Residential Wood Combustion Emission Inventory
South Coast Air Basin and Coachella Valley Portion of Salton Sea Air Basin
2002 Base Year

prepared for:

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October 24, 2006

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1. Introduction

OMNI Environmental Services, Inc. (OMNI), under contract with the Hearth, Patio and Barbecue Association (HPBA) and the South Coast Air Quality Management District (SCAQMD), prepared residential wood combustion (RWC) emission inventories, separately, for the South Coast Air Basin (SCAB) and the Coachella Valley portion of the Salton Sea Air Basin (SSAB) of California. Under instructions from the SCAQMD, the emission inventories were compiled for the 2002 base year. Comments on the first draft were provided by SCAQMD and revisions based on the comments are included in this report.

The report has been prepared with limited text as the tabulations and data are largely self-apparent, particularly to emission inventory specialists. Relevant references are provided for each section. Each column and row of each data table has been labeled with a unique column and row designation shown as a subscript so that subsequent calculations using the data can be illustrated. For example, the SSAB population in Riverside County shown in Table 2.1 is referred to as R3,C3 and calculation of the "Sum of three Heating Equipment Categories" in Table 3.2 is shown as [C18] = [C15] + [C16] + [C17].

2. Basin Apportionment by County

RWC appliance ownership data have historically been compiled on a county-by-county basis or for specific metropolitan areas. The SCAQMD jurisdiction includes all of Orange (OR) County but only portions of Los Angeles (LA), Riverside (RV) and San Bernardino (SB) counties. Further, SCAQMD has requested separate RWC emission inventories for the SCAB and the Coachella Valley portion of the SSAB that are under its jurisdiction. Figure 2.1 shows county boundaries, the boundary of the SCAQMD jurisdiction, the SCAB, and the SSAB. The Coachella Valley portion of the SSAB is that portion of the SSAB that is within SCAQMD's jurisdiction as shown in Figure 2.1.

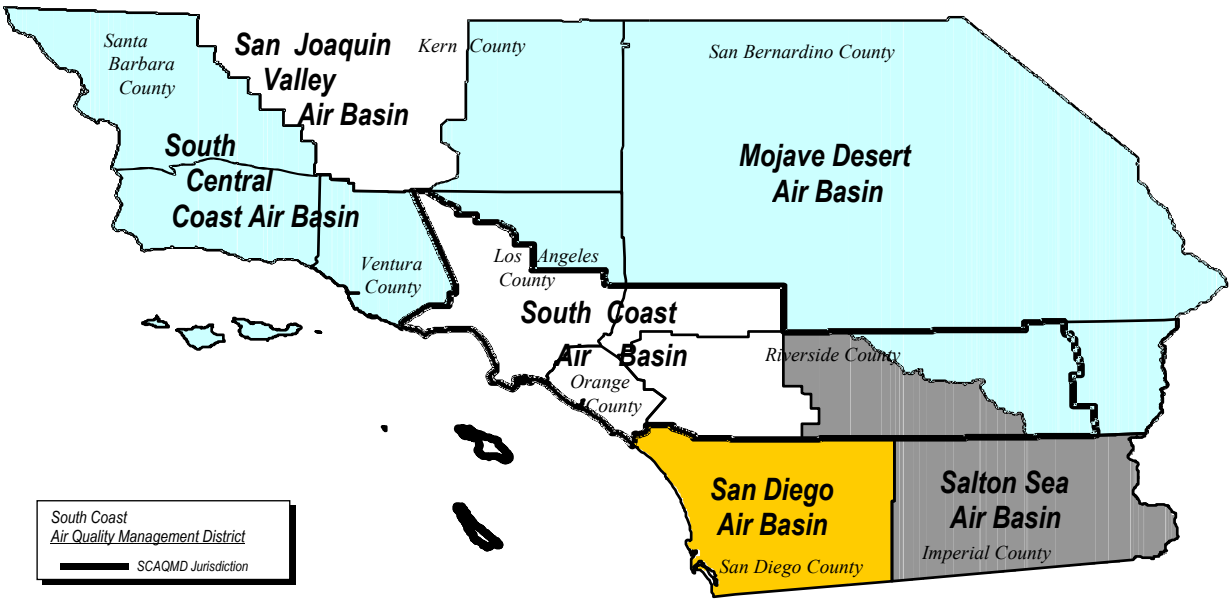

Figure 2.1 South Coast Air Quality Management District Map Showing the South Coast Air Basin (SCAB) and the Salton Sea Air Basin (SSAB) and County Boundaries

Table 2.1
2002 County Populations in the South Coast Air Basin (SCAB) and Salton Sea Air Basin (SSAB)[1]

Population	County			
	LA[C1]	OR[C2]	RV[C3]	SB[C4]
Total Population[R1]	9,871,506	2,956,992	1,683,880	1,858,678
SCAB Population[R2]	9,572,437	2,956,992	1,294,381	1,413,868
SSAB Population[2][R3]	0	0	345,934	0
Fraction of Population in SCAB[R4]	0.9697	1.0000	0.7687	0.7607
Fraction of Population in SSAB[2][R5]	0	0	0.2054	0
Fraction of Population outside SCAQMD[R6]	0.0303	0	0.0261	0.2393

[1]Data from reference 2.1
[2]Coachella Valley Portion

Table 2.2
2002 Households in the South Coast Air Basin (SCAB) and Salton Sea Air Basin (SSAB)[1]

Households	County			
	$LA_{[C5]}$	$OR_{[C6]}$	$RV_{[C7]}$	$SB_{[C8]}$
Households in $SCAB_{[R7]}$	3,064,417	956,485	410,113	415,713
Households in $SSAB^{2}_{[R8]}$	0	0	125,042	0

[1]Data from reference 2.1
[2]Coachella Valley Portion

Reference for Section 2

2.1 Personal communication, September 21, 2005, Micahel Laybourn, South Coast Air Quality Management, data provided by SCAQMD Emission Inventory Group.

3. Numbers of Woodstoves, Wood-burning Fireplace Inserts and Wood-burning Fireplaces without Inserts

3.1 Databases, Assumptions and Procedures

The American Housing Survey (AHS) has conducted surveys specifically in the time frame applicable to the 2002 base year in the SCAB and SSAB and provides useful data for the development of a RWC emission inventory. Surveys have been conducted for: (1) the Anaheim-Santa Ana metropolitan area (all of Orange County), (2) the Riverside-San Bernardino-Ontario metropolitan area (all of Riverside County plus all of San Bernardino County), and (3) the Los Angeles-Long Beach metropolitan area (all of Los Angeles County). Tables 3.1 and 3.2 summarize key data taken from these surveys.

Besides cordwood, (1) the AHS stove category includes other solid fuels (coal, coke, and wood pellets), (2) the AHS fireplace with inserts category includes pellets, piped gas and bottled gas fuels, and (3) the AHS fireplace without insert category includes piped gas and bottled gas fuels, and as such, an adjustment in the AHS numbers by appliance category is required to account for these fuels and to derive the cordwood- and wood pellet-fueled appliance numbers separately. The fact that the sum of all occupied housing units using stoves, fireplaces with inserts and the fireplaces without inserts for heating exceeds the number of occupied housing units that use wood for heating illustrates the significant use of these other fuels in these appliances, i.e., the "Sum of Three Heating Equipment Categories" column [C18] exceeds the "Wood as a Heating Fuel" column [C19] in Table 3.2.

Several minor points also need to be noted in developing an estimate of the number of wood-burning appliances. (1) For 2002, the number of total occupied units for the South Coast counties listed in AHS documents differ slightly from the number of households provided by the SCAQMD Emission Inventory Group. The differences are small on a relative basis and should not substantially affect the development of the RWC emission inventory. (2) The AHS definitions of "fireplaces with inserts" and "fireplaces without inserts" provided in the Definitions Appendix of the AHS reports (references 3.1-3.4, 3.20 and 3-.21) and listed as footnotes to Table 3.1 here are not consistent with normal use of these terms nor are they representative of the actual AHS interview questions (see reference 3.5). Fortunately, upon review of the questionnaire, it is OMNI's opinion that the results of typical interviewee's response to the AHS questionnaire provides "fireplace with insert" and "fireplace without insert" numbers reasonably close for the two appliance categories if the definitions generally understood in the hearth industry were applied. (3) It needs to be emphasized that the number of fireplaces used for heating purposes is much smaller than the total number of fireplaces actually used as many fireplaces are used for "aesthetic" purposes. The AHS questionnaire specifically asks, "Do you consider [your] fireplace to be heating equipment?" Fireplaces used for aesthetics are typically used less frequently and have had lower annual wood usage assigned to them. (4) Because surveys have shown that many fireplace users use both manufactured wax/fiber firelogs and cordwood, the contribution of wax/fiber firelog and cordwood are separated in Section 4 "Annual Wood Consumption by Appliance Type" of

this report. The importance of wax/fiber firelogs is illustrated in a 1994/1995 survey, which showed that 30% of fireplace users used both manufactured wax/fiber firelogs and cordwood and 12% used wax/fiber firelogs exclusively (reference 3.6). Most of the wax/fiber firelog use would be in the asethetic use category, not the heating use category, and the wax/fiber firelog adjustment will be made for fuel use in that category. (5) In contrast, because the sale and use of densified manufactured fuels (not to be confused with wax/fiber manufactured fuels) is very small as compared to the use of cordwood, particularly outside the Pacific Northwest (reference 3.7), and their characteristic emission factors were determined to be only slightly lower than cordwood (references 3.8 and 3.9), their usage will not be separated from cordwood as it will have an insignificant effect. Additionally, detailed records for their use in the Southern California do not exist. (6) The number of masonry heaters (not to be confused with masonry fireplaces) is very small in the SCAB and SSAB and their contribution to RWC in those air basins is insignificant. It has been estimated that there were 11,262 masonry heaters in North America with only 955 of them in the entire southwestern portion of the U.S. in 2002 (reference 3.10). (7) Similarly, wood-fired centralized heaters (forced air furnaces, indoor boilers and outdoor boilers –sometimes referred to as hydronic heaters) will not contribute significantly to the RWC emission inventory in the SCAB or SSAB. Their use is associated with rural, forested, and cold climates. The number in use would be extremely small in the SCAB and SSAB and, while on a case-by-case basis their air quality impact may be observable, their contribution to the RWC emission inventory as a category is insignificant. (8) Wood-fired cookstoves have sometimes been used as a heating appliance. A review of the AHS surveys covering the SCAB and SSAB areas revealed that the use of wood as a cooking fuel was so small as to be lower than the ability to quantify with the surveys. (9) As previously noted, the term “stove” as used in the AHS includes stoves fueled by coal and coke. The ratio of occupied units reporting using wood as a fuel as compared to the sum of coal and coke was 728 to 1 in all of Los Angeles, Orange, Riverside, and San Bernardino counties. A correction in stove numbers for coal or coke use is unnecessary.

Using the data compiled in Tables 3.1 and 3.2 as a starting point, estimates have been made of the number of (1) stoves that burn cordwood, (2) stoves that burn wood pellets, (3) fireplaces with inserts that burn cordwood (4) fireplaces with inserts that burn pellets (5) fireplaces without inserts that burn cordwood and are used for heating purposes, and (6) fireplaces without inserts that burn cordwood (including wax fiber firelogs) that are used for aesthetic purposes. (The terms fireplaces with inserts and fireplace inserts are used interchangeably.) Finally, making the necessary assumption that per capita ownership does not change significantly within each of the four counties, the appliance numbers for the four categories have further been proportioned based on population into the SCAB and SSAB boundaries.

Table 3.1
Number of Occupied Units with Stoves, Fireplaces with Inserts, and Fireplaces without Inserts Used as Main Heating Equipment and as Other Heating Equipment in the Los Angeles Area[1,2]

Metropolitan Area, Year	Main Heating Equipment			Other Heating Equipment		
	Stove[C9]	Fireplace with Insert[C10]	Fireplace w/o Insert[C11]	Stove[C12]	Fireplace with Insert[C13]	Fireplace w/o Insert[C14]
Anaheim-Santa Ana, 2002[R9]	<50	<50	800	2400	32,100	54,100
Riverside-San Bernardino-Ontario, 2002 [R10]	6500	1800	3700	18,200	65,300	84,400
Los Angeles-Long Beach, 1999[3] [R11]	1000	4200	2200	28,400	81,500	184,200
Los Angeles-Long Beach, 2003[3] [R12]	900	6400	2300	13,900	68,500	170,900
Los Angeles-Long Beach, 2002[3] [R13]	925	5850	2275	17,525	71,750	174,225

[1]Data are from AHS references 3.1 – 3.4.

[2]AHS definitions of terms:

Anaheim-Santa Ana Metropolitan area is defined as Orange County
Riverside-San Bernardino-Ontario Metropolitan area is defined as Riverside and San Bernardino Counties
Los Angeles-Long Beach Metropolitan area is defined as Los Angeles County

Other Heating Equipment is the sum of *Parallel Heating Equipment* which is defined as, "Additional heating equipment for an area not heated by the main heating equipment." and *Supplemental Heating Equipment* which is defined as "Additional heating equipment for a heated area of the housing unit."

Fireplaces with inserts have a fan-forced air circulation system to force the heat into the room.

Fireplaces without inserts refers to glass door fire screens or fire backs inserted in the back of the fireplace to passively reflect heat.

Stove refers to any range or stove that burns solid fuel including wood burning, pot belly, and Franklin stoves.

[3]Calculations:

There is no 2002 AHS data for the Los Angeles-Long Beach Metropolitan area. The 2002 estimate was calculated by linearly extrapolating between the 1999 and 2003 data.

Table 3.2
Total Occupied Units Using Stoves, Using Fireplaces with Inserts, and Using Fireplaces without Inserts as Heating Equipment; Total Occupied Units with Wood as a Fuel; and Total Occupied Units Having a Usable Fireplace in the Los Angeles Area[1,2,3]

Metropolitan Area, Year	Heating Equipment (Sum of "Main" and "Other" Heating Equipment from Table 3.1)			Sum of Three Heating Equipment Categories[C18]	Wood as a Heating Fuel[1][C19]	Usable Fireplace[1][C20]
	Stove[C15]	Fireplace with Insert[C16]	Fireplace w/o Insert[C17]			
Anaheim-Santa Ana, 2002[R14]	2450	32,150	54,900	89,500	42,800	531,600
Riverside-San Bernardino-Ontario, 2002[R15]	24,700	67,100	88,100	179,900	138,400	572,800
Los Angeles-Long Beach, 1999[R16]	29,400	85,700	186,400	301,500	172,700	1,121,300
Los Angeles-Long Beach, 2003[R17]	14,800	74,900	173,200	262,900	149,200	1,121,500
Los Angeles-Long Beach, 2002[R18]	18,450	77,600	176,500	272,550	155,075[3]	1,121,450[3]

[1]Data are from AHS references 3.1 – 3.4 and calculated from data shown in Table 3.1.

[2]AHS definitions of term:

Usable fireplace. Excludes the following: fireplaces that have been blocked off or whose chimney or flue has been filled, decorative or artificial fireplaces and wood stoves, even if shaped like a fireplace, like a Franklin stove. Free-standing fireplaces are included in this item.

[3]Calculations:

There is no 2002 AHS data for the Los Angeles-Long Beach Metropolitan area. The 2002 estimate was calculated by linearly extrapolating between the 1999 and 2003 data

One-half the less than values of "50" shown in the Anaheim- Santa Ana row [R9] in Table 3.1 (i.e., 25) was used for subsequent calculations.

[C15] = [C9] + [C12]
[C16] = [C10] + [C13]
[C17] = [C11] + [C14]
[C18] = [C15] + [C16] + [C17]

Table 3.2 shows the total number of occupied units that use wood-burning appliances by appliance category for heating. Because some homes use more than one wood-heating appliance, a correction for multiple ownership is necessary. The correction factors for multiple ownership are shown in Table 3.3 and the numbers of appliances used for heating (not occupied housing units) are shown in Table 3.4. It is assumed that if one appliance in a given category is used then the others in a household are also used.

