

**AREA SOURCE EMISSIONS FOR CALENDAR YEAR 2023  
METHODOLOGY DOCUMENTATION  
RESIDENTIAL WOOD COMBUSTION**

**DESCRIPTION OF CATEGORY**

EIC	Name	MSC	SRC	MAT
610-600-0230-0132	Residential Wood Combustion – Wood Stoves - Uncertified	610	600	0230
610-600-0230-0133	Residential Wood Combustion – Wood Stoves – Certified Catalytic	610	600	0230
610-600-0230-0134	Residential Wood Combustion – Wood Stoves – Certified Non-Catalytic	610	600	0230
610-601-0230-0132	Residential Wood Combustion – Fireplace Insert - Uncertified	610	601	0230
610-601-0230-0133	Residential Wood Combustion – Fireplace insert – Certified Catalytic	610	601	0230
610-601-0230-0134	Residential Wood Combustion – Fireplace Insert – Certified Non-Catalytic	610	601	0230
610-602-0230-0135	Residential Wood Combustion – Fireplaces - Cordwood	610	602	0230
610-602-0230-0136	Residential Wood Combustion – Fireplaces – Manufactured Logs	610	602	0230
610-603-0230-0000	Residential Wood Combustion – Pellet Stoves - Pellets	610	603	0230

Residential wood combustion (RWC) emission inventories for the 2023 base year were prepared for the South Coast Air Basin (SCAB) of California using the methodologies outlined in Houck et al., (2006) and California State Air Resources Board (CARB) methodology guidance on Residential Wood Combustion. The wood-burning appliances here include wood stoves, fireplaces with and without inserts and pellet stoves. American Housing Survey statistics for the Los Angeles-Long Beach-Anaheim, Riverside–San Bernardino–Ontario metropolitan areas were a key source of data. The number of wood-burning appliances that were owned and used were estimated by category for the 2023 base year. The average amount of fuel (cordwood, or wax/fiber fire logs) burned in each category of appliance and distribution fractions among different control technologies for wood stoves and fireplace inserts were adopted from CARB’s Area Source Methodology Technical Document Section 7.1 Residential Wood Combustion (draft version). Updated emission factors (mass emissions/mass dry fuel burned) were obtained from new studies conducted by the NESCAUM and were in turn applied to each category of appliance to produce the overall emission inventories.

## BACKGROUND

This document contains emission estimates for fireplaces (with and without inserts) and woodstoves. Fireplaces without inserts are further divided into cord-burning and manufactured logs-burning types. Fireplace inserts and woodstoves are divided into traditional, phase II non-catalytic and catalytic types. Pellet Stoves were assigned zero emissions due to their minimal contribution and insufficient activity data.

A residential fireplace is a heating system installed in a home, often serving both functional (heating) and aesthetic (ambiance) roles. It typically includes a firebox for the fire, a hearth, and a venting system (chimney or flue) to expel smoke. Traditional fireplaces without inserts have an exposed fire where wood or other fuels burn in an open firebox. This open combustion process tends to be less controlled and leads to incomplete combustion, resulting in higher emissions of particulate matter, carbon monoxide, and other pollutants. A fireplace insert is a sealed, metal or cast-iron unit that can fit into an existing open fireplace. It transforms the open space into a closed combustion chamber. This design promotes complete combustion and fuel efficiency and significantly reduces emissions of harmful pollutants. Since fireplace inserts share operating and combustion characteristics with woodstoves, the same emission factors are used for both fireplace inserts and woodstoves (HPBA, 2009a; U.S. EPA, 1996a).

A woodstove is an enclosed stand-alone heating appliance designed to burn wood fuel in a controlled chamber and is typically used as a primary or supplemental heat source in residential settings and comes in various designs and efficiencies. Conventional woodstoves are old models (in most cases manufactured before July 1, 1986) without any emission reduction technology or design features. Phase II standards were introduced to significantly lower emissions compared to traditional models. They usually come in two main types: non-catalytic and catalytic woodstoves. Phase II non-catalytic woodstoves use improved air flow designs with features like insulated baffles and secondary burn air inlets, which promotes secondary combustion by reintroducing heated air into the combustion zone, helping burn off gases and particulates that would otherwise be emitted (U.S. EPA, 1996a). Phase II catalytic woodstoves include a catalytic combustor (often a honeycomb coated with a catalyst such as platinum or palladium) installed in the firebox or flue. This combustor facilitates oxidation of smoke and unburned gases at lower temperatures, further enhancing the combustion process. However, the catalyst requires periodic maintenance and eventual replacement to maintain optimal performance.

