# SECTION 7.3

# RESIDENTIAL FUEL COMBUSTION

*(Revised March 1993)*

**EMISSION INVENTORY SOURCE CATEGORY**
Miscellaneous Processes/Residential Fuel Combustion

**EMISSION INVENTORY CODES (CES CODES) AND DESCRIPTION**
**610-606-1220-0000 (47209)** Residential Distillate Oil Combustion

**610-995-0120-0000 (47217)** Residential L.P.G. Combustion

## METHODS AND SOURCES

Home Heating by Distillate Oil and LPG vs Natural Gas

Distillate oil was used long before LPG and natural gas were commonly used for residential heating. Gradually natural gas pipe lines were laid out for homes because it was more cost effective in areas of higher population density.

Presently distillate oil for heating is used only in older homes and/or in remote areas where natural gas lines are too expensive to be installed. LPG is the next best choice where natural gas is not available, such as farm houses, resort cabins or hilly areas. LPG is a clean burning fuel and can be easily transported.

Heating with distillate oil requires storage tanks(s), and large furnace(s) for atomization and combustion. Storage tanks should be inspected periodically to prevent leakage. Atomized oil is burned in a combustion chamber where it heats air circulation coils. Air is then pumped through the circulation coils and into the house. Lower equipment maintenance, reduced black soot and SOx emissions are some of the positive factors that result when replacing oil furnaces with LPG or natural gas (if available) furnaces. LPG and natural gas furnaces need little or no maintenance for long periods of time.

The emission estimates for LPG and distillate oil as home-heating fuels are based on the number of housing units, population [1] and LPG and distillate oil capacities.

For the 1979 inventory, and for inventories up to 1990, emissions have been estimated by

applying Growth and Control factors. For the 1991 inventory, the emission estimates are based on the "1991 FUELS REPORT WORKING PAPER" [2] (published by California Energy Commission in December 1991), the monthly HEATING DEGREE DAYS [3] reports and the number of housing units heated by LPG and distillate oil. [4] The projected estimates for home heating oil and LPG for 1991 were six trillion BTU's for oil and 23 trillion BTU's for LPG.

The Fuels Report Working Paper published by the California Energy Commission in December 1991 lists energy demand for 1990 by fuel type. Six trillion BTU's of distillate oil and 20 trillion BTU's of LPG were used by the residential sector in California. This is equivalent to 43.26 million gallons of distillate oil and 203.4 million gallons of LPG respectively.

Heating degree days (HDD) are a measure of how cold a location was over a period of time, relative to the base temperature. In this report the base temperature used is 65 degrees Fahrenheight and the period of time is one year. The HDDs for an individual is the difference between the base temperature and the day's average temperature. The average daily temperature is the mean of the maximum and minimum temperature for a 24-hour period. HDDs are calculated by subtracting the average daily temperature below 65 degrees F from the base 65. For example, a day with an average temperature of 50 degrees F has 15 HDDs (65-50=15), while one with an average temperature of 65 degrees F or higher has zero. The number of houses heated by a specific fuel (distillate oil or LPG) times the number of HDDs determines the quality of energy consumed in California and thus the emissions of the criteria pollutants.

EMISSION FACTORS FOR OIL AND LPG (lb per 1000 gals)

| FUEL | TOG | CO | NOx | SOx* | PM |
|---|---|---|---|---|---|
| DISTILLATE | 2.493 | 5.0 | 18.0 | 36 | 2.5 |
| LPG | 0.73 | 1.85 | 9.1 | 0.014 | 0.28 |

*Distillate oil is assumed to have one quarter of one percent of sulfur by weight.

## TEMPORAL ACTIVITY

The annual, weekly, and daily activities have been estimated by the ARB staff. The annual activity of distillate oil and LPG for residential heating purposes is highest from October to late April. The weekly activity is uniform. The daily activity is greatest during the evenings and early morning hours.

