sample Calculations

The emissions for each criteria pollutant within this area source methodology can be calculated using the following equation:

$$Emissions \left(\frac{tons}{yr} \right) = Fuel\ Consumption \left(\frac{MMSCF}{yr} \right) \times (\% \text{ End Use }) \times Emission\ Factor \left(\frac{lbs\ of\ Emissions}{MMSCF} \right) \times \left(\frac{1\ ton}{2000\ lbs} \right)$$

For NO_x emissions due to natural gas combustion in residential water heaters in Fresno County:

Given:

1. The area source consumption of natural gas by the residential sector in Fresno County was 11,100 MMSCF (million std. cubic feet) in 2006 (Table 2).
2. 44% of residential natural gas end use was for water heating (Table 3).
3. The NOx emission factor for residential natural gas combustion is 94 pounds per million cubic feet of natural gas burned (Table 4).

Calculate Emissions:

$$NOx \text{ Emissions} = \left(\frac{11,100 \text{ MMSCF}}{\text{Year}} \right) \times (0.44) \times \left(\frac{94 \text{ lb of NOx}}{\text{MMSCF}} \right) = \frac{459,096 \text{ lbs of NOx}}{\text{Year}}$$

$$NOx \text{ Emissions} = \left(\frac{459,096 \text{ lbs of NOx}}{\text{Year}} \right) \times \left(\frac{1 \text{ ton}}{2,000 \text{ lbs}} \right) = \frac{229.5 \text{ tons of NOx}}{\text{Year}}$$

VIII. Temporal Variation

The following section outlines the daily, weekly, and monthly consumption of natural gas within the San Joaquin Valley for each end use category due to temporal variations.

A. Space heating:

Daily: ARB code 33. The maximum activity occurs in the mornings and evenings.

Weekly: ARB code 7. Uniform activity.

Monthly: Monthly activity in California is higher in the winter as illustrated by residential delivery data from the U.S. Department of Energy’s Energy Information Administration, presented below:

Table 5: California monthly natural gas consumption.

Month (2005)	Natural Gas Consumption (million cubic feet)	Activity Level (% of annual)
January	81,221	16.0%
February	64,536	12.7%
March	51,395	10.1%
April	41,057	8.1%
May	34,041	6.7%
June	29,186	5.7%
July	27,637	5.4%
August	25,610	5.0%
September	24,567	4.8%
October	30,037	5.9%
November	36,497	7.2%
December	62,440	12.3%
Total	508,224	100.0%

B. Water heating:

Daily: ARB code 33. The maximum activity occurs in the mornings and evenings.

Weekly: ARB code 7. Uniform activity.

Monthly: Monthly activity in California is higher in the winter as illustrated by residential delivery data from the U.S. Department of Energy’s Energy Information Administration presented in Table 5.

C. Cooking:

Daily: ARB code 38. The maximum activity occurs during mealtime hours.

Weekly: ARB code 7. Uniform activity.

Monthly: 8.33% monthly activity. Uniform activity.

D. Other

Daily: ARB code 24. Uniform activity.

Weekly: ARB code 7. Uniform activity.

Monthly: 8.33% monthly activity. Uniform activity.

IX. Spatial Variation

Emissions from this category can be distributed to residential parcels within each county.

X. Growth Factor

Growth factors are developed by either the District’s Planning Department or CARB for each EIC. These factors are used to estimate emissions in future years. The growth factors associated with this emissions category may be obtained from the Air Quality Analysis Section of the District’s Planning Department.

XI. Control Level

Control levels are developed by either the District’s Planning Department or CARB for each EIC. Control levels are used to estimate emissions reductions in future years due to implementation of District rules. These control levels take into account the effect of control technology, compliance and exemptions at full implementation of the rules.

Residential natural gas fired water heaters are subject to District Rule 4902 (Residential Water Heaters). Control levels associated with this emissions category may be obtained from the Air Quality Analysis Section of the District’s Planning Department.

XII. ARB Chemical Speciation

CARB has developed organic gas profiles in order to calculate reactive organic gasses (ROG), volatile organic compounds (VOC) or total organic gas (TOG) given any one of the three values. For each speciation profile, the fraction of TOG that is ROG and VOC is given. The organic gas profile codes can also be used to lookup associated toxics. CARB’s speciation profile for residential natural gas combustion processes is presented in Table 6.

Table 6. CARB chemical speciation profiles for residential natural gas combustion.