## ACTIVITY DATA

### **Number of Woodstoves, Wood-burning Fireplace Inserts and Wood-burning Fireplaces without Inserts**

The American Housing Survey (AHS) has conducted surveys in the SCAB and SSAB every two years and specifically included the 2023 base year which provides useful data for the development of a RWC emission inventory. Surveys have been conducted for: (1) the Los Angeles-Long Beach-Anaheim metropolitan area (all of Los Angeles County and Orange County), and (2) the Riverside-San Bernardino-Ontario metropolitan area (all of Riverside County plus all of San Bernardino County). There are 2023 AHS data for the above metropolitan areas, and it was presented in both the summary tables, which include aggregate data for metropolitan samples, and the Public Use File (PUF) Microdata which contains each housing unit record. In addition to the year 2023, other recent AHS surveys for the year 2021, 2019, 2017, and 2015 are also accessible and useful.

In the AHS datasets, the populations of fireplaces and woodstoves in the Los Angeles–Long Beach–Anaheim and Riverside–San Bernardino–Ontario metropolitan areas are so small that they fall below the reporting threshold in the summary tables available on the AHS website. To estimate these populations, we used the AHS Public Use File (PUF) microdata, which provides individual-level responses to each survey question for sampled housing units. Our estimation relies on the following survey questions:

- **HEATYPE** – “Type of main heating equipment.”
- **SUPP1HEAT/SUPP2HEAT** – “Any other sources to heat your home? And what is used?”
- **FIREPLACE** – “Does this unit have a usable fireplace? ”

Because the AHS categorizes fireplaces and fireplace inserts without distinguishing fuel type, it is important to adjust the appliance population estimates to account for non-wood fuels such as piped and bottled gas. This adjustment allows us to isolate and estimate the number of wood-fueled appliances.

Furthermore, not all fireplaces or inserts are actively used during the burn season. To better estimate the number of wood-burning fireplaces that are actually in use, we rely on two AHS survey questions:

- **OTHERAMT** – “In the last year, what was the total cost for wood, kerosene, or other fuel (excluding gas, electricity, and oil)?”
- **HEATFUEL** – “What fuel is used most for heating this unit?”

We interpret **OTHERAMT = 0** as an indication that the household did not purchase wood or other relevant fuels, suggesting that any fireplaces/stoves present are either unused or not wood-burning, and therefore can be excluded from our emission estimates.

For the **HEATFUEL** question, if “wood” is selected as the primary heating fuel, the unit is assumed to be wood-burning. However, if another fuel is reported, it does not necessarily rule out the presence of a wood-burning appliance—it may simply be used as a supplemental or aesthetic heating source.

The condition of **OTHERAMT > 0** or **HEATFUEL = ‘wood’** were applied to filter out final wood-burning device populations for main heating and supplemental heating, and the data is presented in Table 1. Populations of usable wood-burning fireplaces (inserts & without inserts) for heating or not for heating are also obtained in similar ways and the data is presented in Table 2.

**Table 1. Number of occupied units with wood-burning stoves, fireplaces with inserts, and fireplaces without inserts used as main heating equipment and as supplemental heating equipment for the year 2023.**

Metropolitan Area	Main Heating Equipment			Supplemental Heating Equipment		
	Stove	Fireplace with Inserts	Fireplace w/o Insert	Stove	Fireplace with insert	Fireplace w/o Insert
Los Angeles-Long Beach-Anaheim	0	2882	0	2352	0	0
Riverside-San Bernardino-Ontario	5266	1475	1740	5570	0	0