The codes for temporal profile and monthly throughput are assumed to be as follows:

| CES | Hours | Days | Weeks |
|---|---|---|---|
| 47209 | 33 | 7 | 0 |
| 47217 | 33 | 7 | 0 |

| CES | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 47209 | 182 | 182 | 127 | 91 | 0 | 0 | 0 | 0 | 0 | 91 | 145 | 182 |
| 47217 | 182 | 182 | 127 | 97 | 0 | 0 | 0 | 0 | 0 | 91 | 145 | 182 |

## ASSUMPTIONS

The Average Degree-Days in each county are assumed to be the same throughout the county. Heating units are assumed to be of the same size.

## RELIABILITY FACTOR

The reliability factors have not been determined

## CHANGES IN METHODOLOGY

In the 1979 database, the emissions are based on the number of housing units, the population and an average energy demand per household and the average capacities of LPG and distillate oil.

In the 1990 data base, the emissions are calculated on number of housing units, degree days and the equivalent of energy dissipated by each fuel.

## DIFFERENCES BETWEEN 1989 and 1991 EMISSION ESTIMATES

The 1989 emission estimates are estimated with growth and control factors as are all inventories since 1979. The principal emission factor was “Average Energy Demand Per Household”. For the 1991 inventory, emissions are based on “Heating Degree Days”. These vary in each region of the state and had been taken form 1991 climatic reports. [3]

## SAMPLE CALCULATIONS

The energy dissipated for heating homes where LPG and distillate oil were burned have been taken for the “1991 Fuels Report Working Paper” published by the California Energy Commission. Energy consumed for each fuel has been converted to gallons of fuel and the appropriate emission factors [5] were applied to calculate emissions of criteria pollutants. The number of houses using LPG and distillate were taken from the 1990 Census of Population and Housing. The number of housed in counties with split air basins are based on “Population and

Housing Estimates of California Cities and Counties E-5." [6]

Emissions for each county using these fuels for heating purposes have been calculated as follows: Criteria pollutant emissions for county (A) = Number of houses using LPG or distillate oil in county (A) X the Average Degree Days in county (A) X criteria pollutant emissions for the state / Total of number of Houses x Average degree days (in each county) for all counties (using this fuel in state).

For example:

NOx emissions for LPG in CO (A)

$$E = \frac{\text{\# of houses using LPG In Co (A) x Ave Deg Days in Co (A)}}{\text{NOx emissions using LPG for state x (number of LPG houses x Average Deg Days (each Co))}}$$

For example:

NOx emissions for LPG in Nevada Co.

$$E = \frac{(6785 \times 6225) \times 995}{103{,}1509{,}447} = 40.74 \text{ tons/yr}$$

## ADDITIONAL CODES

SOURCE CATEGORY GROWTH AND CONTROL CODES
- 47209 Growth = 510, Control = 114
- 47217 Growth = 510, Control = 99

SOURCE CATEGORY CODE POLLUTANT SPECIATION PROFILES
- 47209 VOC = 601, PM = 112
- 47217 VOC = 601, PM = 121

SOURCE CATEGORY CODE REACTIVITY FACTORS
- Not Available

## REFERENCES


1. Department of Finance, Controlled County Population Estimate for 1-1-80 (April 1980).

2. California Energy Commission, California Energy Statistics, (December 1991) Report # P300-91-018WPI.

3. National Climatic Data Center, Federal Building, 37 Battery Park Ave., Ash Villa, NC 28801-2733 - Local Climatic Data, 1ssn 0198-0912.

4. Department of Finance, 1990 Census of Population & Housing - Summary Tape File 3A.

5. United States Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle, NC 27711 (AP-42) Fourth Edition, September 1985.

6. Department of Finance, Population and Housing Estimates of California Cities and Counties Report E-5.


## PREPARED BY


Ranjit Grewal
January 3, 1995

Table I
1991 Area Source Emissions
Activity: Residential
Process: Fuel Combustion
Entrainment: Distillate Oil - Combustion
Dimn: Residential
CES: 47209
Process Rate Unit: 1000 Gallons Burned

