



2020 National Emissions Inventory Technical Support Document: Fuel Combustion – Residential Heating -Natural Gas, Oil, and Other

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2020 National Emissions Inventory Technical Support Document: Fuel Combustion –
Residential Heating – Natural Gas, Oil, and Other

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Office of Air Quality Planning and Standards
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26 Fuel Combustion – Residential Heating – Natural Gas, Oil, and Other

Residential heating includes the combustion of fuel, including coal, distillate oil, kerosene, natural gas, and liquefied propane gas (LPG) to heat homes. Common uses of energy associated with this category include space heating, water heating, and cooking. This category does not include the combustion of wood from the residential sector, which is estimated separately in Section 27.

26.1 Sector Descriptions and Overview

The EIS sectors documented in this section include these emissions from residential fuel combustion:

- Fuel Comb - Residential - Natural Gas. Includes fuel natural gas only. Residential natural gas combustion is natural gas that is burned to heat residential housing as well as in grills, hot water heaters, and dryers.
- Fuel Comb - Residential – Oil. Includes the fuels: distillate oil, kerosene, and residual oil. Residual oil is not an EPA-estimated category, and no agencies submitted data for it in 2020. Residential distillate oil combustion is oil that is burned in residential housing. Residential kerosene combustion is kerosene that is burned in residential housing. Common uses of energy associated with this sector include space heating, water heating, cooking, and running a wide variety of other equipment.
- Fuel Comb - Residential – Other: Includes the fuels: coal, liquid petroleum gas (LPG), and “biomass; all except wood”. Note that “biomass; all except wood” is not an EPA-estimated category and no agency submitted data for it in 2020. Residential coal combustion is coal that is burned in residential housing. Residential LPG combustion is liquefied propane gas that is burned in residential housing. Common uses of energy associated with this sector include space heating, water heating, and cooking.

26.2 Sources of data

Table 26-1 shows, for non-wood Residential heating, the nonpoint SCCs covered by the EPA estimates and by the State/Local and Tribal agencies that submitted data. The SCC level 3 and 4 SCC descriptions are also provided. The SCC level 1 and 2 descriptions is “Stationary Source Fuel Combustion; Residential” for all SCCs. According to the State Energy Data System (SEDS) 2020 Consumption tables published by the Energy Information Administration (EIA) [ref 1], there was no residential coal combustion in 2020. However, the old methodology is retained here and provided in an EPA workbook, and as seen in Table 26-1, with zero emissions, in case a state would like to use their own coal consumption data

Table 26-1: Non-wood residential fuel combustion SCCs in the 2020 NEI

SCC	Description	Sector	EPA	SLT
2104002000	Bituminous/Subbituminous Coal; Total: All Combustor Types	Fuel Comb - Residential - Other	X	X
2104004000	Distillate Oil; Total: All Combustor Types	Fuel Comb - Residential - Oil	X	X
2104006000	Natural Gas; Total: All Combustor Types	Fuel Comb - Residential - Natural Gas	X	X

2104007000	Liquified Petroleum Gas (LPG); Total: All Combustor Types	Fuel Comb - Residential - Other	X	X
2104011000	Kerosene; Total: All Heater Types	Fuel Comb - Residential - Oil	X	X

The agencies listed in Table 26-2 submitted emissions for these sectors. Agencies not listed uses EPA estimates for the entire sector.

Table 26-2: Agencies reporting non-wood residential fuel combustion emissions

Agency	Oil	Other	Natural Gas
Alaska Department of Environmental Conservation	X	X	
California Air Resources Board	X	X	X
Coeur d'Alene Tribe	X	X	X
Delaware Department of Natural Resources and Environmental Control	X	X	X
Idaho Department of Environmental Quality	X	X	X
Illinois Environmental Protection Agency	X	X	X
Kootenai Tribe of Idaho	X	X	X
Maricopa County Air Quality Department	X	X	X
Maryland Department of the Environment	X	X	X
Massachusetts Department of Environmental Protection	X	X	X
Memphis and Shelby County Health Department - Pollution Control	X	X	X
Metro Public Health of Nashville/Davidson County	X	X	X
New Hampshire Department of Environmental Services	X	X	X
New Jersey Department of Environment Protection	X	X	X
New York State Department of Environmental Conservation	X	X	X
Nez Perce Tribe	X	X	X
Northern Cheyenne Tribe		X	X
Shoshone-Bannock Tribes of the Fort Hall Reservation of Idaho	X	X	X
Southern Ute Indian Tribe		X	X
Texas Commission on Environmental Quality	X	X	X
Utah Division of Air Quality		X	X
Washoe County Health District	X	X	X

26.3 EPA-developed estimates

The general approach to calculating emissions for these SCCs is to take state-level fuel consumption from the EIA State Energy Data System (SEDS) [ref 1] and allocate it to the county level based on data from the Census Bureau on the number of homes in each county that use each fuel type [ref 2]. County-level fuel consumption is multiplied by emissions factors to calculate emissions.

Note that SEDS no longer includes data on residential coal consumption, as it is assumed to be near zero, and therefore emissions will be nonexistent for residential coal consumption. However, the methodology for estimating emissions from coal has been retained if states have additional data on residential coal consumption that they would like to use.