**Table 2. Number of occupied units having a usable wood-burning fireplace in 2023.**

Metropolitan Area	Number of usable wood-burning fireplaces (inserts & no inserts)	For heating	Not for heating
Los Angeles-Long Beach-Anaheim	61577	43231	18346
Riverside-San Bernardino-Ontario	65403	55530	9873

For Table 2, the usable fireplaces (with and without inserts) for heating include both main heating and supplemental heating, and not for heating category corresponds to aesthetic purpose. Since the populations of fireplaces with insert and without insert for supplemental heating in Table 1 are much lower than that in Table 2, so the number in Table 2 are adopted in the emission calculation. When subtracting the number for main heating in Table 1, the number for supplemental heating can be calculated as  $N_{\text{fireplace, supp}} + N_{\text{insert, supp}} = 40349$  and  $52315$  for Los Angeles-Long Beach-Anaheim and Riverside-San Bernardino-Ontario, respectively. The number for aesthetic purpose is  $N_{\text{fireplace, aesthetic}} + N_{\text{insert, aesthetic}} = 18346$  and  $9873$ , respectively.

Based on the device fractions from EPA 2023 Wagon Wheel BETA and the number of occupied households, we can get the ratio of device populations in each area. These ratios are used to split the supplemental heating population into fireplace and fireplace inserts. The AHS survey results do not provide the population of woodstoves for aesthetic purposes, so the ratio of supplemental to aesthetic use for fireplaces is used to derive the woodstove populations for aesthetic use. The final wood-burning device populations for different purposes in each county is shown in Table 3.

**Table 3. Number of occupied units with wood-burning stoves, fireplaces with inserts, and fireplaces without inserts used as main heating equipment, supplemental heating equipment and for aesthetic purposes for the year 2023.**

Purpose	Device	Los Angeles	Orange	Riverside	San Bernardino
Main Heating	Fireplace	0	0	482	1258
	Woodstove	0	0	1458	3808
	Insert	2287	595	408	1067
Supplemental Heating	Fireplace	23046	8452	19998	17232
	Woodstove	1866	486	1542	4028
	Insert	6785	2066	7994	7091
Aesthetic Use	Fireplace-Cord Burning	8289	3040	2919	2516
	Woodstove	849	221	291	760
	Insert	2441	743	1167	1035
	Fireplace-Manufactured Log Burning	2548	1285	1188	1047

**Table 4. Percentage of woodstove-containing households in different counties from both Redfin and AHS datasets. LA, OR, RS and SB represent Los Angeles County, Orange County, Riverside County and San Bernardino County respectively.**

County	From Redfin			From AHS			
	Total Homes	With Woodstove	Percentage (%)	Total Occupied Households	With Woodstoves	Percentage (% , 2023)	Percentage (% , 3-yr Average)
LA	189,307	203	0.09	4,597,824	2,352	0.05	0.11
OR	73,080	36					
RS	102,400	223	0.79	1,519,977	13,379	1	0.69
SB	81,612	1,249					

Notes: (1) Redfin data only includes houses on sale or sold within the past 3 years. (2) 3-year average includes data from 2019, 2021 and 2023 survey data.

To validate our estimation method, we also pulled housing data from the Redfin website and conducted a simple comparison which is shown in Table 4. According to Redfin, the percentage of homes with woodstoves is approximately 0.09% in Los Angeles and Orange Counties combined, and 0.79% in Riverside and San Bernardino Counties. In comparison, our estimates based on AHS PUF microdata are 0.11% and 0.69%, respectively, for these two regions. The close agreement between the two data sources supports the validity of our method for estimating the population of residential wood-burning appliances using the AHS PUF microdata.

#### **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. Table 5 shows the total population of counties in the SCAB and SSAB and the fraction of the population of the counties in the respective air basins.