| AB | County | Process Rate | TOG Emis. (Tons / Year) | CO Emis. (Tons / Year) | NOX Emis. (Tons / Year) | SOX Emis. (Tons / Year) | PM Emis. (Tons / Year) |
|---|---|---|---|---|---|---|---|
| GBV | ALPINE | 96 | 0.10 | 0.20 | 0.90 | 1.70 | 0.10 |
| | INYO | 103 | 0.10 | 0.30 | 0.90 | 1.90 | 0.10 |
| | MONO | 210 | 0.30 | 0.50 | 1.90 | 3.80 | 0.30 |
| LC | LAKE | 1808 | 2.30 | 4.50 | 16.30 | 32.50 | 2.30 |
| LT | EL DORADO | 484 | 0.60 | 1.20 | 4.40 | 8.70 | 0.60 |
| | PLACER | 91 | 0.10 | 0.20 | 0.80 | 1.60 | 0.10 |
| MC | AMADOR | 140 | 0.20 | 0.30 | 1.30 | 2.50 | 0.20 |
| | CALAVERAS | 132 | 0.20 | 0.30 | 1.20 | 2.40 | 0.20 |
| | EL DORADO | 1380 | 1.70 | 3.40 | 12.40 | 24.80 | 1.70 |
| | MARIPOSA | 91 | 0.10 | 0.20 | 0.80 | 1.60 | 0.10 |
| | NEVADA | 2703 | 3.40 | 6.80 | 24.30 | 48.70 | 3.40 |
| | PLACER | 203 | 0.30 | 0.50 | 1.80 | 3.70 | 0.30 |
| | PLUMAS | 1139 | 1.40 | 2.80 | 10.30 | 20.50 | 1.40 |
| | SIERRA | 215 | 0.30 | 0.50 | 1.90 | 3.90 | 0.30 |
| | TUOLUMNE | 416 | 0.50 | 1.00 | 3.70 | 7.50 | 0.50 |
| NC | DEL NORTE | 766 | 1.00 | 1.90 | 6.90 | 13.80 | 1.00 |
| | HUMBOLDT | 1145 | 1.40 | 2.90 | 10.30 | 20.60 | 1.40 |
| | MENDOCINO | 3126 | 3.90 | 7.80 | 28.10 | 56.30 | 3.90 |
| | SONOMA | 114 | 0.10 | 0.30 | 1.00 | 2.10 | 0.10 |
| | TRINITY | 220 | 0.30 | 0.50 | 2.00 | 4.00 | 0.30 |
| NCC | MONTEREY | 698 | 0.90 | 1.70 | 6.30 | 12.60 | 0.90 |
| | SAN BENITO | 103 | 0.10 | 0.30 | 0.90 | 1.90 | 0.10 |
| | SANTA CRUZ | 1376 | 1.70 | 3.40 | 12.40 | 24.80 | 1.70 |
| NEP | LASSEN | 2274 | 2.80 | 5.70 | 20.50 | 40.90 | 2.80 |
| | MODOC | 767 | 1.00 | 1.90 | 6.90 | 13.80 | 1.00 |
| | SISKIYOU | 3768 | 4.70 | 9.40 | 33.90 | 67.80 | 4.70 |
| SC | LOS ANGELES | 1095 | 0.10 | 2.70 | 18.10 | 21.10 | 2.30 |
| | ORANGE | 108 | 0.00 | 0.30 | 1.80 | 2.10 | 0.20 |
| | RIVERSIDE | 62 | 0.00 | 0.20 | 1.00 | 1.20 | 0.10 |
| | SAN BERNARDINO | 153 | 0.00 | 0.40 | 2.50 | 2.90 | 0.30 |
| SCC | SAN LUIS OBISPO | 146 | 0.20 | 0.40 | 1.30 | 2.60 | 0.20 |
| | SANTA BARBARA | 165 | 0.20 | 0.40 | 1.50 | 3.00 | 0.20 |