Profile Description	ARB Organic Gas Profile#	Fractions	
		ROG	VOC
External Combustion Boiler - Natural Gas	3	0.422181	0.422181

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CARB has developed particulate matter speciation profiles in order to calculate particulate matter (PM), particulate matter with a diameter less than or equal to 10 microns (PM₁₀) or particulate matter with a diameter less than or equal to 2.5 microns (PM_{2.5}) given any one of the three values. For each speciation profile, the fraction of PM that is PM₁₀ and PM_{2.5} is given. The particulate matter profile codes can also be used to lookup associated toxics. CARB's speciation profile for residential natural gas combustion processes is presented in Table 7.

Table 7. CARB chemical speciation profile for residential natural gas combustion.

Profile Description	ARB PM Profile#	Fractions	
		PM ₁₀	PM _{2.5}
Residential Natural Gas	121	1	1

XIII. Assessment Of Methodology

This is a top down estimation of area wide emissions from natural gas combustion in the residential sector. Due to the many assumptions necessary for this type of estimation, we have tried to be as conservative as possible.

XIV. Emissions

Following is the 2006 area source emissions inventory for residential natural gas combustion REICs 610-606-0110-0000 (Space Heating), 610-608-0110-0000 (Water Heating), 610-610-0110-0000 (Cooking) and 610-995-0110-0000 (Other) estimated by this methodology. Emissions are reported for each county in the District.

Table 8. Area source emissions for residential natural gas combustion (2006).

County	Emissions (tons/year)				
	NOx	CO	SOx	VOC	PM
RESIDENTIAL FUEL COMBUSTION – NAT. GAS - SPACE HEATING					
Fresno	229.97	97.86	1.47	13.46	18.59
Kern	198.12	84.31	1.26	11.59	16.02
Kings	31.51	13.41	0.20	1.84	2.55
Madera	17.01	7.24	0.11	1.00	1.38
Merced	53.57	22.80	0.34	3.13	4.33
San Joaquin	184.81	78.64	1.18	10.81	14.94
Stanislaus	136.44	58.06	0.87	7.98	11.03
Tulare	106.48	45.31	0.68	6.23	8.61
TOTAL	957.92	407.62	6.11	56.05	77.45
RESIDENTIAL FUEL COMBUSTION – NAT. GAS - WATER HEATING					
Fresno	229.97	97.86	1.47	13.46	18.59
Kern ⁽¹⁾	198.12	84.31	1.26	11.59	16.02
Kings	31.51	13.41	0.20	1.84	2.55
Madera	17.01	7.24	0.11	1.00	1.38
Merced	53.57	22.80	0.34	3.13	4.33
San Joaquin	184.81	78.64	1.18	10.81	14.94
Stanislaus	136.44	58.06	0.87	7.98	11.03
Tulare	106.48	45.31	0.68	6.23	8.61
TOTAL	957.92	407.62	6.11	56.05	77.45
RESIDENTIAL FUEL COMBUSTION – NAT. GAS – COOKING					
Fresno	36.59	15.57	0.23	2.14	2.96
Kern ⁽¹⁾	31.52	13.41	0.20	1.84	2.55
Kings	5.01	2.13	0.03	0.29	0.41
Madera	2.71	1.15	0.02	0.16	0.22
Merced	8.52	3.63	0.05	0.50	0.69
San Joaquin	29.40	12.51	0.19	1.72	2.38
Stanislaus	21.71	9.24	0.14	1.27	1.76
Tulare	16.94	7.21	0.11	0.99	1.37
TOTAL	152.40	64.85	0.97	8.92	12.32
RESIDENTIAL FUEL COMBUSTION – NAT. GAS – OTHER					
Fresno	26.13	11.12	0.17	1.53	2.11
Kern ⁽¹⁾	22.51	9.58	0.14	1.32	1.82
Kings	3.58	1.52	0.02	0.21	0.29
Madera	1.93	0.82	0.01	0.11	0.16
Merced	6.09	2.59	0.04	0.36	0.49
San Joaquin	21.00	8.94	0.13	1.23	1.70
Stanislaus	15.50	6.60	0.10	0.91	1.25
Tulare	12.10	5.15	0.08	0.71	0.98
TOTAL	108.85	46.32	0.69	6.37	8.80

(1) Includes both the Valley and non-Valley portions of Kern County.