**Table 5. 2023 population in the South Coast Air Basin (SCAB) and Salton Sea Air Basin (SSAB).**

County	LA	OR	RV	SB
Total Population	9,966,227	3,200,465	2,500,159	2,211,204
SCAB Population	9,605,491	3,200,465	2,008,652	1,647,469
SSAB Population	0	0	469,561	0
Fraction of Population in SCAB	0.96	1	0.8	0.75
Fraction of Population in SSAB (Coachella Valley)	0	0	0.19	0
Fraction of Population outside SCAQMD	0.04	0	0.01	0.25

**Table 6. 2023 households in the South Coast Air Basin (SCAB) and Salton Sea Air Basin (SSAB).**

	LA	OR	RV	SB
Total Households	3,399,977	1,101,795	801,850	517,363
Households in SCAB	3,399,977	1,101,795	618,854	517,363
Households in SSAB (Coachella Valley)	0	0	182,996	0

### Determining the Amount of Wood Burned in Wood-burning Appliances

The preceding tables present estimates of total number of occupied homes using wood-burning appliances. To estimate the total amount of wood burned, the wood consumption rate must be determined. The burning rates used in this methodology are adopted from CARB's Area Source Methodology Technical Document Section 7.1 Residential Wood Combustion (draft version).

**Table 7. Burn Rates of wood-burning devices for different purposes. When the fireplace is burning manufactured logs for aesthetic use, the unit of burn rate is tons/unit. For all the other categories, the unit is cords/unit.**

Purpose	Device	Los Angeles	Orange	Riverside	San Bernardino
Main Heating	Fireplace	1.736	1.682	1.715	2.023
	Woodstove	1.765	2.36	1.776	2.066
	Insert	1.765	2.36	1.776	2.066
Supplemental Heating	Fireplace	0.278	0.264	0.278	0.330
	Woodstove	0.339	0.446	0.345	0.405
	Insert	0.332	0.439	0.337	0.393
Aesthetic Use	Fireplace-Cord Burning	0.106	0.103	0.103	0.121
	Woodstove	0.055	0.073	0.055	0.064
	Insert	0.072	0.097	0.073	0.085
	Fireplace-Manufactured Log Burning	0.08	0.08	0.08	0.08

Number of devices and burn rates are multiplied to estimate the amount of wood burned in each county, in cords or tons, depending on whether the appliance burns cordwood or manufactured logs. For devices that burn cordwood, the estimated number of cords are multiplied by a wood density factor of 1.54 tons/cord which is based on the local survey data for California. The burn rates presented in Table 7 were further distributed based on control technology only for wood stoves and fireplace inserts. The burn rates are apportioned to three levels: non-EPA certified, EPA certified non-catalytic, and EPA certified catalytic with split factors of 0.31, 0.138 and 0.552 respectively. It is well established that uncertified wood stoves and fireplace inserts are less efficient and tend to consume more wood than their certified counterparts to produce the same amount of heat. Thus, a Control Technology Factor ( $F_{dev}$ ) is necessary to reflect the higher wood usage of uncertified units.

$$WB_{dev,p} = N_{dev,p} \times BR_{dev,p} \times F_{dev}$$

Where

- $WB_{dev,p}$  = Total amount of wood burned in device  $dev$  and for heating type  $p$  (tons)
- $N_{dev,p}$  = Number of wood-burning devices of device type  $dev$  and heating type  $p$
- $BR_{dev,p}$  = Amount of wood burned per device for device type  $dev$  and heating type  $p$  (cords/year for fireplaces, wood stoves and fireplace inserts)
- $F_{dev}$  = control technology factor. 1.08 for woodstoves and fireplace inserts; 1 for other devices.

Manufactured logs are treated separately from cordwood because they are assumed to be used exclusively for aesthetic heating in fireplaces. The number of households that use manufactured logs for aesthetic fireplace use is multiplied by an annual burn rate for manufactured logs to obtain the total manufactured log consumption.

$$WB_{fp,aes,ml} = N_{fp,aes,ml} \times BR_{fp,aes,ml}$$

- $WB_{fp,aes,ml}$  = Total amount of manufactured logs burned in fireplaces for aesthetic heating (tons)

- $N_{fp,aes,ml}$  = Number of households using manufactured logs for aesthetic heating in fireplaces
- $BR_{fp,aes,ml}$  = Annual burn rate of manufactured logs per household using fireplaces for aesthetic heating (tons/year)