| | VENTURA | 109 | 0.10 | 0.30 | 1.00 | 2.00 | 0.10 |
| SD | SAN DIEGO | 3476 | 4.30 | 8.70 | 31.30 | 62.60 | 4.30 |
| SED | IMPERIAL | 24 | 0.00 | 0.10 | 0.20 | 0.40 | 0.00 |
| | KERN | 31 | 0.00 | 0.10 | 0.30 | 0.60 | 0.00 |
| | LOS ANGELES | 98 | 0.00 | 0.20 | 1.60 | 1.90 | 0.20 |
| | RIVERSIDE | 72 | 0.00 | 0.20 | 1.20 | 1.40 | 0.20 |
| | SAN BERNARDINO | 138 | 0.20 | 0.30 | 1.20 | 2.50 | 0.20 |
| SF | ALAMEDA | 469 | 0.59 | 1.17 | 4.22 | 16.66 | 0.59 |
| | CONTRA COSTA | 137 | 0.17 | 0.34 | 1.24 | 4.88 | 0.17 |
| | MARIN | 235 | 0.29 | 0.59 | 2.11 | 8.33 | 0.29 |
| | NAPA | 90 | 0.11 | 0.22 | 0.81 | 3.18 | 0.11 |
| | SAN FRANCISCO | 1944 | 2.43 | 4.86 | 17.50 | 69.02 | 2.43 |
| | SAN MATEO | 396 | 0.49 | 0.99 | 3.56 | 14.04 | 0.49 |
| | SANTA CLARA | 545 | 0.68 | 1.36 | 4.91 | 19.36 | 0.68 |
| | SOLANO | 92 | 0.11 | 0.23 | 0.83 | 3.26 | 0.11 |
| | SONOMA | 270 | 0.34 | 0.68 | 2.43 | 9.60 | 0.34 |
| SJV | FRESNO | 426 | 0.50 | 1.10 | 3.80 | 7.70 | 0.50 |
| | KERN | 191 | 0.20 | 0.50 | 1.70 | 3.40 | 0.20 |
| | KINGS | 18 | 0.00 | 0.00 | 0.20 | 0.30 | 0.00 |
| | MADERA | 146 | 0.20 | 0.40 | 1.30 | 2.60 | 0.20 |
| | MERCED | 131 | 0.20 | 0.30 | 1.20 | 2.40 | 0.20 |
| | SAN JOAQUIN | 452 | 0.60 | 1.10 | 4.10 | 8.10 | 0.60 |
| | STANISLAUS | 201 | 0.30 | 0.50 | 1.80 | 3.60 | 0.30 |
| | TULARE | 166 | 0.20 | 0.40 | 1.50 | 3.00 | 0.20 |
| SV | BUTTE | 236 | 0.30 | 0.60 | 2.10 | 4.20 | 0.30 |
| | COLUSA | 103 | 0.10 | 0.30 | 0.90 | 1.90 | 0.10 |
| | GLENN | 88 | 0.10 | 0.20 | 0.80 | 1.60 | 0.10 |
| | PLACER | 1216 | 1.50 | 3.00 | 10.90 | 21.90 | 1.50 |
| | SACRAMENTO | 401 | 0.50 | 1.00 | 3.60 | 7.20 | 0.50 |
| | SHASTA | 777 | 1.00 | 1.90 | 7.00 | 14.00 | 1.00 |
| | SOLANO | 72 | 0.10 | 0.20 | 0.60 | 1.30 | 0.10 |
| | SUTTER | 129 | 0.20 | 0.30 | 1.20 | 2.30 | 0.20 |
| | TEHAMA | 441 | 0.50 | 1.10 | 4.00 | 7.90 | 0.60 |
| | YOLO | 191 | 0.20 | 0.50 | 1.70 | 3.40 | 0.20 |
| | YUBA | 154 | 0.20 | 0.40 | 1.40 | 2.80 | 0.20 |
| TOTAL | | 38962 | 46.71 | 97.04 | 362.51 | 776.63 | 50.01 |