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Following is the net change in total emissions between this update (2006 inventory year) and the previous update (2005 inventory year) for residential natural gas combustion REICs 610-606-0110-0000 (Space Heating), 610-608-0110-0000 (Water Heating), 610-610-0110-0000 (Cooking) and 610-995-0110-0000 (Other) estimated by this methodology. Emissions are reported for each county in the District.

Table 9. Net change in area source emissions for residential natural gas combustion (2005-2006).

County	Emissions (tons/year)				
	NOx	CO	SOx	VOC	PM
RESIDENTIAL FUEL COMBUSTION – NAT. GAS - SPACE HEATING					
Fresno	6.62	2.82	0.04	0.39	0.54
Kern ⁽¹⁾	-0.41	-0.17	0.00	-0.02	-0.03
Kings	0.49	0.21	0.00	0.03	0.04
Madera	0.47	0.20	0.00	0.03	0.04
Merced	-0.20	-0.08	0.00	-0.01	-0.02
San Joaquin	-1.31	-0.56	-0.01	-0.08	-0.11
Stanislaus	-0.04	-0.02	0.00	0.00	0.00
Tulare	1.02	0.43	0.01	0.06	0.08
TOTAL	6.64	2.82	0.04	0.39	0.54
RESIDENTIAL FUEL COMBUSTION – NAT. GAS - WATER HEATING					
Fresno	6.62	2.82	0.04	0.39	0.54
Kern ⁽¹⁾	-0.41	-0.17	0.00	-0.02	-0.03
Kings	0.49	0.21	0.00	0.03	0.04
Madera	0.47	0.20	0.00	0.03	0.04
Merced	-0.20	-0.08	0.00	-0.01	-0.02
San Joaquin	-1.31	-0.56	-0.01	-0.08	-0.11
Stanislaus	-0.04	-0.02	0.00	0.00	0.00
Tulare	1.02	0.43	0.01	0.06	0.08
TOTAL	6.64	2.82	0.04	0.39	0.54
RESIDENTIAL FUEL COMBUSTION – NAT. GAS – COOKING					
Fresno	1.05	0.45	0.01	0.06	0.09
Kern ⁽¹⁾	-0.06	-0.03	0.00	0.00	-0.01
Kings	0.08	0.03	0.00	0.00	0.01
Madera	0.07	0.03	0.00	0.00	0.01
Merced	-0.03	-0.01	0.00	0.00	0.00
San Joaquin	-0.21	-0.09	0.00	-0.01	-0.02
Stanislaus	-0.01	0.00	0.00	0.00	0.00
Tulare	0.16	0.07	0.00	0.01	0.01
TOTAL	1.06	0.45	0.01	0.06	0.09
RESIDENTIAL FUEL COMBUSTION – NAT. GAS – OTHER					
Fresno	0.75	0.32	0.00	0.04	0.06
Kern	-0.05	-0.02	0.00	0.00	0.00
Kings	0.06	0.02	0.00	0.00	0.00
Madera	0.05	0.02	0.00	0.00	0.00
Merced	-0.02	-0.01	0.00	0.00	0.00
San Joaquin	-0.15	-0.06	0.00	-0.01	-0.01
Stanislaus	-0.01	0.00	0.00	0.00	0.00
Tulare	0.12	0.05	0.00	0.01	0.01
TOTAL	0.75	0.32	0.00	0.04	0.06

(1) Includes both the Valley and non-Valley portions of Kern County.

XV. Revision History

2006. The methodology was reformatted to the new District standard. Process rates were updated.

2005. This is a new District methodology.

XVI. Update Schedule

The area source categories within this methodology have update authority “B” codes. This means that ARB develops default emissions for these sources, but Districts may overwrite them subject to ARB review and approval. Since the District is not directly responsible for maintaining these area source categories, they will only be updated as needed.

XVII. References

1. California Air Resources Board. (1998). Methods for assessing area source emissions in California Section 7.2 – Residential natural gas combustion. <http://www.arb.ca.gov/ei/areasrc/ONEHTM/ONE7-2.HTM>. 12 pp.
2. California Gas Utilities. (2005). California gas report 2005 supplement. <http://www.pge.com/pipeline/library/regulatory/downloads/cgr05.pdf>
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4. KEMA-XENERGY, Itron, and RoperASW. (2004). “California Statewide Residential Appliance Saturation Study,” Report prepared for the California Energy Commission. Publication No. 400-04-009.
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7. United States Environmental Protection Agency. (1993). Supplement D to Compilation of Emission Factors (AP-42), U.S. GPO, Washington D.C., 1993. <http://www.epa.gov/ttn/chief/ap42/>