Table 3.3
Multiple Ownership Factors

Area,Year,Reference	Stove[C21]	Fireplace Insert[C22]	Fireplace w/o Insert[C23]
California, 2002, Reference 3.11[R19]	1.1	1.1	1.1
West/Mountain, 2004, Reference 3.12[R20]	1.1	-	1.1
U.S.,1988, Reference 3.13[R21]	1.1	1.1	1.2
Mean[R22]	1.1	1.1	1.1

Table 3.4
Total Stoves, Fireplaces with Inserts and Fireplaces without Inserts Used for Heating in the Los Angeles Area in 2002[1]

Metropolitan Area, Year	Stoves[C24]	Fireplace Inserts[C25]	Fireplaces w/o Inserts[C26]
Anaheim-Santa Ana, 2002 [R23]	2695	35,365	60,390
Riverside-San Bernardino-Ontario, 2002[R24]	27,170	73,810	96,910
Los Angeles-Long Beach, 2002[R25]	20,295	85,360	194,150

[1]Calculations:
[C24] = [C15] X [R22,C21]
[C25] = [C16] X [R22,C22]
[C26] = [C17] X [R22,C23]

3.2 Stoves

An estimate of the fraction of wood-burning stoves that were pellet stoves was made based on the review of the available literature (Table 3.5). This fraction was applied to the total number to wood-burning stoves used in each southern California metropolitan area (Table 3.4). The number of cordwood stoves and number of pellet stoves in each of the metropolitan areas were then calculated (Table 3.6).

Table 3.5
Fraction of Wood-Burning Stoves that Were Pellet Stoves

Area, Year, Reference	Fraction[C27]
U.S., 2003, references 3.14, 3.15, and 3.16[R26]	0.0544
California, 2002, reference 3.11[R27]	0.0782
U.S., 2002, reference 3.17 [R28]	0.0731
San Joaquin Valley, 1999, reference 3.18[R29]	0.126
San Joaquin Valley 2002, reference 3.19[R30]	0.174
West-Mountain, 2004, reference 3.12[R31]	0.133
Mean[R32]	0.11

Table 3.6
Total Cordwood Stoves and Total Pellet Stoves Used for Heating in The Los Angeles Area in 2002[1]

Metropolitan Area, Year	Cordwood Stoves[C28]	Pellet Stoves[C29]
Anaheim-Santa Ana, 2002[R33]	2398	296
Riverside-San Bernardino-Ontario, 2002[R34]	24,181	2989
Los Angeles-Long Beach, 2002[R35]	18,063	2232

[1]Calculations:
[C28] = (1-[R33,C27]) X [C24]
[C29] = [R33,C27] X [C24]

3.3 Fireplace Inserts

The number of gas-fueled fireplace inserts, the number of cordwood-fueled fireplace inserts and the number of pellet-fueled fireplace inserts that were used for heat were calculated for the three metropolitan areas from the total number of fireplace inserts [C25] shown in Table 3.4. The fraction of fireplaces that were gas-fueled on a national basis was used to estimate the number of gas-fueled fireplaces that were in the Los Angles area. Because the number of fireplace inserts that are gas-fueled are influenced by the number of homes that have piped or bottle gas hook-ups, the ratio of the of fraction of households in the Los Angeles area that use gas for any purpose, (i.e. have

hook-ups) to the national average (Table 3.7) and the ratio of the fraction of households that use gas as their main heating fuel (Table 3.8) were calculated to provide two independent ways to adjust the national average to the Los Angeles area. The mean of the two values was used. (When calculated it was found that the two values were identical to three significant figures.) Adjustment factors for the San Joaquin Valley to the Los Angeles area and for California as a whole to the Los Angeles area are also included in Table 3.8 as they are needed in the calculation of fireplace without insert numbers discussed in the next section.

Table 3.9 shows the calculation of the fraction of fireplaces without inserts that were gas-fueled in the Los Angeles area. Table 3.10 show the estimate of the fraction of fireplace inserts that were pellet fueled. Table 3.11 shows the number of cordwood-fueled, gas-fueled and pellet-fueled fireplace inserts that were used for heating in the Los Angeles area. The values were calculated from the number of fireplaces inserts used in the Los Angeles area for heating shown in Table 3.4 and the fraction that were of gas-and pellet-fueled shown in Tables 3.10 and 3.11.

Table 3.7
Fraction of Household that Used Gas for Any Purpose in 2002[1,2]

Area, Reference	Fraction of Households[C30]
U.S., References 3.20 and 3.21[R36]	0.701
Anaheim-Santa Ana, Reference 3.1[R37]	0.915
Riverside-San Bernardino-Ontario, Reference 3.2[R38]	0.958
Los Angeles-Long Beach, References 3.3 and 3.4[R39]	0.952
Population Weighted Los Angeles Area [R40]	0.946
National to Los Angeles Area Adjustment Factor [R41]	1.36

[1]Calculations
There is no 2002 AHS data for the United States. The 2002 estimate was calculated by linearly extrapolating between the 2001 and 2003 data.
There is no 2002 AHS data for the Los Angeles-Long Beach Metropolitan area. The 2002 estimate was calculated by linearly extrapolating between the 1999 and 2003 data.
[R40,C30] = {[R1,C1]/([R1,C1 + R1,C2 + R1,C3 + R1,C4]) X [R39,C30]} +{([R1, C3 + R1,R4])/([R1,C1 + R1,C2 + R1,C3 + R1,C4]) X [R38,C30]} +{[R1,C2]/ ([R1,C1 + R1,C2 + R1,C3 + R1,C4]) X [R37,C30]}
[R41] = [R40,C30]/[R36,C30]
[2]Sum of piped and bottled gas

Table 3.8
Fraction of Households that Used Gas as Their Main Heating Fuel in 2000[1,2,3]

Area	Population[C31]	Fraction of Households with Gas as Their Main Heating Fuel[C32]
U.S.[R42]	281,421,906	0.577
California[R43]	33,871,648	0.743
San Joaquin Valley[R44]	3,302,792	0.710 (Population weighted average)
San Joaquin Co.[R45]	563,598	0.703
Stanislaus Co.[R46]	446,997	0.700
Merced Co.[R47]	210,554	0.624
Fresno Co.[R48]	799,407	0.638
Madera Co.[R49]	123,109	0.616
Kings Co.[R50]	129,461	0.774
Kern Co.[R51]	661,645	0.788
Tulare Co.[R52]	368,021	0.805
Los Angeles Area[R53]	15,620,450	0.782 (Population weighted average)
Orange Co.[R54]	2,846,289	0.770
Riverside Co.[R55]	1,542,387	0.804
San Bernardino Co.[R56]	1,709,434	0.838
Los Angeles Co.[R57]	9,519,338	0.772
California to Los Angeles Area Adjustment Factor[R58] 1.05		
San Joaquin Valley to Los Angeles Area Adjustment Factor[R59] 1.10		
National to Los Angeles Area Adjustment Factor[R60] 1.36		

[1]Reference 3.22
[2]Sum of piped and bottled gas
[3]Calculations:
[R44,C31] = [R45,C31] + [R46,C31] + [R47,C31] + [R48,C31] + [R49,C31] + [R50,C31] +[R51,C31] +[R52,C31]
[R44,C32] = [R45,C31]/[R44,C31] X [R45,C32] + [R46,C31]/[R44,C31] X [R46,C32] + [R47,C31]/[R44,C31] X [R47,C32] + [R48,C31]/[R44,C31] X [R48,C32] + [R49,C31]/[R44/C31] X [R49,C32] + [R50,C31]/[R44,C31] X [R50,C32] + [R51,C31]/[R44,C31] X [R51,C32] +[R52,C31]/[R44,C31] X [R52,C32]
[R53,C31] = [R54,C31] + [R55,C31] + [R56,C31] + [R57,C31]
[R53,C32] = [R54,C31]/[R53,C31] X [R54,C32] + [R55,C31]/[R53,C31] X [R55,C32] + [R56,C31]/[R53,C31] X [R56,C32] + [R57,C31]/[R53,C31] + [R57,C32]
[R58] = [R53,C32]/[R43,C32]
[R59] = [R53,C32]/[R44,C32]
[R60] = [R53,C32]/[R42,C32]

Table 3.9
Fraction of Fireplace Inserts that Were Gas-Fueled in the Los Angeles Area in 2002[1]

Total Number of Households in the U.S. 2002, references 3.20 and 3.21[R61]	106,051,500
Fraction of Households Nationally that Own a Wood-Fired Fireplace Insert 2002, reference 3.16[R62]	0.058
Multiple Ownership Factor(see [R22, C22] Table 3.3)[R63]	1.1
Number of Total Wood-Fired Inserts in 2002[R64]	6,766,086
Total Number of Gas-Fueled Inserts sold as of 2002, references 3.14 and 3.15[R65]	559,483
Fraction of Total Fireplace Inserts Nationally that Are Gas-Fueled[R66]	0.076
National to Los Angeles Area Adjustment Factor[R67]	1.36
Fraction of Total Fireplace Inserts in the Los Angeles Area that were Gas-Fueled in 2002[R68]	0.104

[1]Calculations:
There is no 2002 AHS data for the United States. The 2002 estimate was calculated by linearly extrapolating between the 2001 and 2003 data.
[R64] = [R61] X [R62] X [R63]
[R66] = [R65]/([R64] + [R65])
[R67] = ([R41] +[R60])/2 (mean of two independent methods)
[R68] = [R66] X [R67]

Table 3.10
Fraction of Wood-Burning Fireplace Inserts that Were Pellet-Fueled in 2002[1]

Number of Total Wood-Fired Inserts Nationally in 2002 (See [R64] Table 3.9)[R69]	6,766,086
Total Number of Pellet-Fueled Inserts Sold Nationally as of 2002, references 3.14 and 3.15[R70]	200,000
Fraction of Wood-burning Inserts in 2002 that were Pellet-Fueled[R71]	0.029

[1]Calculations:
[R71] = [R70]/[R69]

Table 3.11
Total Gas-Fueled, Cordwood-Fueled, and Pellet-Fueled Fireplace Inserts Used for Heating in the Los Angeles Area in 2002[1]

Metropolitan Area	Gas-Fueled Fireplace Inserts[C33]	Total Wood-Fueled Fireplace Inserts[C34]	Pellet-Fueled Fireplace Inserts[C35]	Cordwood-Fueled Fireplace Inserts[C36]
Anaheim-Santa Ana[R72]	3678	31,687	919	30,768
Riverside-San Bernardino-Ontario[R73]	7676	66,134	1918	64,216
Los Angeles-Long Beach[R74]	8877	76,483	2218	74,266

[1]Calculations:
[C33] = [C25] X [R68]
[C34] = [C25] – [C33]
[C35] = [C34] X [R71]
[C36] = [C34] – [C35]

3.4 Fireplaces without Inserts

The total number of usable fireplaces owned and the total number of fireplaces that were used for heating in the three metropolitan areas are shown in Table 3.2. The fraction of fireplaces that were gas-fueled (Table 3.12) and the fraction that were not used (Table 3.13) allowed for the number of fireplaces (both gas-fueled and cordwood-fueled) that were (1) owned, (2) that were not used, (3) that were used for heating, and (4) that were used for aesthetics to be calculated/tabulated (Tables 3.14 and 3.15). Because the use of gas-fueled fireplaces is more convenient than the use of cordwood-fueled units an adjustment factor reflecting the difference was taken into consideration when calculating the fraction that was used versus not used. This adjustment can be seen in the equations shown as footnotes to Tables 3.14 and 3.15.

Table 3.12
Fraction of Fireplaces without Inserts that Were Gas-Fueled[1]

Area, Reference, Year	Fraction that Were Gas-Fueled[C37]	Adjustment Factor for Los Angeles Area (See [R58] and [R59] in Table 3.8.)[C38]	Fraction Predicted to be Gas-Fueled in Los Angeles Area[C39]
San Joaquin Valley, 1999, reference 3.18[R75]	0.20	1.10	0.22
San Joaquin Valley, 2002, reference 3.19[R76]	0.22	1.10	0.24
California, 2002, reference 3.11[R77]	0.29	1.05	0.30
California, 2001, reference 3.12 [R78]	0.26	1.05	0.27
Mean[R79]			0.26

[1]Calculations:
[C39] = [C37] X [C38]

Table 3.13
Fireplace without Insert Usage

Area, Reference, Year	Usage Category	Fraction by Category	Fraction Not Used
San Joaquin Valley, 2002, reference 3.19	Almost Every Day[R80]	0.16	
	Several Times a Week[R81]	0.20	
	Several Times a Month[R82]	0.14	
	Rarely[R83]	0.28	
	Never[R84]	0.22	0.22
San Joaquin Valley, 1999, reference 3.18	Daily[R85]	0.12	
	4-6 Times a Week[R86]	0.10	
	1-3 Times a Week[R87]	0.24	
	Less than Once a Week[R88]	0.22	
	Never[R89]	0.32	0.32
California, 2002, reference 3.11	Used Last Year? Yes[R90]	0.77	
	Used Last Year? No[R91]	0.23	0.23
U.S., 2002, reference 3.17	Almost Every Day[R92]	0.15	
	1 or 2 Times a Week[R93]	0.23	
	1 or 2 Times a Month[R94]	0.24	
	1 or 2 Times a Season[R95]	0.17	
	Almost Never/Never[R96]	0.19	0.19
U.S., 1994-1995, reference 3.6	5-7 Times per week[R97]	0.11	
	3-4 Times per Week[R98]	0.10	
	1.2 Times per Week[R99]	0.18	
	1-2 Times per Month[R100]	0.13	
	1-2 Times per Season[R101]	0.17	
	Don't Use[R102]	0.31	0.31
West/Mountain, 2004, reference 3.12	1-2 Times or More Per Month[R103] and [R103a] in parenthesis	0.51 (0.65)[1]	
	1-2 Times per Season[R104] and [R104a] in parenthesis	0.15 (0.15)[1]	
	Almost Never/Never [R105] with [R105a] in parenthesis	0.34 (0.20)[1]	0.34
Mean of "Not Used" Category[R106]			0.27

[1]Gas-Fueled Fireplaces without Inserts

Table 3.14
Fireplaces without Inserts by Category in the Los Angeles Area in 2002 (Part 1)[1]

Metropolitan Area	Total Fireplaces Owned[C40]	Total Wood-Burning Fireplaces Owned[C41]	Total Gas-Fueled Fireplaces Owned[C42]	Wood-burning Fireplaces Not in Use[C43]	Gas-Fueled Fireplaces Not in Use[C44]
Anaheim-Santa Ana[R107]	584,760	432,722	152,038	116,835	24,147
Riverside-San Bernardino-Ontario[R108]	630,080	466,259	163,821	125,890	26,018
Los Angeles-Long Beach[R109]	1,233,430	912,738	320,692	246,439	50,933

[1]Calculations:
[C40] = [C20] X [R22,C23]
[C41] = [C40] X (1-[R79])
[C42] = [C40] X [R79]
[C43] = [C41] X [R106]
[C44] = [C42] X [R106] X [R105a]/[R105]

Table 3.15
Fireplaces without Inserts by Category in the Los Angeles Area in 2002 (Part 2)[1]

Metropolitan Area	Wood-Burning Fireplaces in Use[C45]	Gas-Fueled Fireplaces in Use[C46]	Wood-Burning Fireplaces Used for Heating[C47]	Gas-Fueled Fireplaces Used for Heating[C48]	Wood-Burning Fireplaces Used for Aesthetics[C49]	Gas-Fueled Fireplaces Used for Aesthetics[C50]
Anaheim-Santa Ana[R110]	315,887	127,891	40,827	19,212	275,060	108,679
Riverside-San Bernardino-Ontario[R111]	340,369	137,803	65,899	31,011	274,470	106,792
Los Angeles-Long Beach[R112]	666,229	269,759	132,022	62,128	534,207	207,631

[1]Calculations:
[C45] = [C41] – [C43]
[C46] = [C42] – [C44]
[C47] = [C26] X (1 - [R79] X ([R105a]-1)/([R105]-1), Note: The ([R105a]-1)/([R105]-1) adjustment is approximate since it is representative of all fireplace usage not just for fireplaces used for heating.
[C48] = [C26] X [R79] X ([R105]-1)/([R105a]-1)
[C49] = [C45] – [C47]
[C50] = [C46] – [C48]

3.5 Summary of Wood-Burning Appliances in the SCAB and Coachella Valley Portion of the SSAB

To obtain the final estimate of the number of wood-burning appliances owned and used by appliance category in the SCAB and SSAB, several other adjustments need to be made to the numbers obtained for the three MSA's derived primarily from American Housing Survey reports. These are: (1) The fraction of each of the three MSA's population that are in the SCAB and SSAB, respectively – Table 3.16. (2) The fraction of cordwood heaters that are certified catalytic, certified non-catalytic or pre-EPA certification conventional units – Table 3.17. (3) The fraction of cordwood stoves and fireplace inserts that are not in use – Table 3.18. (4) Adjustment to take into account wood burning units that are in vacant houses – Table 3.19. Tables 3.20, 3.21 and 3.22 are compilations of intermediate data used in the calculations. The summary of wood-burning appliances both owned and used in the SCAB and the SSAB are provided in Tables 3.23 and 3.24, respectively.