Fraction of Reactive Organic Gases (FROG): .8324
(Reactive Organic Gases (ROG) Emissions = TOG X FROG)
Fraction of PM10 (FRPM10): .9760
(PM10 Emissions = PM X FRPM10)

Table II
1991 Area Source Emissions
Activity: Residential
Process: Fuel Combustion
Entrainment: LPG - Combustion
Dimn: Residential
CES: 47217
Process Rate Unit: 1000 Gallons Burned

| AB | County | Process Rate | TOG Emis. (Tons / Year) | CO Emis. (Tons / Year) | NOX Emis. (Tons / Year) | SOX Emis. (Tons / Year) | PM Emis. (Tons / Year) |
|---|---|---|---|---|---|---|---|
| GBV | ALPINE | 302 | 0.10 | 0.30 | 1.40 | 0.00 | 0.00 |
| | INYO | 2491 | 0.90 | 2.30 | 11.30 | 0.00 | 0.30 |
| | MONO | 1717 | 0.60 | 1.60 | 7.80 | 0.00 | 0.20 |
| LC | LAKE | 4615 | 1.70 | 4.30 | 21.00 | 0.00 | 0.60 |
| LT | EL DORADO | 2554 | 0.90 | 2.40 | 11.60 | 0.00 | 0.40 |
| | PLACER | 377 | 0.10 | 0.20 | 1.70 | 0.00 | 0.10 |
| MC | AMADOR | 1360 | 0.50 | 1.30 | 6.20 | 0.00 | 0.20 |
| | CALAVERAS | 3374 | 1.20 | 3.10 | 15.40 | 0.00 | 0.50 |
| | EL DORADO | 7268 | 2.70 | 6.70 | 33.10 | 0.10 | 1.00 |
| | MARIPOSA | 2536 | 0.90 | 2.30 | 11.50 | 0.00 | 0.40 |
| | NEVADA | 10627 | 3.90 | 9.80 | 48.40 | 0.10 | 1.50 |
| | PLACER | 847 | 0.30 | 0.80 | 3.90 | 0.00 | 0.10 |
| | PLUMAS | 1991 | 0.70 | 1.80 | 9.10 | 0.00 | 0.30 |
| | SIERRA | 288 | 0.10 | 0.30 | 1.30 | 0.00 | 0.00 |
| | TUOLUMNE | 5420 | 2.00 | 5.00 | 24.70 | 0.00 | 0.80 |
| NC | DEL NORTE | 683 | 0.20 | 0.60 | 3.10 | 0.00 | 0.10 |
| | HUMBOLDT | 2493 | 0.90 | 2.30 | 11.30 | 0.00 | 0.30 |
| | MENDOCINO | 3011 | 1.10 | 2.80 | 13.70 | 0.00 | 0.40 |
| | SONOMA | 742 | 0.30 | 0.70 | 3.40 | 0.00 | 0.10 |
| | TRINITY | 964 | 0.40 | 0.90 | 4.40 | 0.00 | 0.10 |
| NCC | MONTEREY | 4249 | 1.60 | 3.90 | 19.30 | 0.00 | 0.60 |
| | SAN BENITO | 806 | 0.30 | 0.70 | 3.70 | 0.00 | 0.10 |
| | SANTA CRUZ | 4753 | 1.70 | 4.40 | 21.60 | 0.00 | 0.70 |
| NEP | LASSEN | 2305 | 0.80 | 2.10 | 10.50 | 0.00 | 0.30 |
| | MODOC | 730 | 0.30 | 0.70 | 3.30 | 0.00 | 0.10 |
| | SISKIYOU | 1896 | 0.70 | 1.80 | 8.60 | 0.00 | 0.30 |
| SC | LOS ANGELES | 89931 | 24.30 | 143.90 | 575.60 | 206.80 | 12.60 |
| | ORANGE | 25505 | 6.90 | 40.80 | 163.20 | 58.70 | 3.60 |
| | RIVERSIDE | 9676 | 2.60 | 15.50 | 61.90 | 22.30 | 1.40 |
| | SAN BERNARDINO | 12302 | 3.30 | 19.70 | 78.70 | 28.30 | 1.70 |
| SCC | SAN LUIS OBISPO | 4935 | 1.80 | 4.60 | 22.50 | 0.00 | 0.70 |