**Table 8. The amount of fuel burned (tons) in wood-burning devices in 2023**

Purpose	Device	Los Angeles	Orange	Riverside	San Bernardino
Main Heating	Fireplace	0	0	1272	3920
	Woodstove	0	0	3987	12117
	Insert	6215	2164	1117	3394
Supplemental Heating	Fireplace	9858	3437	8556	8751
	Woodstove	974	334	818	2512
	Insert	3467	1396	4154	4286
Aesthetic Use	Fireplace-Cord Burning	1352	480	463	470
	Woodstove	72	25	25	75
	Insert	272	111	131	135
	Fireplace-Manufactured Log Burning	204	103	95	84

## EMISSION FACTORS

Table 9 contains values for emission factors. These factors were based on recommended values by ARB's RWC methodology and include updates from recent lab studies (Traviss et al. 2024).

**Table 9. Residential Wood Combustion Emission Factors in lbs/ton fuel burned.**

Device	Type	CO	NOx	SOx	PM2.5	ROG	NH3
Fireplace	Conventional	149	2.6	0.4	23.6	18.9	1.8
Fireplace	Manufactured Log	125	7.684	0.4	28.42	39.56	1.8
Wood stove	Uncertified	175	1.12	0.4	29.2	65.4	1.7
	EPA Certified – Non Catalytic	97	1.28	0.4	17.96	33.6	0.6658
	EPA Certified – Catalytic/Hybrid	43	2.1	0.4	6.76	19.76	0.6706
Fireplace Insert	Uncertified	175	1.12	0.4	29.2	65.4	1.7
	EPA Certified – Non Catalytic	97	1.28	0.4	17.96	33.6	0.6658
	EPA Certified – Catalytic/Hybrid	43	2.1	0.4	6.76	19.76	0.6706
Pellet Stove	All	26	3.16	0.32	1.72	3.66	0.3

## EMISSIONS CALCULATIONS

### Emission Calculation Assumptions

$$\text{Emission} = \text{Activity Data} \times \text{Emission Factors}$$

Using the fuel consumption data and emission factors described above, total emissions are calculated based on the specified equation and summarized in Table 10 and Table 11.

**Table 10. Emissions in the South Coast Air Basin for Base Year 2023 in tons per day.**

Device	Type	CO	NOx	SOx	PM2.5	ROG	NH3
Fireplace	Conventional	6.19	0.11	0.02	0.98	0.79	0.07
Fireplace	Manufactured Log	0.07	0.00	0.00	0.02	0.02	0.00
Wood stove	Uncertified	0.79	0.01	0.00	0.13	0.30	0.01
	EPA Certified – Non Catalytic	0.62	0.01	0.00	0.12	0.22	0.00
	EPA Certified – Catalytic/Hybrid	0.07	0.00	0.00	0.01	0.03	0.00
Fireplace Insert	Uncertified	1.88	0.01	0.00	0.31	0.70	0.02
	EPA Certified – Non Catalytic	1.47	0.02	0.01	0.27	0.51	0.01
	EPA Certified – Catalytic/Hybrid	0.16	0.01	0.00	0.03	0.08	0.00
Pellet Stove	All	0.00	0.00	0.00	0.00	0.00	0.00

**Table 11. Emissions in the South Coast Salton Sea for Base Year 2023 in tons per day.**

Device	Type	CO	NOx	SOx	PM2.5	ROG	NH3
Fireplace	Conventional	0.46	0.01	0.00	0.07	0.06	0.01
Fireplace	Manufactured Log	0.00	0.00	0.00	0.00	0.00	0.00
Wood stove	Uncertified	0.07	0.00	0.00	0.01	0.03	0.00
	EPA Certified – Non Catalytic	0.05	0.00	0.00	0.01	0.02	0.00
	EPA Certified – Catalytic/Hybrid	0.01	0.00	0.00	0.00	0.00	0.00
Fireplace Insert	Uncertified	0.11	0.00	0.00	0.02	0.04	0.00
	EPA Certified – Non Catalytic	0.08	0.00	0.00	0.02	0.03	0.00
	EPA Certified – Catalytic/Hybrid	0.01	0.00	0.00	0.00	0.00	0.00
Pellet Stove	All	0.00	0.00	0.00	0.00	0.00	0.00

**REFERENCES**

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