Table 3.16
Metropolitan Area to Air Basin Conversions[1]

Metropolitan Area	Counties	Fraction to $SCAB_{[C51]}$	Fraction to $SSAB_{[C52]}$
Anaheim-Santa $Ana_{[R113]}$	Orange	1	0
Riverside-San Bernardino-$Ontario_{[R114]}$	Riverside and San Bernardino	0.7645	0.09765
Los Angeles-Long Beach, see [R4,C1] in $Table\ 2.1_{[R115]}$	Los Angeles	0.96907	0

[1]Calculations:
[R114,C51] = ([R2,C3] + [R2,C4])/([R1,C3] + [R1,C4])
[R114,C52] = [R3,C3]/ ([R1,C3] + [R1,C4])

Table 3.17
Fraction of Cordwood Heaters[1] by Type

Area, Year, Reference	Type	$Fraction_{[C53]}$[2]
Minnesota, 2002-2003, Reference 3.24 (Used)	Conventional Pre-EPA $Certification_{[R116]}$	0.76
	$Certified\ Catalytic_{[R117]}$	0.07
	$Certified\ Non\text{-}Catalytic_{[R118]}$	0.17
U.S. 2003, References 3.14-3.16 (Owned)	Conventional Pre-EPA $Certification_{[R119]}$	0.79
	$Certified\ Catalytic_{[R120]}$	0.07
	Certified Non-Catalytic $_{[R121]}$	0.14

[1]The term "heaters" refers to the sum of freestanding stoves and inserts
[2]Fraction is for appliances used from reference 3.24 and for appliances owned from references 3.14-3.16.

Table 3.18
Fraction of Cordwood Stoves and Fireplace Inserts Not in Use

Area, Year, Reference	Fraction of Stoves Not Used[C54]		Fraction of Fireplace Inserts Not Used[C55]	
Minnesota, 2002-2003, reference 3.24[R122]	0.18	conv. 0.22[R122a]	0.039	conv. 0.044[R122a]
		cert. cat. 0.057[R122b]		cert. cat. 0[R122b]
		cert. non-cat. 0.061[R122c]		cert. non-cat 0[R122c]
California, 2002, reference 3.11[R123]	0.17		0.03	
San Joaquin Valley, 1999, reference 3.18[R124]	0.14		-	
U.S., 2002, reference 3.17[R125]	0.15		-	
West/Mountain Region, 2004, reference 3.12[R126]	0.13		-	
Mean[R127]	0.15		0.03	

Table 3.19
Adjustment Factor for Ownership Due to Vacant Housing[1,2]

Area, Year	Total Housing Units[C56]	Occupied Units (Households)[C57]	Adjustment Factor[C58]
Anaheim-Santa Ana, 2002[R128]	995,600	937,500	1.062
Riverside-San Bernardino-Ontario, 2002[R129]	1,229,500	1,187,500	1.035
Los Angeles – Long Beach, 1999[R130]	3,278,500	3,269,300	-
Los Angeles – Long Beach, 2003[R131]	3,318,500	3,310,200	-
Los Angeles –Long Beach, 2002[R132]	3,308,500	3,300,000	1.002

[1]Data are from references 3.1-3.4.
[2]Calculations:
There is no 2002 AHS data for the Los Angeles-Long Beach Metropolitan area. The 2002 estimate was calculated by linearly extrapolating between the 1999 and 2003 data.
[C58] = [C56]/[C57]

Table 3.20
Summary of Wood-Burning Stove Ownership and Usage by Metropolitan Area and Air Basin[1]

Metropolitan Area/Air Basin	Number Owned – Cordwood				Number Used – Cordwood				Number Owned	Number Used
	Total[C59]	Conv. [C60]	Cat. [C61]	Non-Cat. [C62]	Total[C63]	Conv. [C64]	Cat. [C65]	Non-Cat.[C66]	Pellet[C67]	Pellet[C68]
Anaheim Santa Ana[R133]	2845	2196	189	460	2395	1820	168	407	314	296
Riverside-San Bernardino-Ontario [R134]	28,004	21,615	1858	4531	24,181	18,378	1693	4111	3094	2989
Los Angeles-Long Beach[R135]	20,249	15,630	1343	3276	18,062	13,727	1264	3070	2232	2232
SCAB[R136]	43,877	33,868	2916	7099	38,384	29,172	2687	6525	4842	4744
SSAB[R137]	2735	2111	181	442	2361	1794	165	401	302	292

[1]Calculations:
R133 through R135 column C63 from Table 3.6
R133 through R135 column C64 = C63 X [R116,C53]
R133 through R135 column C65 = C63 X [R117,C53]
R133 through R135 column C66 = C63 X [R118,C53]
R133 through R135 column C68 from Table 3.6
R133 through R135 column C67 = C68 X C58
R133 through R135 column C62 = C66 X C58/(1-[R122c,C54])
R133 through R135 column C61 = C65 X C58/(1-[R122b,C54])
R133 through R135 column C60 = C64 X C58/(1-[R122a,C54])
R133 through R135 column C59 = C60 + C61 + C62
R136 = R133 + R134 X [R114,C51] + R135 X [R115,C51]
R137 = R134 X [R114,C52]

Table 3.21
Summary of Wood-BurningFireplace Insert Ownership and Usage by Metropolitan Area and Air Basin[1]

Metropolitan Area/Air Basin	Number Owned –Cordwood				Number Used –Cordwood				Number Owned	Number Used
	Total[C69]	Conv. [C70]	Cat. [C71]	Non-Cat. [C72]	Total[C73]	Conv. [C74]	Cat. [C75]	Non-Cat. [C76]	Pellet[C77]	Pellet[C78]
Anaheim Santa Ana[R138]	34,829	26,752	2356	5721	31,687	24,082	2218	5387	974	919
Riverside-San Bernardino-Ontario [R139]	70,843	54,415	4791	11,637	66,134	50,262	4629	11,243	1995	1918
Los Angeles-Long Beach[R140]	79,317	60,924	5365	13,028	76,483	58,127	5354	13,002	2218	2218
SCAB[R141]	165,852	127,392	11,218	27,242	156,363	118,836	10,945	26,582	4648	4534
SSAB[R142]	6918	5314	468	1148	6459	4908	450	1098	195	187

[1]Calculations:
R138 through R140 column C73 from Table 3.11
R138 through R140 column C74 = C73 X [R116,C53]
R138 through R140 column C75 = C73 X [R117, C53]
R138 through R140 column C76 = C73 X [R118,C53]
R138 through R140 column C78 from Table 3.11
R138 through R140 column C77 = C78 X C58
R138 through R140 column C72 = C76 X C58/(1-[R122c,C55])
R138 through R140 column C71 = C75 X C58/(1-[R122b,C55])
R138 through R140 column C70 = C74 X C58/(1-[R122a,C55])
R138 through R140 column C69 = C70 + C71 + C72
R141 = R138 + R139 X [R114,C51] + R140 X [R115,C51]
R142 = R139 X [R114,C52]

Table 3.22
Summary of Wood-Burning Fireplace without Insert Ownership and Usage by Metropolitan Area and Air Basin[1]

Metropolitan Area/Air Basin	Owned[C79]	Used[C80]	Used for Heating[C81]	Used for Aesthetics[C82]
Anaheim Santa Ana[R143]	432,722	315,887	40,827	275,060
Riverside-San Bernardino-Ontario[R144]	466,259	340,369	65,899	274,470
Los Angeles-Long Beach[R145]	912,738	666,229	132,022	534,207
SCAB[R146]	1,673,684	1,221,721	219,146	1,002,576
SSAB[R147]	45,530	33,237	6435	26,802

[1]Calculations:
C79 = C41 in Table 3.14
C80 = C45 in Table 3.15
C81 = C47 in Table 3.15
C82 = C49 in Table 3.15
R146 = R143 + R144 X [R114,C51] + R145 X [R115,C51]
R147 = R144 X [R114,C52]

Table 3.23
Wood-burning Appliances in the SCAB[1]

Category	Owned[C83]	Used[C84]
Total Wood-Burning Appliances (Wood Heaters + Fireplaces w/o Inserts)[R148]	1,892,909	1,426,746 427,915[2] 1,002,576[3]
Wood Heaters (Cordwood + Pellet)[R149]	224,061	208,769
Cordwood Heaters (Stoves + Inserts)[R150]	214,571	199,491
Pellet Heaters (Stoves + Inserts)[R151]	9490	9278
Total Stoves (Cordwood + Pellet)[R152]	48,719	43,128
Cordwood Stoves (Conv. + Cat. + Non-Cat.)[R153]	43,877	38,384
Conventional Stoves[R154]	33,868	29,172
Certified Catalytic Stoves[R155]	2916	2687
Certified Non-Catalytic Stoves[R156]	7099	6525
Pellet Stoves[R157]	4842	4744
Fireplace Inserts(Cordwood + Pellet)[R158]	170,500	160,897
Cordwood Fireplace Inserts (Conv. + Cat. + Non-Cat.)[R159]	165,852	156,363
Conventional Inserts[R160]	127,392	118,836
Certified Catalytic Inserts[R161]	11,218	10,945
Certified Non-Catalytic Inserts[R162]	27,242	26,582
Pellet Inserts[R163]	4648	4534
Fireplace w/o Inserts[R164] [R164a] [R164b]	1,673,684	1,222,721 219,146[2] 1,002,576[3]

[1]Calculations:
R153 through R157 from Table 3.20
R159 through R163 from Table 3.21
R164 is from Table 3.22
R152 = R153 + R157
R158 = R159 + R163
R150 = R153 + R159
R151 = R157 + R163
R149 = R150 + R151
R148 = R149 + R164
[2]Used for heating
[3]Used for aesthetics, no heaters are considered used for aesthetics, only fireplaces are included in this category.

Table 3.24
Wood-burning Appliances in the Coachella Valley Portion of the SSAB[1]

Category	Owned[C85]	Used[C86]
Total Wood-Burning Appliances (Wood Heaters + Fireplaces w/o Inserts)[R165]	55,691	42,532 15,734[2] 26,805[3]
Wood Heaters (Cordwood + Pellet)[R166]	10,150	9299
Cordwood Heaters (Stoves + Inserts [R167]	9653	8820
Pellet Heaters (Stoves + Inserts)[R168]	497	479
Total Stoves (Cordwood + Pellet)[R169]	3037	2653
Cordwood Stoves (Conv. + Cat. + Non-Cat.)[R170]	2735	2361
Conventional Stoves[R171]	2111	1794
Certified Catalytic Stoves [R172]	181	165
Certified Non-Catalytic Stoves [R173]	442	401
Pellet Stoves[R174]	302	292
Fireplace Inserts (Cordwood + Pellet)[R175]	7113	6646
Cordwood Fireplace Inserts(Conv. + Cat. + Non-Cat.)[R176]	6918	6459
Conventional Inserts[R177]	5314	4908
Certified Catalytic Inserts[R178]	468	450
Certified Non-Catalytic Inserts[R179]	1148	1098
Pellet Inserts[R180]	195	187
Fireplace w/o Inserts[R181] [R181a] [R181b]	45,530	33,237 6435[2] 26,805[3]

[1]Calculations:
R170 through R174 from Table 3.20
R176 through R180 from Table 3.21
R181 is from Table 3.22
R169 = R170 + R174
R175 = R176 + R180
R167 = R170 + R174
R168 = R174 + R180
R166 = R167 + R168
R165 = R166 + R181
[2]Used for heating
[3]Used for aesthetics, heaters are considered used for aesthetics, fireplaces only are included in this category.

References for Section 3

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4. Annual Wood Consumption by Wood-burning Appliance Type

To calculate the wood burning activity (mass of dry fuel burned per year) for each appliance type, the number of units of each appliance type (Tables 3.23 and 3.24) that were used were multiplied by the average mass of cordwood or pellets they burned annually. The mass of wax/fiber firelogs were estimated separately from (1) sales records and from (2) a household survey conducted in the San Francisco, San Joaquin Valley and Sacramento areas.

Two different methods were used to estimate the average amount of cordwood (and pellets) burned in wood burning appliances. One method was used for wood heaters and a different method was used for fireplaces without inserts. The survey conducted by Sierra Research that specifically covered SSAB and the Coachella Valley portion of SSAB was used to estimate the number of cords burned in wood heaters (Table 4.1). The data provided by the Sierra Research survey was consistent with data obtained for wood heaters in other parts of the country in similar mild climate settings. For fireplaces without inserts, surveys conducted in other parts of California that included questions regarding the frequency of use and the duration of each fire (instead of simple direct questions asking how many cords were burned per year that were part of the Sierra Research survey) were used to estimate the average amount of fuel consumed annually. This was done because it has been widely acknowledged (including in the Sierra Research report itself) that consumers tend to overestimate the amount of fuel consumed in appliances that use well less than a cord per year when ask directly how many cords were burned. Small amounts of firewood are often referred to as a cord or half a cord and it is a common response in surveys for a home occupant to simply state "about a cord" without fully understanding the magnitude of a true cord. This is less of a problem among home consumers that use more wood in wood heaters and use them as serious secondary or primary heating sources.

For wood heaters, after an estimate of the amount of wood burned in a conventional wood heater, (the only type available prior to 1990 and included in the 1989 Sierra Research report) was obtained from the Sierra Research survey data, the second step was to assign efficiency to each wood-burning heater type (Table 4.2). This was done to adjust the annual cordwood usage for wood heaters shown in Table 4.1 that were for pre-EPA certified wood heaters to cordwood usage for current certified catalytic and certified non-catalytic cordwood heaters as well as for pellet heaters since less fuel will be used in these devices for the same heat demand due to their higher efficiencies. Because there are numerous methods for measuring and conventions for reporting efficiency, a "best professional judgment" value rather than a true mean was used for these calculations.

The first step in calculating the average cords per fireplace without insert was to compile the heating degree day (HDD) data for each area in California where a useful survey was conducted. Representative values were calculated for the San Joaquin Valley (where surveys have been conducted), SCAB, and the Coachella Valley portion of the SSAB (Table 4.3). The representative values were calculated by averaging data from geographically separated stations in each of the areas. As the frequency of fireplace usage should be roughly proportional to number of cooler weather days, the HDD data were used to adjust the values obtained from the surveys in other parts of California to the SCAB and the Coachella Valley portion of the SSAB.