| | SANTA BARBARA | 2065 | 0.80 | 1.90 | 9.40 | 0.00 | 0.30 |
| | VENTURA | 1572 | 0.60 | 1.50 | 7.20 | 0.00 | 0.20 |
| SD | SAN DIEGO | 15534 | 5.70 | 14.40 | 70.70 | 0.10 | 2.20 |
| SED | IMPERIAL | 514 | 0.20 | 0.50 | 2.30 | 0.00 | 0.10 |
| | KERN | 1216 | 0.40 | 1.10 | 5.50 | 0.00 | 0.20 |
| | LOS ANGELES | 2329 | 0.60 | 3.70 | 14.90 | 5.40 | 0.30 |
| | RIVERSIDE | 3418 | 0.90 | 5.50 | 21.90 | 7.90 | 0.50 |
| | SAN BERNARDINO | 2715 | 1.00 | 2.50 | 12.40 | 0.00 | 0.40 |
| SF | ALAMEDA | 2902 | 1.06 | 2.76 | 13.21 | 0.78 | 0.39 |
| | CONTRA COSTA | 2989 | 1.09 | 2.84 | 13.60 | 0.81 | 0.40 |
| | MARIN | 1911 | 0.70 | 1.82 | 8.69 | 0.52 | 0.26 |
| | NAPA | 930 | 0.34 | 0.88 | 4.23 | 0.25 | 0.13 |
| | SAN FRANCISCO | 2459 | 0.90 | 2.34 | 11.19 | 0.66 | 0.33 |
| | SAN MATEO | 2711 | 0.99 | 2.58 | 12.34 | 0.73 | 0.37 |
| | SANTA CLARA | 4514 | 1.65 | 4.29 | 20.54 | 1.22 | 0.61 |
| | SOLANO | 1184 | 0.43 | 1.12 | 5.39 | 0.32 | 0.16 |
| | SONOMA | 4324 | 1.58 | 4.11 | 19.67 | 1.17 | 0.58 |
| SJV | FRESNO | 11610 | 4.20 | 10.70 | 52.80 | 0.10 | 1.60 |
| | KERN | 7727 | 2.80 | 7.10 | 35.20 | 0.10 | 1.10 |
| | KINGS | 1275 | 0.50 | 1.20 | 5.80 | 0.00 | 0.20 |
| | MADERA | 4436 | 1.60 | 4.10 | 20.20 | 0.00 | 0.60 |
| | MERCED | 2572 | 0.90 | 2.40 | 11.70 | 0.00 | 0.40 |
| | SAN JOAQUIN | 4431 | 1.60 | 4.10 | 20.20 | 0.00 | 0.60 |
| | STANISLAUS | 2167 | 0.80 | 2.00 | 9.90 | 0.00 | 0.30 |
| | TULARE | 6614 | 2.40 | 6.10 | 30.10 | 0.00 | 0.90 |
| SV | BUTTE | 3727 | 1.40 | 3.40 | 17.00 | 0.00 | 0.50 |
| | COLUSA | 402 | 0.10 | 0.40 | 1.80 | 0.00 | 0.10 |
| | GLENN | 503 | 0.20 | 0.50 | 2.30 | 0.00 | 0.10 |
| | PLACER | 4958 | 1.80 | 4.60 | 22.60 | 0.00 | 0.70 |
| | SACRAMENTO | 2164 | 0.80 | 2.00 | 9.50 | 0.00 | 0.50 |
| | SHASTA | 5410 | 2.00 | 5.00 | 24.60 | 0.00 | 0.80 |
| | SOLANO | 437 | 0.20 | 0.40 | 2.00 | 0.00 | 0.10 |
| | SUTTER | 947 | 0.30 | 0.90 | 4.30 | 0.00 | 0.10 |
| | TEHAMA | 3300 | 1.20 | 3.10 | 15.00 | 0.00 | 0.50 |
| | YOLO | 884 | 0.30 | 0.80 | 4.00 | 0.00 | 0.10 |
| | YUBA | 1420 | 0.50 | 1.30 | 6.50 | 0.00 | 0.20 |
| TOTAL | | 329019 | 106.34 | 401.54 | 1761.86 | 336.36 | 46.33 |

Fraction of Reactive Organic Gases (FROG): .8414
(Reactive Organic Gases (ROG) Emissions = TOG X FROG)
Fraction of PM10 (FRPM10): 1.0000
(PM10 Emissions = PM X FRPM10)