As previously noted, the frequency of fires and the duration of fires were the primary input for the calculation of the amount of cords burned per fireplace without inserts (Table 4.4). Additionally, the typical burn rate of a fireplace without an insert was used in the calculations and is also shown in Table 4.4. Compilations of fireplace burn rates have been conducted. (See Appendices A and B.) The mode of these compilations rather than the median or mean was used as a representative fireplace burn rate as the compilations contain data from research and laboratory studies in which larger fireplaces with commensurately higher burn rates were disproportionably included. Overwhelmingly, the most common sizes of fireplaces in use are the smaller sizes referred to as 36-inch or 42-inch, which relate to their front openings. Therefore, the mode of the database is the best representation of central tendency for fireplaces in homes. It should be noted that, unlike a wood heater, there is little control of burn rate in fireplaces and there is only a limited range of fire sizes that are reasonable regardless of climatic conditions.

Besides calculating the number of cords of wood from the frequency, duration and typical burn rate of fires, data from a national projection of fireplace usage in both the aesthetic and heating use categories (reference 4.12) was used to estimate the number of cords burned per fireplace without an insert. (Method 2 in Table 4.4) These data were used in conjunction with the proportion of fireplaces used in the SCAB and the Coachella Valley portion of the SSAB that were independently determined from other databases to be used for aesthetic and heating purposes.

For both wood heaters and fireplaces without inserts, the final step in the calculation of the mass of fuel used per appliance was to determine the tree species used for fuel and their corresponding mass per cord. The percent of fuel by tree species was determined by conducting a phone interview with ten wood vendors in southern California and averaging their responses with the survey results obtained from the interview with 318 wood-burning households in the South Coast Air Basin (Table 4.5). The dry cord weights for wood by tree type was obtained from various sources and are compiled in Table 4.6. From the relative fraction of each tree type used for fuel in southern California and from the characteristic weight per cord of each of the tree types, a weighted mass for a cord of wood was calculated as 3081 lbs (1.540 tons or 1400 kg).

The mass of wax/fiber firelogs burned in 2002 in both the SCAB and SSAB is tabulated in Table 4.7. The averages of the wax/fiber firelog mass calculated by the two methods previously discussed and shown in Table 4.5 is used in the subsequent calculations. Once the total mass of wax/fiber firelogs used annually was calculated, a cordwood equivalent mass was calculated and it was subtracted from the cordwood mass burned in fireplaces without inserts to obtain a corrected cordwood value and prevent “double counting”. The cordwood equivalent value takes into account the difference in heat content and moisture content between wax/fiber firelogs and cordwood and the one-at-a-time usage of wax/fiber firelogs.

The annual fuel consumption (activity) per appliance type is tabulated in Table 4.8. The activity for five appliance types were compiled: (1) conventional pre-EPA certification cordwood heaters, (2) EPA-certified non-catalytic cordwood heaters, (3) EPA-certified catalytic cordwood heaters, (4) pellet heaters, and (5) fireplaces without inserts. Activity for fireplaces were further divided into cordwood and wax/fiber firelog usage. The term heater is the sum of freestanding

stoves and fireplace inserts. The term fireplace without insert includes both wall-mounted and freestanding units. The activity was divided into these categories to be consistent with emission factor groupings that, when multiplied by the activities, will provide the emission inventory.

Table 4.1
Average Cords Burned per Year in Cordwood Heaters[1]

Air basin	Cordwood stoves and fireplace inserts (cordwood heaters) (cords/year)[C87]
SCAB[R182]	0.95
SSAB[R183]	1.00

[1]All data from reference 4.1. The cordwood heater number is the weighted average of the "woodstove" and "stovelike insert" numbers. The SCAB values were estimated from 318 wood-burning households in the South Coast Air Basin The SSAB were estimated by taking the weighted average from 24 wood-burning households in desert portion of Los Angeles County, 9 wood-burning households in the desert portion of Riverside County and from 102 households in the San Diego Air Basin. The data from the desert portions of Los Angeles and Riverside counties and the San Diego Air Basin were used due to the geographic proximity and similar mild climates of these areas. The desert portion of San Bernardino County was not used as it may contain some homes in a significantly cooler climate.

Table 4.2
Wood-burning Appliance Efficiencies (%)

Appliance Type	AP-42[1][C88]	EPA-600/R-98-174a[2][C89]	NSPS Default[3][C90	Sonoma Co. Rept.[4][C91]	Value Used Here[C92]
Conv. pre-EPA cert.[R184]	54	54	-	-	54
EPA-cert. Non-cat.[R185]	68	68	63	57.4-70.1[7]	65
EPA-cert Cat.[R186]	68	72	72	-	70
Pellet[R187]	56[5], 68[6]	78	78	-	75

[1]reference 4.2
[2]reference 4.3
[3]reference 4.4
[4]reference 4.5
[5]older EPA exempt pellet stove
[6]older EPA certified pellet stove
[7]range for multiple tests on a single model wood stove with different burn rates

Table 4.3
Heating Degree Day Data[1]

City/Area	Average Annual $HDD_{[C93]}$
SCAB Average$_{[R188]}$	1598
Los Angeles (LAX)$_{[R189]}$	1274
Los Angeles (USC)$_{[R190]}$	928
Elsinore$_{[R191]}$	1924
Fontana Kaiser$_{[R192]}$	1364
Dry Canyon Reservoir$_{[R193]}$	2502
SSAB Average$_{[194]}$	1035
Palm Springs$_{[R195]}$	951
Mecca Fire Station$_{[R196]}$	1118
Sacramento$_{[R197]}$	2666
San Francisco*$_{[R198]}$	2730
San Joaquin Valley Average$_{[R199]}$	2377
Bakersfield$_{[R200]}$	2120
Fresno$_{[R201]}$	2447
Stockton$_{[R202]}$	2563

*Average of San Francisco International Airport and Downtown San Francisco
Data from reference 4.6.
[1]Calculations:
[R188,C93] = ([R189,C93] + [R190,C93] + [R191,C93] + [R192,C93] + [R193,C93])/5
[R194,C93] = ([R195,C93] + [R196,C93])/2
[R199,C93] = (R200,C93] + [R201,C93] + [R202,C93])/3

Table 4.4
Average Cords Burned per Year in Fireplaces without Inserts[1]

Method 1				
Length of Fire – Location				Hours
Composite of Homes in San Francisco, Sacramento, Seattle, Los Angeles, and Dallas[2] [R203]				3.3
Composite of Homes in San Francisco, San Joaquin Valley and Sacramento area[3] [R204]				4.6
Fresno[4] [R205]				2.6
Average [R206]				3.5
Typical Cordwood Burn Rate of Fireplace without Insert[5] [R207]			3.5 dry kg/hr	
Fires per Year – Location	Number[6] [C94]	HDD [C95]	Adjusted to SCAB (HDD =1598) [C96]	Adjusted to SSAB (HDD = 1035) [C97]
San Joaquin Valley[7] [R208]	39	2377	24	17
San Joaquin Valley[8] [R209]	48	2377	32	21
Fresno[4] [R210]	46	2447	30	19
San Francisco[3] [R211]	26	2730	15	10
San Joaquin Valley[3] [R212]	47	2377	32	20
Sacramento Area[3] [R213]	31	2666	19	12
Average [R214]	-	-	25	16
Average Number of Cords per Fireplace per Year				
SCAB [R215]	0.22 cords			
SSAB [R216]	0.14 cords			
Method 2				
Avg. cords burned per year in fireplaces without inserts used for heating[9] [R217]				0.656 cords
Avg. cords burned per year in fireplaces without inserts used for aesthetics[9] [R218]				0.069 cords
Avg. cords burned per year weighted for relative heating and aesthetic use (SCAB) [R219]				0.17 cords
Avg. cords burned per year weighted for relative heating and aesthetic use (SSAB) [R220]				0.19 cords

[1]Calculations:
R206 = (R203 + R204 + R205)/3
[R208,C96] through [R213,C96] = C94 X (1598/C95)
[R208,C97] through [R213,C97] = C94 X (1035/C95)
[R214,C96] = average [R208,C96] through [R213,C96]
[R214,C97] = average [R208,C97] through [R213,C97]
R215 = R206 X R207 X [R214,C96] / R236
R216 = R206 X R207 X [R214,C97] / R236
R219 = R217 X ([R164a,C84]/[R164,C84]) + R218 X ([R164b,C86]/[R164/C86])
R220 = R217 X ([R181a,C86]/[R181,C86]) + R218 X ([R181b,C86]/[R181,C86])
[2]reference 4.7
[3]reference 4.8
[4]reference 4.9
[5]See Appendix A.
[6]Number of fires per year in fireplaces that are used.
[7]reference 4.10
[8]reference 4.11
[9]reference 4.12

Table 4.5
Cordwood by Tree Type in Southern California

Firewood Dealers	City	Almond/ Fruitwood[C98]	Ash[C99]	Cedar[C100]	Eucalyptus[C101]	Juniper[C102]	Maple[C103]	Oak[C104]	Orange[C105]	Pine/ Fir/ Tamarack[C106]	Walnut[C107]	Urban/ Other[C108]
Holiday Firewood[R221]	Pasadena	60%	0%	0%	0%	0%	0%	20%	0%	0%	0%	20%
Southern California Tree & Landscape[R222]	Torrance	0%	0%	0%	25%	0%	0%	0%	0%	25%	0%	50%
Tru Inc.[R223]	Rancho Cucamonga	0%	0%	0%	75%	0%	0%	0%	0%	0%	0%	25%
Jones Firewood Yard[R224]	Hawthorne	15%	0%	20%	15%	0%	0%	10%	0%	40%	0%	0%
Gallagher Firewood[R225]	North Hollywood	0%	40%	0%	15%	0%	5%	10%	0%	0%	10%	5%
Woodshed Firewood Co. [R226]	Orange	15%	0%	0%	0%	5%	0%	15%	15%	5%	0%	45%
Freeburn Firewood[R227]	Pomona	0%	0%	0%	70%	0%	0%	10%	0%	0%	0%	20%
A & L Firewood & Landscape[R228]	Newport Beach	0%	0%	0%	75%	0%	0%	20%	0%	0%	0%	5%
All Seasons Firewood[R229]	Pasadena	0%	0%	0%	30%	0%	0%	40%	0%	20%	0%	10%
Treeco Inc. Products & Services[R230]	Brea	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
Survey[1] [R231]	South Coast Basin	7.5%	0%	1.6%	18.8%	0%	0%	19.5%	0%	25%	0%	55.8%
Average[R232]		8.9%	3.6%	2.0%	29.4%	0.5%	0.5%	13.1%	1.4%	10.5%	0.9%	30.5%

[1] Survey of 318 wood-burning households, reference 4.1

Table 4.6
Cord Weight by Tree Type and Weight of Average Area Cord[1]

	Almond/ Fruitwood[2,3,4] [C109]	Ash[3] [C110]	Cedar[1,3,5] [C111]	Eucalyptus[4] [C112]	Juniper[3] [C113]	Maple[1,3,6] [C114]	Oak[3,4] [C115]	Orange[5] [C116]	Pine/ Fir/ Tamarack[1,3,4] [C117]	Walnut[5] [C118]	Urban/ Other[7] [C119]
Dry Weight Per Cord (lb/cord) [R233]	3000	2867	1812	3568	2625	3267	3253	3227	2245	2600	2846
Percent of total wood [R234]	8.9%	3.6%	2.0%	29.4%	0.5%	0.5%	13.1%	1.4%	10.5%	0.9%	30.5%
Contribution to Dry Weight Per Area Average Cord (lb/cord) [R235]	266	104	36	1050	12	15	427	44	235	24	869
			Average Dry Weight Per Cord [R236]			3081 lb	(1.540 tons or 1400 kg)				

[1]Calculation:
R235 = R233 X R234
R236 = sum of R233,C109 through R233,C119
[2]Firewood Ratings and Info: http://mb-soft.com/juca/print/firewood.html
[3]Correspondence with southern California firewood dealers, Almond wood has a cord weight close to that of oak (~4000 lb/cord)
[4]Fuelwood Facts: Oregon State University Extension Service
[5]Wood Weights and Values:
http://72.14.203.104/search?q=cache:vsfr1FesUIoJ:www.consumerenergycenter.org/homeandwork/homes/inside/heatandcool/fireplaces.html+eucalyptus+cord+weight&hl=en&gl=us&ct=clnk&cd=2&client=firefox-a
[6]Wood Fuel for Heating, University of Missouri Extension. http://muextension.missouri.edu/explore/agguides/forestry/g05450.htm
[7]Urban/Other was determined by taking an average of all of the different wood weights per cord.

Table 4.7
Wax/Fiber Firelog Activity[1]

Parameters – Calculation Method 1	Value
Total firelogs sold nationally Sept. 98 to Sept. 99[2] [R237]	103,738,112 logs
Average weight of a firelog [R238]	4.95 lbs (2.25 kg)
Fraction of firelogs sold in California[2] [R239]	0.22
Mass of firelogs sold in California 1999 [R240]	51,350,365 kg
Households in California 1999[3] [R241]	11,213,201
Households in California 2002[3] [R242]	11,707,270
Households in SCAB 2002 [R243]	4,846,728
Households in SSAB 2002 [R244]	125,042
Mass of firelogs used in SCAB 2002 [R245]	22,195,380 kg
Mass of firelogs used in SSAB 2002 [R246]	572,624 kg
Calculation Method 2	
Average number of firelogs used per fireplace that is used in San Francisco, San Joaquin Valley and Sacramento areas[4] [R247]	16 logs
Fraction of fireplaces that are used that use firelogs at least sometimes in San Francisco, San Joaquin Valley and Sacramento areas[4] [R248]	0.42
Number of fireplaces used in SCAB 2002 [R249]	1,222,721 fireplaces
Number of fireplaces used in SSAB 2002 [R250]	33,237 fireplaces
Mass of firelogs used in SCAB 2002 [R251]	18,487,541 kg
Mass of firelogs used in SSAB 2002 [R252]	502, 543 kg
Average of Method 1 and Method 2 Results	
Mass of firelogs used in SCAB 2002 [R253]	20,341,461 kg
Mass of firelogs used in SSAB 2002 [R254]	537,584 kg
Mean moisture content of firelogs[5] [R255]	2.2%
Dry mass of firelogs used in SCAB 2002 [R256]	19,893,949 kg
Dry mass of firelogs used in SSAB 2002 [R257]	525,757 kg
Dry mass cordwood replacement equivalent SCAB [R258]	91,512,165 kg
Dry mass cordwood replacement equivalent SSAB [R259]	2,418,482 kg

[1]Calculations and assumptions:
Mass of firelogs sold in 1999 assumed to be equal to those sold between Sept. 1998 and Sept 1999.
Average weight of firelog is 4.95 lbs, reference 4.7, 4.95 lbs = 0.34 X 6 lbs + 0.32
X 5 lbs + 0.34 X 3.5 lbs, the fraction of firelogs in weight sizes other than 6 lb, 5 lb and 3.5 lb is insignificant., reference 4.13.
R240 = R237 X R238 X R239
R243 = [R7,C5] + [R7,C6] + [R7,C7] + [R7,C8]
R244 = [R8,C7]
R245 = R240 X (R242/R241) X (R243/R242)
R246 = R240 X (R242/R241) X (R244/R2242)
R249 = [R164,C84]
R250 = [R181,C86]
R251 = R238 X R247 X R248 X R249
R252 = R238 X R247 X R248 X R250
R253 = (R251 + R245)/2
R254 = (R252 + R246)/2

R256 = R253 X (1-R255/100%)
R257 = R254 X (1-R255/100%)
R258 = R253 X (R206 X R207)/(2.72 X (1-R255/100%))
R259 = R254 X (R206 X R207)/(2.72 X (1-R255/100%))
[2]reference 4.14
[3]reference 4.15
[4]reference 4.8
[5]see Appendix A

Table 4.8
Annual Fuel Consumption (Activity) by Appliance Type[1]

Appliance Type	SCAB – mass dry fuel 2002 $(kg)_{[C120]}$	SSAB – mass dry fuel 2002 $(kg)_{[C121]}$
Conventional pre-EPA certification wood heaters (freestanding stoves + fireplace inserts)$_{[R260]}$	1.97×10^8	9.38×10^6
EPA certified non-catalytic wood heaters (freestanding stoves +fireplace inserts)$_{[R261]}$	3.66×10^7	1.74×10^6
EPA certified catalytic wood heaters (freestanding stoves + fireplace inserts)$_{[R262]}$	1.40×10^7	6.64×10^5
Pellet heaters (freestanding stoves + fireplace inserts)$_{[R263]}$	8.89×10^6	4.82×10^5
Fireplaces without inserts$_{[R264a] \text{ cordwood}, [R264b] \text{ wax/fiber firelogs}}$	2.48×10^8 cordwood 1.99×10^7 mass firelogs	4.09×10^6 cordwood 5.26×10^5 mass firelogs

[1]Calculations:
[R260,C120] = ([R154,C84] + [R160,C84]) X [R182,C87] X R236
[R260,C121] = ([R171,C86] + [R177,C86]) X [R183,C87] X R236
[R261,C120] = ([R156,C84] + [R162,C84]) X [R182,C87] X R236 X ([R184,C92]/[R185,C92])
[R261,C121] = ([R173,C86] + [R179,C86]) X [R183,C87] X R236 X ([R184,C92]/[R185,C92])
[R262,C120] = ([R155,C84] + [R161,C84]) X [R182,C87] X R236 X ([R184,C92]/[R186,C92])
[R262,C121] = ([R172,C86] + [R178,C86]) X [R183,C87] X R236 X ([R184,C92]/[R186,C92])
[R263,C120] = [R151,C84]/([R154,C84] + [R160,C84]) X ([R184,C92]/[R187,C92]) X [R260,C120]
[R263,C121] = [R168,C86]/([R171,C86] + [R177,C86]) X ([R184,C92]/[R187,C92]) X [R260,C121]
[R264a,C120] = ([R164,C84] X R215 X R236) – R258
[R264a,C121] = ([R181,C86] X R216 X R236) – R259
[R264b,C120] = R256
[R264b,C121] = R257

References for Section 4

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4.2 U.S. Environmental Protection Agency, Compilation of Air Pollution Emission Factors – Volume 1: Stationary Point and Area Sources, Ap-42, Chapter 1.10, Residential Woodstoves, Research Triangle Park, NC, revised October 1996.

4.3 Houck, J.E. and Tiegs, P.E., Residential Wood Combustion Technology Review, Volume 1. Technical Report, report to U.S. Environmental Protection Agency, EPA-600/R-98-174a.

4.4 U.S. Federal, Register, Standards for Particulate Matter, Vol. 53, No. 38, Section 60.536, February 26, 1988.

4.5 Tiegs, P. and Houck, J.E., Evaluation of the Northern Sonoma County Wood-burning Fireplace and Masonry Heater Emissions Testing Protocols, OMNI Environmental Services, Inc. report to Northern Sonoma County Air Quality Management District, Healdsburg, CA., November 30, 2000.

4.6 NOAA Satellite and Information Service, U.S. Climate Normals, http://cdo.ncdc.noaa.gov/cgi-bin/climatenormals/climatenormals.pl.

4.7 Perry Lawson & Associates, Consumer Research Results, report to Duraflame, Inc, Stockton, CA.

4.8 Broderick, D. and Houck, J.E., Results of Wood Burning Survey – Sacramento, San Joaquin, and San Francisco Areas, University of California Berkeley/California Air Resources Board – GIS Study, report prepared for Hearth, Patio, and Barbecue Association, 2003.

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4.11 META Information Services, Summary Results, San Joaquin Valley Unified Air Pollution Control District Baseline Telephone Survey, January 1999, report to San Joaquin Valley Unified Air Pollution Control District, 1999.

4.12 Houck J.E., Mangino J., Brooks, G., and Huntley R.H., A Recommended Procedure for Compiling Emission Inventory National, Regional and County Level Activity

Data for the Residential Wood Combustion Source Category, proceedings U.S. Environmental Protection Agency Emission Inventory Conference, Denver CO, 2001.

4.13 Solari, S., Duraflame, Inc. Stockton CA, 2000, personnel communication.

4.14 Information Resource, Infoscan Region Profile, report to Duraflame, Inc., Stockton, CA, Jan. 2000.

4.15 U.S. Census Bureau, American Fact Finder, California, Selected Housing Characteristics, 2004.

5. Annual Particulate Emissions by Wood-burning Appliance Type

Annual particulate emissions were calculated simply by multiplying the mass of fuel burned by appliance category (Table 4.8) by the corresponding emission factor. The source of the emission factor for conventional wood heaters is the U.S. EPA AP-42 document (Reference 5.1). The AP-42 document is also the basis for the emission factors for certified catalytic and non-catalytic wood heaters, however since it is generally acknowledged that the performance of certified wood heaters has improved since the earliest models included in the AP-42 references, the emission factors for certified catalytic and non-catalytic models have been revised based on the certification values of modern certified wood heaters as compared to the earliest models included in AP-42 (Table 5.1 and Reference 5.2). Similarly, the emission factors for pellet heaters included in AP-42 are for the earliest models, and emission factors for both current certified and exempt models are similar and considerably lower than the earliest models shown in AP-42, and data from reference 5.3 has been used here. The AP-42 emission factors for fireplaces without inserts are based on relatively few data points and the AP-42 does not include emission factors for wax/fiber firelogs. Much larger compilations for fireplace emission factors, including emissions factors for both cordwood and wax/firelogs, have been compiled (See Appendices A and B), and have been used here for their emission factors. Based on the information above, the factors used to estimate emissions are presented in Table 5.2.

It should be noted that all particulate emission factors are in the form of "Method 5H equivalents" and total particulate emissions are treated equivalent to $PM_{2.5}$ emissions since well over 90% of residential wood combustion particulate emissions are submicron in size. Two other additional notes on emission factors should also be made. First, the emission factor for EPA certified catalytic wood heaters is estimated to be higher than for EPA certified non-catalytic wood heaters, even though new catalytic models often have lower emission than non-catalytic models, due to normal degradation of catalytic activity with use. Second, even though the wax/fiber firelog emission factor is higher than cordwood, the use of wax/fiber firelogs typically produce less emissions than cordwood since they contain a higher heat content and less mass is burned to produce a satisfactory fireplace fire.

The $PM_{2.5}$ emission inventory for SCAB and SSAB by appliance type is provided in Table 5.2

Table 5.1
Comparison of Average Certified Emission Rates for Old and New Phase 2 Cordwood Stoves[1]

Time Period	Woodstove Type	Number of Stoves[C122]	Average Emission Rate (g/hr, 5H equivalent)[C123]	Percent Reduction (%)[C124]
First 5 years of certification (1988-1992)	Non-catalytic[R265]	115	5.1	-
	Catalytic[R266]	110	2.9	-
Currently certified woodstoves (certified or renewed in the last 5 years)	Non-catalytic[R267]	137	4.1	19.6
	Catalytic[R268]	23	2.7	6.9

[1]Data from Reference 5.2
Calculations:
[R267,C124] = (([R265,C123] – [R267,C123])/[R265,C123]) X 100%
[R268,C124] = (([R266,C124] – [R268,C123])/[R266,C123]) X 100%

Table 5.2
Emission Factors[1]

Appliance Type	Emission Factor (g/dry kg fuel) listed in AP-42[2] [C125]	Updated Emission Factor (g/dry kg fuel)[C126]
Conventional pre-EPA certification wood heaters (freestanding stoves + fireplace inserts) [R269]	15.3	15.3
EPA certified non-catalytic wood heaters (freestanding stoves + fireplace inserts) [R270]	7.3	5.87
EPA certified catalytic wood heaters (freestanding stoves + fireplace inserts) [R271]	8.1	7.54
Pellet heaters (freestanding stoves + fireplace inserts) [R272]	4.4 exempt, 2.2 certified	1.25[3]
Fireplaces without inserts [R273a] cordwood, [R273b] wax/fiber firelogs	17.3	13.0 cordwood[4] 21.2 firelogs[5]

[1]Calculations:
[R270,C126] = [R270,C125] X (1-[R267,C124]/100%)
[R271,C126] = [R271,C125] X (1-[R268,C124]/100%)
[2]References 5.1 and 5.4
[3]Reference 5.3
[4]See Appendices A and B
[5]See Appendix A

Table 5.3
2002 PM $_{2.5}$ Emission Inventory for SCAB and SSAB by Appliance Type[1]

Appliance Type	Total $PM_{2.5}$ in SCAB $2002_{[C127]}$		Total $PM_{2.5}$ in SSAB $2002_{[C128]}$	
	kg	English tons	kg	English tons
Conventional pre-EPA certification wood heaters (freestanding stoves + fireplace inserts) [R274]	3.01×10^{6}	3.31×10^{3}	1.43×10^{5}	1.57×10^{2}
EPA certified non-catalytic wood heaters (freestanding stoves + fireplace inserts) [R275]	2.15×10^{5}	2.36×10^{2}	1.02×10^{4}	1.12×10^{1}
EPA certified catalytic wood heaters (freestanding stoves + fireplace inserts) [R276]	1.06×10^{5}	1.17×10^{2}	5.01×10^{3}	5.51×10^{0}
Pellet heaters (freestanding stoves + fireplace inserts) [R277]	1.11×10^{4}	1.22×10^{1}	6.02×10^{2}	6.62×10^{-1}
Fireplaces without inserts burning cordwood[R278]	3.22×10^{6}	3.55×10^{3}	5.32×10^{4}	5.85×10^{1}
Fireplaces without inserts burning firelogs[R279]	4.22×10^{5}	4.64×10^{2}	1.12×10^{4}	1.23×10^{1}

[1]Calculations:
Emissions in kg converted to English tons by multiplying by 2.2 and dividing by 2000.
[R274,C127] = [R260,C120] X ([R269,C126]/1000)
[R274,C128] = [R260,C121] X ([R269,C126]/1000)
[R275,C127] = [R261,C120] X ([R270,C126]/1000)
[R275,C128] = [R261,C121] X ([R270,C126]/1000)
[R276,C127] = [R262,C120] X ([R271,C126]/1000)
[R276,C128] = [R262,C121] X ([R271,C126]/1000)
[R277,C127] = [R263,C120] X ([R272,C126]/1000)
[R277,C128] = [R263,C121] X ([R272,C126]/1000)
[R278,C127] = [R264a,C120] X ([R273a,C126]/1000)
[R278,C128] = [R264a,C121] X ([R273a,C126]/1000)
[R279,C127] = [R264b,C120] X ([R273b,C126]/1000)
[R279,C128] = [R264b,C121] X ([R273b,C126]/1000)

References for Section 5

5.1 U.S. Environmental Protection Agency, Compilation of Air Pollution Emission Factors – Volume 1: Stationary Point and Area Sources, AP-42, Chapter 1.10, Residential Woodstoves, Research Triangle Park, NC, revised October 1996.

5.2 List of EPA Certified Wood Stoves, http://www.epa.gov/Compliance/resources/publications/monitoring/programs/woodstoves/certifiedwood.pdf

5.3 Houck, J.E., Scott, A.T., Purvis, C.R., Kariher, P.H., Crouch, J., and Van Buren, J., Low Emission and High Efficiency Residential Pellet-Fired Heaters, Proceedings of the Ninth Biennial Bioenergy Conference, Buffalo, NY, October 15-19, 2000.

5.4 U.S. Environmental Protection Agency, Compilation of Air Pollution Emission Factors – Volume 1: Stationary Point and Area Sources, AP-42, Chapter 1.9, Residential Fireplaces, Research Triangle Park, NC, revised October 1996.

6. Summary of Wood-burning Appliance Data and Monthly Apportionment of Particulate Emissions

Tables 6.1 and 6.2 are compilations of the key data for the SCAB and SSAB for the 2002 base year. They contain the number of appliances owned and used by appliance type, the mass of fuel burned in them, and the mass of $PM_{2.5}$ emitted.

Table 6.3 contains the heating degree day (HDD) data for the SCAB and the Coachella Valley portion of the SSAB. Figure 6.1 shows the individual monitoring sites from which data was used to develop average basin values for each air basin. The percent of the total annual HDD occurring in each month is also shown in Table 6.3. The percent of total annual HDD occurring in each month was used to proportion the $PM_{2.5}$ emissions from residential wood combustion on a monthly basis (Figure 6.2).

Table 6.1
Data Summary for the SCAB, 2002 Base Year[1]

Appliance Type	Number owned	Number used	Mass dry fuel burned (kg)	Mass $PM_{2.5}$ emitted (kg)
Conventional pre-EPA certification wood heaters	161,260	148,008	1.97×10^8	3.01×10^6
EPA certified non-catalytic wood heaters	34,341	33,107	3.66×10^7	2.15×10^5
EPA certified catalytic wood heaters	14,134	13,632	1.40×10^7	1.06×10^5
Pellet heaters	9490	9278	8.89×10^6	1.11×10^4
Fireplaces without inserts	1,673,684	1,221,721	2.48×10^8 cw[2] 1.99×10^7 fl[3]	3.22×10^6 cw[2] 4.22×10^5 fl[3]
Total	1,892,909	1,426,746	5.24×10^8	6.96×10^6

[1]Heaters = freestanding stoves + fireplace inserts
[2]cw = cordwood
[3]fl = firelogs

Table 6.2
Data Summary for the Coachella Valley Portion of the SSAB, 2002 Base Year[1]

Appliance Type	Number owned	Number used	Mass dry fuel burned (kg)	Mass $PM_{2.5}$ emitted (kg)
Conventional pre-EPA certification wood heaters	7425	6702	9.38×10^6	1.43×10^5
EPA certified non-catalytic wood heaters	1590	1499	1.74×10^6	1.02×10^4
EPA certified catalytic wood heaters	649	615	6.64×10^5	5.01×10^3
Pellet heaters	497	479	4.82×10^5	6.02×10^2
Fireplaces without inserts	45,530	33,237	4.09×10^6 cw[2] 5.26×10^5 fl[3]	5.32×10^4 cw[2] 1.12×10^4 fl[3]
Total	55,691	42,532	1.69×10^7	2.23×10^5

[1]Heaters = freestanding stoves + fireplace inserts
[2]cw = cordwood
[3]fl = firelogs

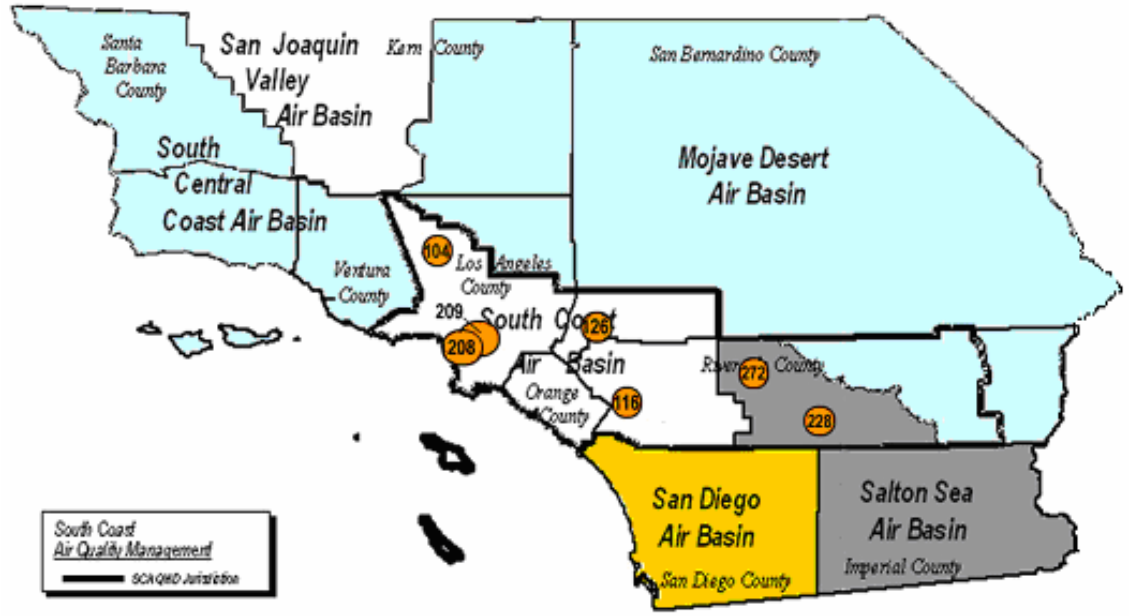

Figure 6.1 Location of Meteorological Monitoring Sites Used in the Calculation of Average Annual and Monthly Heating Degree Day Values for SCAB and Coachella Valley Portion of SSAB.

Table 6.3
Monthly and Annual Heating Degree Day Data

Basin	Site	Category	HDD												
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
SCAB	104 - Dry Canyon Res.	HDD	457	385	374	251	142	29	4	2	21	97	293	447	2502
		% HDD	18.3%	15.4%	14.9%	10.0%	5.7%	1.2%	0.2%	0.1%	0.8%	3.9%	11.7%	17.9%	100%
	116 - Elsinore	HDD	398	305	263	163	73	10	0	0	8	63	236	405	1924
		% HDD	20.7%	15.9%	13.7%	8.5%	3.8%	0.5%	0.0%	0.0%	0.4%	3.3%	12.3%	21.0%	100%
	126 - Fontana Kaiser	HDD	270	196	203	149	72	16	0	0	4	27	154	273	1364
		% HDD	19.8%	14.4%	14.9%	10.9%	5.3%	1.2%	0.0%	0.0%	0.3%	2.0%	11.3%	20.0%	100%
	208 - LAX	HDD	252	205	200	141	78	19	1	0	2	21	121	234	1274
		% HDD	19.8%	16.1%	15.7%	11.1%	6.1%	1.5%	0.1%	0.0%	0.2%	1.6%	9.5%	18.4%	100%
	209 - LA USC	HDD	207	149	144	83	36	5	0	0	1	11	91	201	928
		% HDD	22.3%	16.1%	15.5%	8.9%	3.9%	0.5%	0.0%	0.0%	0.1%	1.2%	9.8%	21.7%	100%
	Average	**HDD**	**317**	**248**	**237**	**157**	**80**	**16**	**1**	**0**	**7**	**44**	**179**	**312**	**1598**
		% HDD	**19.8%**	**15.5%**	**14.8%**	**9.8%**	**5.0%**	**1.0%**	**0.1%**	**0.0%**	**0.5%**	**2.7%**	**11.2%**	**19.5%**	**100%**
SSAB	228 - Mecca F.S.	HDD	321	174	90	25	2	0	0	0	0	14	150	342	1118
		% HDD	28.7%	15.6%	8.1%	2.2%	0.2%	0.0%	0.0%	0.0%	0.0%	1.3%	13.4%	30.6%	100%
	272 - Palm Springs	HDD	257	140	111	42	8	0	0	0	0	8	112	273	951
		% HDD	27.0%	14.7%	11.7%	4.4%	0.8%	0.0%	0.0%	0.0%	0.0%	0.8%	11.8%	28.7%	100%
	Average	**HDD**	**289**	**157**	**101**	**34**	**5**	**0**	**0**	**0**	**0**	**11**	**131**	**308**	**1035**
		% HDD	**27.9%**	**15.2%**	**9.7%**	**3.2%**	**0.5%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**1.1%**	**12.7%**	**29.7%**	**100%**

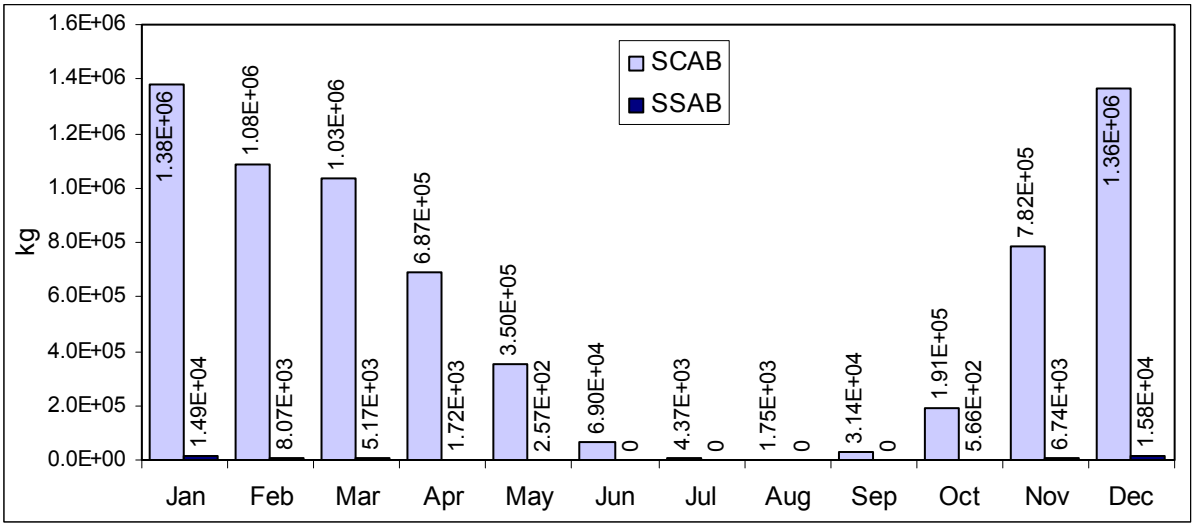

Figure 6.2 Residential Wood Combustion Particulate Emissions Proportioned by Month

Appendix A

Updated Emissions Data for Revision of AP-42 Section 1.9, Residential Fireplaces

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December 18, 2002

1.9 Residential Fireplaces

1.9.1 General[1-11]

In 2002 there were an estimated 35 million homes with fireplaces in the United States. Fireplaces are used primarily for aesthetics and secondary heating. Only 0.2% of home occupants with fireplaces report using fireplaces as their main heat source. Survey data have shown that 17% of the homes with fireplaces have more than one fireplace suggesting a total of 41 million fireplaces nationwide. Approximately 26% of fireplaces use natural gas as a fuel. Of the 74% (30 million) solid fuel burning fireplaces, 28% have inserts, leaving 22 million true solid fuel burning fireplaces. Solid fuel fireplace inserts burning cordwood or pellets are essentially heaters and the emissions of cordwood and pellet heaters are provided in Section 1.10, Residential Wood Stoves. Among true solid fuel burning fireplaces (i.e., those without inserts), wood is the most common fuel with 30% of users reporting burning manufactured wax/sawdust firelogs some of the time along with wood and 12% using manufactured wax/sawdust firelogs exclusively. Emission factors for true fireplaces without inserts, burning both cordwood and manufactured wax/sawdust firelogs, are provided here.

Notably, many fireplaces are used infrequently. Thirty-one percent of home occupants with fireplaces report not using them in a given year and 17% report using them only one or two times during the heating season.

Fireplaces can be divided into two categories: (1) site-built masonry, and (2) prefabricated factory-built. It is estimated that about 20% of the fireplaces in homes are masonry and 80% are factory built. Both masonry and factory-built fireplaces can be installed and operated with or without doors (generally made of glass) and louvers. Doors and louvers reduce the intake of combustion air. The reduction of combustion air volume generally increases overall efficiency since less heated air is exhausted out the chimney. Some factory-built fireplaces are surrounded by ducts through which floor level air is drawn by natural convection, heated and returned to the room. Fireplaces have dampers above the combustion area to limit room air and heat losses when the fireplace is not being used.

Masonry fireplaces are generally constructed of, mortar, brick, cement blocks, cinder blocks and/or stone. The firebox is frequently constructed with firebrick or sometimes with metal. Their chimneys are often lined with chimney tiles. The chimneys are usually rectangular or square with dimensions ranging from as small as 6 inches by 6 inches to as large as 2 feet by 2 feet. Masonry fireplaces are usually an integral part of the structure.

There are two types of factory-built fireplaces. One type is the freestanding fireplace, which usually consists of an inverted sheet metal funnel and stovepipe directly above the fire bed. Only a few percent of the factory-built fireplaces are freestanding. The other type (by far the most common) is the “zero-clearance” fireplace. The zero-clearance fireplace is constructed with an iron or heavy-gauge steel firebox lined with firebrick and surrounded by multiple steel walls with

spaces for air circulation. The zero-clearance models are installed on site directly into a wall. There are three common sizes of zero-clearance fireplaces. These are 36-inch, 42-inch and 48-inch, which refer to the front width of the firebox opening. However, these are nominal size designations, in that, the height, depth and, back width are variable with models. Typical factory-built fireplace chimneys are made of round metal pipe and range in size from 6 inches in diameter to 12 inches in diameter.

Fireplace chimney heights (above the fireplace) range from about 8 feet for a mobile home to about 12 feet, 22 feet, and 32 feet for one, two, and three story frame homes, respectively. Most chimneys are topped with a chimney cap to minimize sparks from escaping and precipitation from entering the chimney. Creosote accumulates on the chimney walls but at a slower rate than for a wood stove due to the more complete combustion associated with excess air in fireplaces.

During operation, the user intermittently adds fuel to the fire by hand. Over 50 tree species are used as fuel in the U.S. Fuel moisture ranges widely depending on seasoning practices. The average cordwood moisture content of cordwood was found from numerous in-home measurements to be 24.1% on a dry basis (Table 1.9-1). Wet wood burns with less efficiency and higher emissions than properly seasoned wood. Properly seasoned wood has a moisture content of less than about 25% on a dry basis.

The most common commercially available manufactured firelogs are composed of 40% to 60% petroleum wax with the remaining portion being sawdust. The moisture content of wax/sawdust firelogs is about one-tenth that of typical cordwood (Table 1.9-1) and their heat content per unit mass is nearly twice that of cordwood. Consequently, the manufacturers' instructions and the commensurate aesthetic/radiant heat satisfaction level for wax/sawdust firelog use is a one-at-a-time burning scenario. Other types of manufactured logs made of biomass and recycled material are sometimes used in fireplaces, but their usage is very small as compared to wax/sawdust firelogs.

The mean burn rate for cordwood in fireplaces in the U.S. was determined to be 5.13 dry kg/hr. The median and mode burn rate values were considerably less than the mean value due to the preponderance of smaller zero-clearance fireplaces in use (Table 1.9-2). Firelog burn rates are much smaller than cordwood burn rates due to their higher heat content per unit mass and their one-at-a-time usage (Table 1.9-2).

The aesthetic warming and space heating effects from fireplaces are primarily from radiant heat. Little heat is gained from convection or conduction. The efficiency of a fireplace without a door is often cited as 7% and with a door it is in the 30% range. Both these efficiency values are quite variable depending on home and fireplace construction as well as operational practices and weather. The low efficiencies are primarily from the large amount of excess air heated and lost out the chimney (see Table 1.9-2 for chimney flow rates) which is made up by cold air infiltrating into the house. Efficiency also tends to be low due to the fact that fireplaces are generally on outside walls rather than in the center of a structure, hence radiant and convective heat transfers are not efficient.

It should be noted that two other appliance types are frequently confused with fireplaces. One of these types is the wood stove which is certified and made to look like a fireplace. These are sometimes call "high technology fireplaces." The other type is the masonry heater. Masonry heaters look similar to a masonry fireplace, but are constructed and operated differently. They have air tight doors, a large mass to absorb and re-radiate heat, and have folded exhaust channels to facilitate heat transfer to their "heat sink." Masonry heaters operate by burning wood at a high burn rate for short period. Once their large mass is heated it then re-radiates the heat for a long time period after the active fire is out. The emission factors for both high technology fireplaces (wood stoves) and masonry heaters are provided in Section 1.10, Residential Wood Stoves.

1.9.2 Emissions and Controls

Fireplace pollutant emissions are caused by the incomplete combustion of fuel. The key pollutants are particles, carbon monoxide and organic compounds, emitted both as particles and as gases. Some of the organic compounds are hazardous air pollutants (HAPs), notable among them are formaldehyde, benzene, and polycyclic organic matter (POM). Because the fuel sources, wood or firelogs, are made up of primarily organic compounds, a variety of other organic products of incomplete combustion have been measured. These include numerous aldehydes, phenols, alcohols, ketones, carboxylic acids, and hydrocarbons. Measurable levels of the simple organic compounds of methane, ethane, methanol, ethanol, formaldehyde, acetaldehyde, acrolein, phenol, cresol, formic acid and acetic acid have been well documented. In addition, many dozens of other more complex organic compounds, many produced by build-up by radical chains, have been measured at trace levels.

The nitrogen, sulfur, halide and metal contents of the cordwood and wax/sawdust firelogs are low, therefore air emissions of compounds containing them are also low. However, as with any combustion process in the presence of atmospheric nitrogen, some nitrogen oxides are produced.

The particles that are emitted are primarily submicron. Approximately 90% of the total particles emitted are PM_{10} and 84% are $PM_{2.5}$. Elemental carbon makes up between 10% to 30% of the particulate emissions, depending on combustion conditions. Inorganic salts contribute only a few percent to the total particulate emissions. These are principally benign salts composed of sodium, magnesium, potassium, calcium, zinc and ammonium cations with sulfate, chloride, carbonate, and nitrate anions. The remaining and by far the largest fraction of particulate emissions are made up of organic compounds.

Fireplace emissions are acidic because they contain carboxylic acids and phenols. Combustion residues (ash) are basic because they contain alkaline earth and alkali metal oxides. Creosote formed on the inside of chimneys is a mixture of organic compounds, elemental carbon and inorganic salts. The organic compound content of creosote formed by fireplaces is lower than that formed by wood stoves, due to less pyrolysis occurring in the oxygen rich conditions of a fireplace environment as compared to that of a wood stove.

In terms of greenhouse gases, carbon dioxide, methane and a variety of non-methane volatile

organic compounds (NMVOC) are emitted. Roughly equal amounts of methane and NMVOC are emitted. As with the complete combustion of any organic material, carbon dioxide and water are the end products of complete combustion. (Even the much smaller amount of carbon monoxide as compared to carbon dioxide that is emitted is oxidized to carbon dioxide in the atmosphere.) The combustion efficiency in fireplaces is over 90%, consequently the carbon dioxide emission levels can be estimated from the carbon content of the fuel. Typical cordwood contains 51% carbon. A typical wax/sawdust firelog contains 72% carbon. Because the combustion of biomass recycles recent carbon rather than introducing fossil carbon into the atmosphere and because usually more mature trees are harvested for fuel which are replaced by younger more rapidly photosynthesizing trees, the burning of cordwood and the sawdust component of firelogs has less of a greenhouse effect than the carbon dioxide emissions alone would suggest.

There are a few practical control measures for fireplace emissions. About 11% of particulate emissions (and a high fraction of other pollutants) occur during the very short kindling phase of a fire due to incomplete combustion that occurs before optimal temperatures are reached. Measures that shorten the kindling phase tend to reduce pollutant emissions. These include the use of natural gas starter grates, wax starter logs and forced air grates. Forced air grates also tend to reduce emissions throughout the fire by enhancing combustion. Some masonry fireplaces with specially shaped fireboxes also have been shown to reduce emissions. Natural gas and electrically heated after burner devices have been shown to be effective, but because of the large amount of energy that is needed to treat dilute particulate and organic gas emissions at high flow rates characteristic of fireplaces, they are not practical for most residential applications. The most practical pollutant emission reductions are related to fuel. Properly sized, clean, well-seasoned (dry) cordwood produces the lowest emissions for cordwood. Notably, significant reductions, as compared to cordwood, are achieved through the use of manufactured fuels. Wax/sawdust firelogs are the most common, readily available, type of manufactured fuel for residential fireplaces currently in use.

Key pollutant emissions for cordwood burned in fireplaces are provided in Table 1.9-3. The mean, standard deviation, median, and "n" value for each pollutant are provided based on a review of values provided in available publications and reports. The n value varies for each pollutant depending on the number of measurements that have been reported for it. Different particulate measurement methods have been used in the various studies. The different measurement methods produce different particulate values primarily due to the differential capture of condensible organic compounds. Consequently, all particulate data have been converted to a EPA method 5H equivalent value, following conversion equations developed by the EPA. Also, the particulate material (PM) values shown in Table 1.9-3 are for total particles. For fireplace emissions, studies have shown that a conversion factor of 0.90 should be used to convert total PM to PM_{10} and a conversion factor of 0.84 should be used to convert total PM to $PM_{2.5}$.

Fireplace nitrogen oxides emissions are primarily a mixture of nitrogen dioxide (NO_2) and nitric oxide (NO) with trace levels nitrous oxide (N_2O). The sum of all nitrogen oxides is reported as nitrogen dioxide in Table 1.9-3.

The 16-PAH and 7-PAH conventions have been used to characterize polycyclic organic matter (POM) emissions and their values are tabulated in Table 1.9-3. The 16 polycyclic aromatic hydrocarbons (16-PAH) were designated by the EPA as compounds of interest under a suggested procedure for reporting test measurements. They are a subset of the almost infinite number of POM compounds that can occur in air emissions from the combustion of biomass and they are routinely used as an indicator of total POM emissions for a variety of air pollutant sources. A subset of seven (7-PAH) of the 16 compounds has been identified by the International Agency for Research on Cancer (IARC) as animal carcinogens. The seven compounds have been studied by the EPA as potential human carcinogens. To provide uniformity and permit comparisons of data compiled for other air pollutant sources the 16-PAH and 7-PAH values are provided here for fireplace emissions.

The emissions for fireplaces burning wax/sawdust firelogs are provided Table 1.9-4. The mean, standard deviation, median, and n values are provided for the same pollutants as have been compiled for fireplaces burning cordwood in Table 1.9-3. The mode is not provided, as it is with cordwood, because the number of reported measurements is much smaller for fireplaces burning wax/sawdust firelogs then it is for fireplaces burning cordwood. In addition to the standard mean and median emission factors, a wood equivalent emission factor is also provided. Less mass of wax/sawdust firelogs is burned during a given time period as compared to cordwood due to their higher heat content, lower moisture content, and their one-at-a-time pattern. For this reason, the wood equivalent emission factors are provided to permit the direct calculation of the change in emissions if wax/sawdust firelogs are burned in lieu of cordwood in fireplaces.

Table 1.9-1. Fuel Moisture

Parameter	Cordwood Percent Moisture (DB)[1,2]	Firelog Percent Moisture (DB)[1,3]
Mean	24.1	2.2
Standard Deviation	12.9	0.4
Median	21.4	2.2
Mode	17.0	2.2
n	820	30

1. DB = dry basis, i.e, the mass of water divided by the mass of dry wood.
2. Data from references 12-34.
3. Data from references 35-46.

Table 1.9.2. Fireplace Burn Rate and Chimney Flow Rate

Parameter	Cordwood[1]		Firelogs[2]	
	Burn Rate (dry kg/hr)	Flow Rate (std m^3/min)	Burn Rate (dry kg/hr)	Flow Rate (std m^3/min)
Mean	5.13	6.42	0.74	4.24
Standard Deviation	3.03	4.16	0.28	1.18
Median	4.20	4.58	0.70	4.27
Mode	3.50	3.90	0.58	4.10
N	557	275	28	10

1. Data from references 24, 29, 47-65.
2. Data from references 35-46.

Table 1.9-3. Fireplace Cordwood Emission Factors[1]

Pollutant	Emission Factor Data (g/ dry kg)[2]			
	Mean	Standard Deviation	Median	n
Particles (PM)[3]	11.1	8.9	9.3	552
Carbon Monoxide	72.9	44.3	69.0	491
Nitrogen Oxides[4]	1.6	1.3	1.3	48
Methane	6.7	6.0	5.6	15
Benzene	0.30	0.27	0.31	17
Formaldehyde	1.2	1.4	0.7	24

16-PAH[5]	0.62	1.2	0.26	49
7-PAH[6]	0.11	0.28	–	21

1. Data from references 24, 39, 47-65.
2. To convert g/kg to lb/ton multiply by 2.00.
3. All particulate data converted to 5H equivalent values. PM from fireplaces has been shown to be approximately 90% PM_{10} and 84%$PM_{2.5}$ (references 61 and 66).
4. Nitrogen oxide values reported as NO_2.
5. The 16-PAH (Polycyclic Aromatic Hydrocarbon) value is the sum of: naphthalene, acenaphthene, acenaphthylene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(ghi)perylene, benz(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene.
6. The 7-PAH (Polycyclic Aromatic Hydrocarbon) value is the sum of: benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoanthene, benzo(a)fluoranthene, benzo(a)pyrene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene.

Table 1.9-4. Firelog Emission Factors[1]

Pollutant	Emission Factors (g/ dry kg)[2]			Wood Equivalent[3] (g/ dry kg)	n
	Mean	Standard Deviation	Median		
Particles (PM)	21.2	13.9	17.6	4.5	26
Carbon Monoxide	58.5	41.8	51.0	12.4	26
Nitrogen Oxides[4]	2.0	1.4	1.6	0.42	4
Methane	27.0	-	-	5.7	2

Benzene	0.84	0.60	0.71	0.18	3
Formaldehyde	1.2	0.2	1.3	0.26	3
16-PAH[5]	0.06	0.03	0.05	0.01	5
7-PAH[6]	nd[7]	nd	nd	nd	5

1. Data from references 35-46.
2. To convert g/kg to lb/ton multiply by 2.00.
3.. The wood equivalent emission factors were calculated by multiplying the mean emission factors by the ratio of the mean firelog burn rate (0.74 dry kg/hr) and the mode of the cordwood burn rates (3.5 dry kg/hr). For example, the usage wood equivalent emission factor for PM = 21.2 g/ dry kg X(0.74/3.5) = 4.5 g/dry kg. The mode was used for estimating the central tendency for the burn rate for cordwood in fireplaces rather than the mean or medium since fewer firelogs are burned in the very large fireplaces with the highest burn rates. The most common fireplace size (nominal 36 inch) is also the smallest.
4. Nitrogen oxide values reported as NO_2.
5. The 16-PAH (Polycyclic Aromatic Hydrocarbon) value is the sum of: naphthalene, acenaphthene, acenaphthylene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(ghi)perylene, benz(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene.
6. The 7-PAH (Polycyclic Aromatic Hydrocarbon) value is the sum of: benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoanthene, benzo(a)fluoranthene, benzo(a)pyrene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene.
7. All 7-PAH compounds were below the detection limits of the methods reported in studies.

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Appendix B

Development of a Fireplace Baseline Particulate Emission Factor Database

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ABSTRCT

A review was conducted of all available fireplace particulate emissions test reports and publications in order to develop a fireplace particulate emissions database. This project was done to provide baseline emissions levels to an ASTM committee developing an emissions test method for factory-built fireplaces. These data also provide improved information for emissions inventory development as compared to the AP-42 fireplace particulate emission factor. The AP-42 fireplace particulate emission factor is based on only four studies and it's database is dated, as two of the studies were conducted in the 1970s and two in the early 1990s. Most of the appliances tested in the four studies were site-built, masonry fireplaces; there were only three factory-built fireplaces tested in these four studies. In the last decade, roughly 650,000 wood-burning factory-built fireplaces have been installed annually in U.S. new home construction. Consequently, factory-built fireplaces now represent the majority of fireplaces in U.S. homes. Additionally, 24 of the 54 tests included in the four studies, used to develop the AP-42 value, were from a single 1990 study, which had higher values than typically reported in the other studies.

The database developed and reported here was from 34 [ref. 1-34] studies, which included pertinent fireplace emissions data, and represents 360 test runs. The resulting database shows that the 17.3 g/kg AP-42 value is approximately 33% high.

With roughly 28 million wood-burning fireplaces (without inserts) in the U.S., as of the end of 2003, a change in wood-burning fireplace emission factors could have a significant effect on emission inventories. To provide additional insight we have divided the data into several categories: (1) masonry and factory-built fireplaces, (2) cordwood and dimensional lumber and (3) fireplace doors open and closed.

INTRODUCTION

The emissions from fireplaces are becoming increasingly important. Wood-burning fireplaces are being installed into U.S. homes at a rate of about 650,000 per year. The total number of fireplaces sold annually is on the order of six times the number of wood heaters (wood stoves, inserts and freestanding fireplaces). Moreover, most new fireplaces are associated with new home construction, whereas many wood stoves are sold as replacements of older models. State and local air quality managers are looking for ways to lower $PM_{2.5}$ in response to the new federal standards. Fireplace emissions are largely unregulated at this time and the technology to reduce $PM_{2.5}$ emissions from them is unproven or impractical, additionally, a standard test method to measure emissions has not yet been developed. Because of the increased importance in fireplace emissions it is foreseeable in the future that fireplaces will be regulated nationwide and a test protocol will be developed to document emissions from them. An ASTM committee is drafting a test method that could be adopted by the EPA or other regulatory agencies.

This database was developed in order to provide fireplace baseline data to that ASTM committee. It is important that the test method under development reflect emissions from real world use of fireplaces. The hearth industry learned from the wood stove NSPS process that a test method that produced values that do not reflect real world values is a consistent problem for emission inventory development. Therefore, there was particular focus on emissions results of factory-built fireplaces burning cordwood, which is the most common in-home fireplace use scenario.

LITERATURE REVIEW AND DATA COMPILATION

Of the available sources of data on fireplace particulate tests in OMNI's archive, 34 sources of data were used. Some of the tests reviewed collected sample over only parts of fires, some tests used novel test methods or used research appliances, etc. We used our best professional judgment when removing runs from the database or when averaging multiple samples collected over single burns. Some of the test reports had very little supporting documentation; in a few cases to convert results in g/hr to g/kg, when the burn rate was not reported, the average burn rate for the database was used (4.8 kg/hr).

There are four main sampling methods utilized in fireplace emissions testing. They are: EPA Method 5, EPA Method 5G, EPA Method 5H and the ESS/AWES sampling systems. EPA Method 5 collects sample at a rate proportional to exhaust flow, directly from the flue exhaust and historically included only the particulate caught on a heated filter, this method does not include the condensable portion of the emissions, in order to represent total emissions a "conversion" factor has been developed. EPA Method 5G involves a large dilution tunnel run at a constant rate, which collects all of the exhaust from an appliance and mixes it with ambient air. This method cools the exhaust stream, the condensable portion of the emissions form particles and the total particulate mass is

collected on an ambient temperature filter. This method was designed to collect particles in the form that they will be in once they enter the atmosphere. EPA Method 5H collects sample from inside the flue exhaust at a rate proportional to exhaust flow, as does Method 5, but includes cooled impingers and a "back half" filter after the front filter to collect the condensable portion of the emissions, which Method 5 failed to collect. The results from testing with EPA Method 5H have become the standard format for regulations and emission calculations. For this reason the other three test methods have conversion factors to convert them into Method 5H equivalents. The ESS method, designed for the Washington State Fireplace Test Method (WAC 51-40-31200), and the AWES sampling systems [described in three publications – ref. 35,36,37] were both designed to be "in-home" samplers. Once an appliance is installed into a residence, it is difficult to test by the previously mentioned EPA test methods. The ESS/AWES systems utilize a heated front filter and cooled canisters of XAD-2 resign designed to collect condensable emissions. The methods sample at a constant rate throughout the test. All of these test methods use dimensional lumber, as opposed to cordwood, as the fuel. This is done to create fires that are reproducible and consistent.

EPA Methods 5, 5G and 5H and associated wood heater operational Method 28 can be found in 40CFR Part 60 but were not designed for fireplace testing; Methods 5G, 5H and 28 were designed for wood heater testing, while Method 5 was designed for industrial smoke stack testing. In order to use any of the three EPA methods for fireplace testing significant modifications have to be made. Because there is no standard test method for fireplaces, different modifications to the EPA methods were been made in different studies. This causes difficulty in comparing one study to the next and when converting values into EPA Method 5H equivalent values. Due to the variability in test methods all the studies in this database, which were based on the EPA methods, were grouped together into three categories, Method 5 like, Method 5G like and Method 5H like.

For this database the conversion factors used were:

EPA Method 5 to EPA Method 5H equivalent

$$\text{EPA Method 5H equivalent} = \text{EPA Method 5} / 0.89 \quad \text{[ref. 24]}$$

EPA Method 5G to EPA Method 5H equivalent (g/hr)

$$\text{EPA Method 5H equivalent} = 1.619 * (\text{M5G})^{0.905} \quad \text{[ref. 38, 39]}$$

AWES to EPA Method 5G equivalent (g/hr)

$$\text{EPA Method 5G equivalent} = 0.8635 * (\text{AWES})^{0.9288} \quad \text{[ref. 38, 39]}$$

ESS to EPA Method 5H equivalent (g/kg)

$$\text{EPA Method 5H equivalent} = 1.254 + (0.302 * \text{ESS}) + (1.261*10^{-\text{ESSA}}) \quad \text{[ref. 40]}$$

RESULTS

Table 1 is a summary of the key findings. For comparison to the database developed here, OMNI attempted to recreate the original database that produced the values listed in AP-42. OMNI was unable to repeat the exact values using the same data as was used by the EPA.

Figures 1-6 are histograms of the emission results, in both Method 5H and Method 5G equivalence, for the three key categories: (1) all of the tests, (2) all cordwood tests and (3) all factory-built, cordwood tests.

Table 1
Database Summary of Particulate Emission Factors for Masonry and Factory-Built Fireplaces

Parameter	5G g/kg		5H g/kg		Count
	Mean	Median	Mean	Median	n
All masonry and factory-built (zero clearance)	8.4	6.4	9.5	7.5	360
All cordwood	11.7	11.3	13.0	12.6	167
All dimensional lumber	5.6	4.3	6.5	5.2	193
All with closed doors	4.8	3.5	5.6	4.4	104
All with open doors	9.9	8.4	11.1	9.8	256
All masonry fireplaces	9.6	7.2	10.6	8.7	90
All factory-built fireplaces	8.0	6.1	9.2	7.2	270
Cordwood, factory-built, open doors	12.4	11.9	13.9	13.5	92
Dimensional lumber, factory-built, open doors	7.1	5.6	8.2	6.5	92
AP-42 calculated from referenced tests*	15.2	14.5	16.4	15.9	54
AP-42	16.2	-	17.3	-	-

Notes: Three outlier runs were removed from the database, average moisture for all runs was 20% and average burn rate for all runs was 4.8 kg/hr.
*OMNI was unable to duplicate the exact AP-42 values from the tests cited.

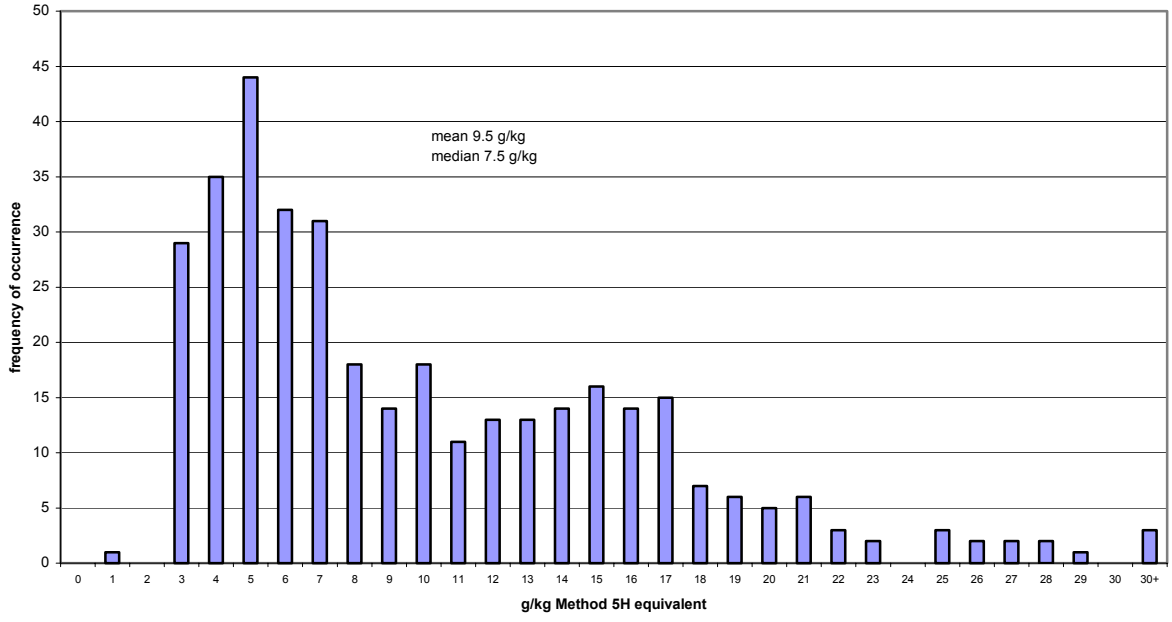

Figure 1 Distribution of Emissions – Data from All Tests, 5H equivalent

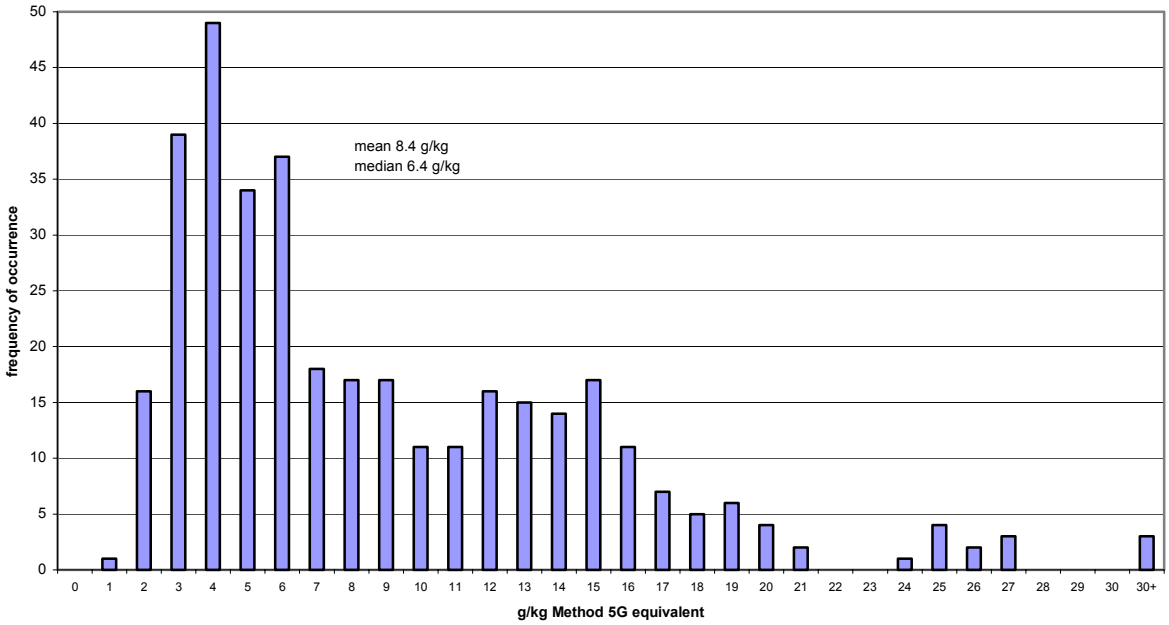

Figure 2 Distribution of Emissions – Data from All Tests, 5G equivalent

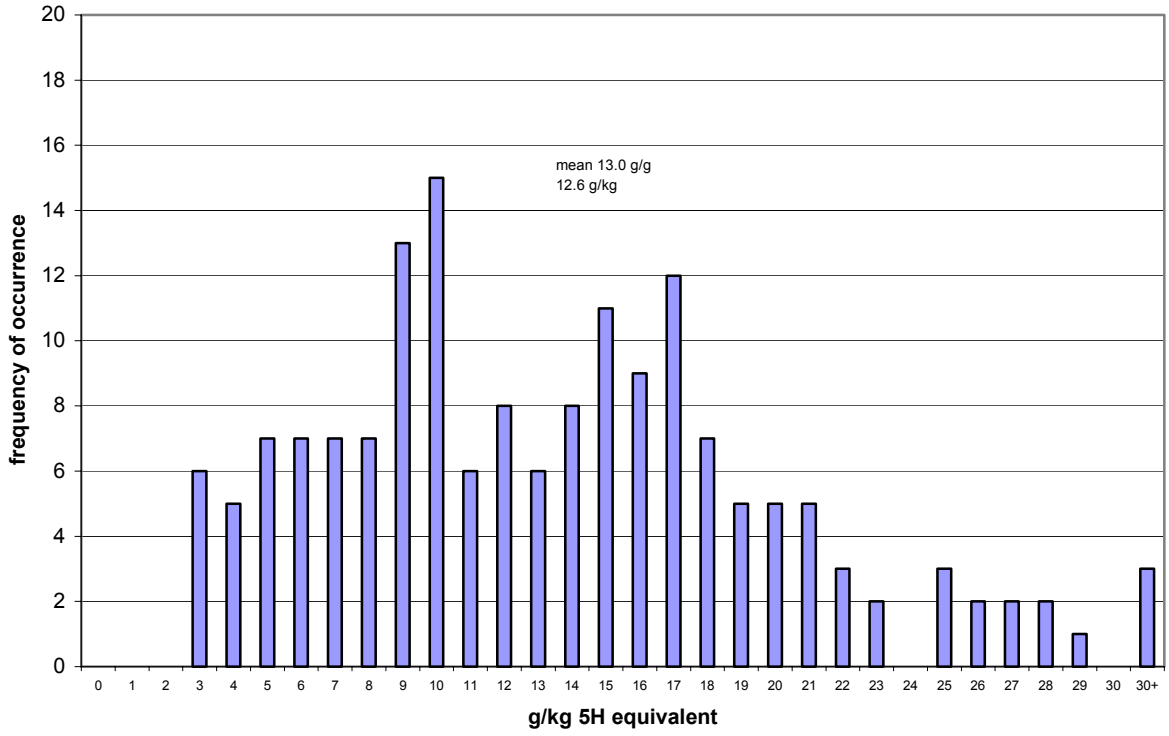

Figure 3 Distribution of Emissions – Data from Only Cordwood Tests, 5H equivalent

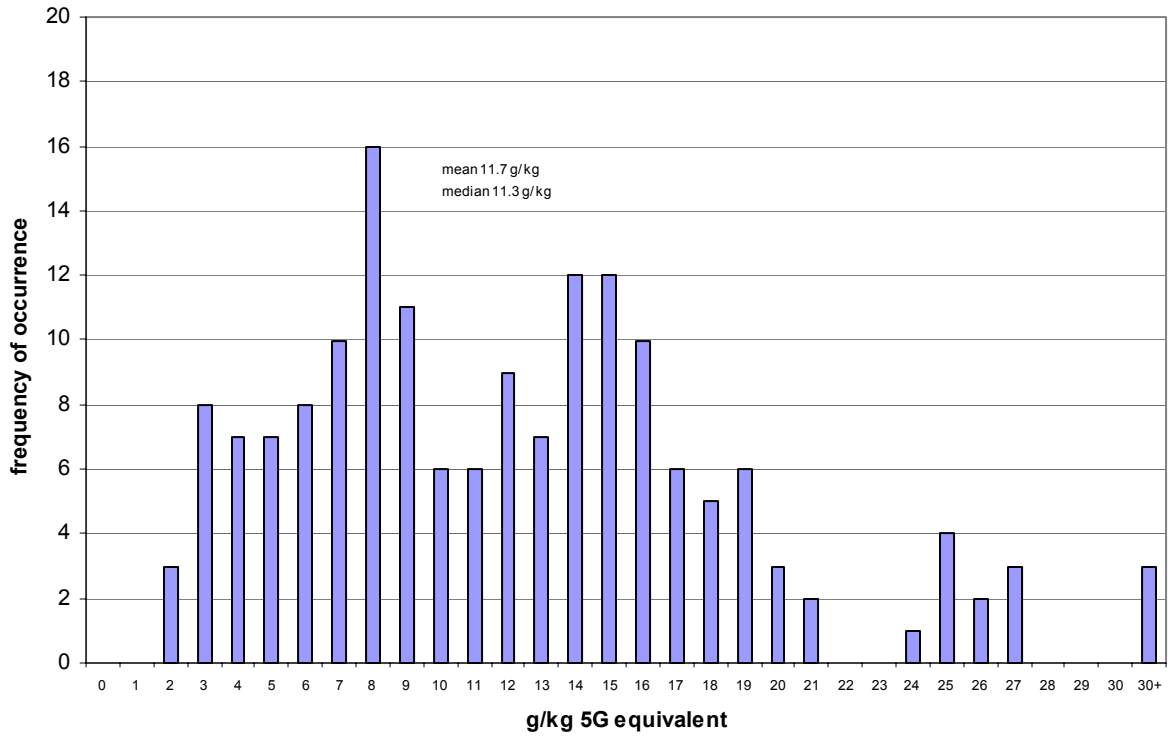

Figure 4 Distribution of Emissions – Data from Only Cordwood Tests, 5G equivalent

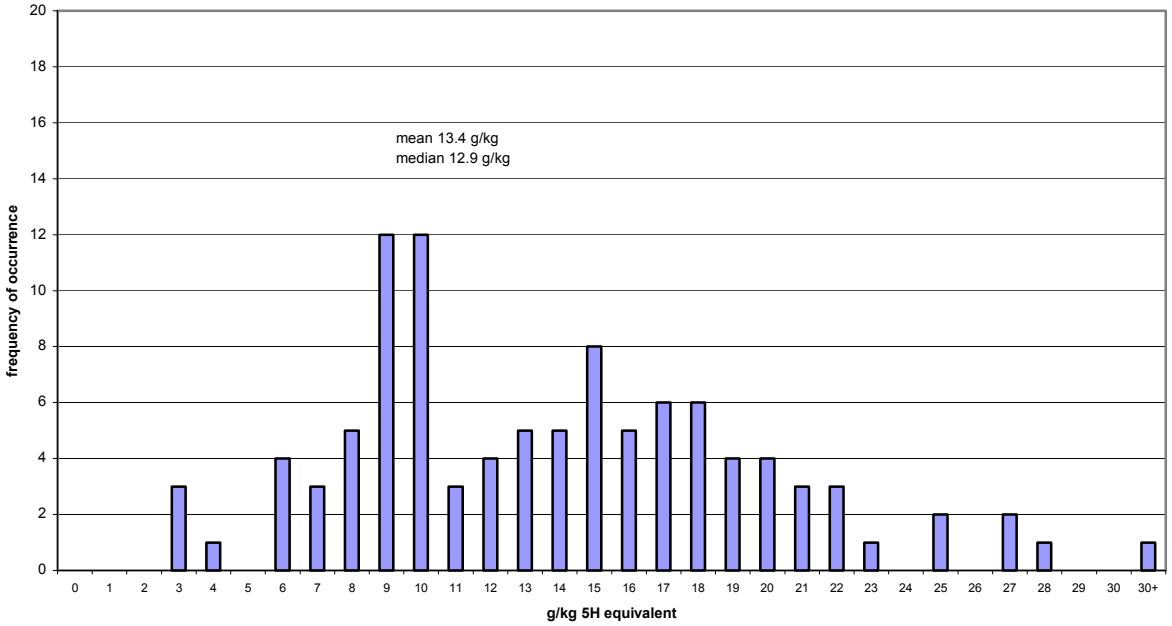

Figure 5 **Distribution of Emissions – Data from Factory-Built, Cordwood Tests, 5H equivalent**

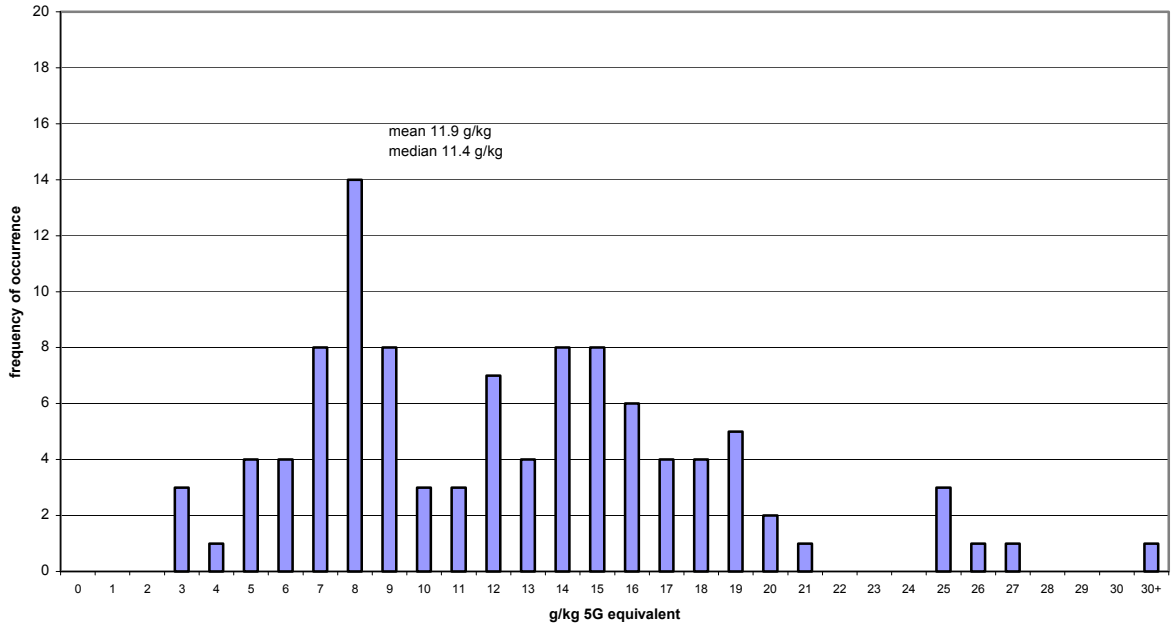

Figure 6 Distribution of Emissions – Data from Factory-built, Cordwood Tests, 5G equivalent

CONCLUSIONS

The average emissions from the database for all fireplaces, burning all wood types, are 9.5 g/kg 5H equivalent, 8.4 g/kg 5G equivalent.

The average emissions from all factory-built fireplaces, burning cordwood with open doors, which is the category most relevant to the ASTM committee, are 13.5 g/kg 5H equivalent, 12.4 g/kg 5G.

AP-42 is 33% higher than suggested by this database.

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