The calculations for estimating emissions from residential heating involve distributing state-level energy consumption data from SEDS to each county based on the proportion of houses in that county that use each fuel type as a primary fuel source. Additional calculations are necessary to distribute coal consumption to anthracite or bituminous coal consumption and to distribute fuel oil consumption to distillate fuel oil and kerosene consumption. County-level consumption of each fuel is multiplied by an emissions factor to estimate emissions of criteria air pollutants (CAPs) and hazardous air pollutants (HAPs).

26.3.1 Activity data

The amount of fuel consumed by residential sector in the United States from SEDS [ref 1] is used to estimate emissions for this source category. The relevant fuel codes from SEDS are shown in Table 26-3.

Table 26-3: EIA State Energy Data System Fuel Codes

Fuel	SEDS Fuel Code
Coal	CLRCP
Distillate fuel oil	DFRCP
Kerosene	KSRCP
Natural Gas	NGRCP
LPG	LGRCF

The SEDS data do not distinguish between anthracite and bituminous/subbituminous coal consumption estimates. The EIA table “Domestic Distribution of U.S. Coal by Destination State, Consumer, Origin and Method of Transportation” [ref 3] provides state-level residential coal distribution data for 2006 that is used to estimate the fraction of coal consumption that is anthracite and bituminous/subbituminous. The amount of anthracite distributed to each state and the total coal delivered to each state is used to estimate the proportion of anthracite and bituminous coal consumption. Table 26-4 presents the anthracite and bituminous coal ratios for each state.

Table 26-4: Anthracite and Bituminous Coal Distribution for the Residential and Commercial Sectors

State	Ratio of Bituminous	Ratio of Anthracite	State	Ratio of Bituminous	Ratio of Anthracite
Alabama	1.000	0.000	Montana	1.000	0.000
Alaska	1.000	0.000	Nebraska	1.000	0.000
Arizona	0.814	0.186	Nevada	1.000	0.000
Arkansas	0.814	0.186	New Hampshire	0.000	1.000
California	1.000	0.000	New Jersey	0.000	1.000
Colorado	0.996	0.004	New Mexico	1.000	0.000
Connecticut	0.000	1.000	New York	0.600	0.400
Delaware	0.814	0.186	North Carolina	1.000	0.000
Dist. Columbia	1.000	0.000	North Dakota	1.000	0.000
Florida	0.814	0.186	Ohio	0.873	0.127
Georgia	1.000	0.000	Oklahoma	0.917	0.083
Hawaii	1.000	0.000	Oregon	1.000	0.000
Idaho	0.979	0.021	Pennsylvania	0.194	0.806
Illinois	0.998	0.002	Rhode Island	0.000	1.000

State	Ratio of Bituminous	Ratio of Anthracite	State	Ratio of Bituminous	Ratio of Anthracite
Indiana	0.947	0.053	South Carolina	0.997	0.003
Iowa	0.999	0.001	South Dakota	1.000	0.000
Kansas	1.000	0.000	Tennessee	0.994	0.006
Kentucky	0.998	0.002	Texas	0.814	0.186
Louisiana	1.000	0.000	Utah	1.000	0.000
Maine	0.000	1.000	Vermont	0.000	1.000
Maryland	0.929	0.071	Virginia	0.963	0.037
Massachusetts	0.500	0.500	Washington	1.000	0.000
Michigan	0.667	0.333	West Virginia	0.905	0.095
Minnesota	0.997	0.003	Wisconsin	0.991	0.009
Mississippi	1.000	0.000	Wyoming	1.000	0.000
Missouri	1.000	0.000			

The SEDS data on residential coal consumption are split into consumption of anthracite and bituminous/subbituminous coal based on the ratios in Table 26-4.

$$FC_{ant/bit,s} = FC_{coal,s} \times R_{ant/bit} \quad (1)$$

Where:

- $FC_{ant/bit,s}$ = anthracite or bituminous coal consumption in state s , in tons
- $FC_{coal,s}$ = total fuel consumption of coal in state s from SEDS, in tons
- $R_{ant/bit}$ = ratio of anthracite or bituminous coal to total coal, as found in Table 26-4

26.3.2 Allocation procedure

State-level fuel consumption is allocated to each county using the US Census Bureau's 5-year estimate Census Detailed Housing Information [ref 2], which includes the number of housing units using a specific type of fuel for their primary fuel source. State fuel consumption is allocated to each county using the ratio of the number of houses using each fuel in each county to the total number of houses using each fuel in the state.

For most fuels, the fuel type in SEDS matches well to the fuel type used in the Census data. However, the Census data report only for total fuel oil, which does not distinguish between distillate fuel oil and kerosene. Therefore, the ratio of distillate fuel oil versus kerosene in the heating fuel oil mix, which is used to determine the fraction of homes in each county that use distillate and those that use kerosene, is calculated.

$$R_{dfo/ker,s} = \frac{FC_{dfo/ker,s}}{FC_{dfo,s} + FC_{ker,s}} \quad (2)$$

Where:

- $R_{dfo/ker,s}$ = ratio of residential distillate fuel oil or kerosene to total distillate fuel oil and kerosene in state s

$A_{dfo/ker,s}$ = fuel consumption of distillate fuel oil or kerosene in state s from SEDS, in thousand barrels

Then, the ratio of distillate fuel oil or kerosene to total fuel oil is used to determine how many housing units in each county use distillate fuel oil or kerosene.

$$HU_{dfo/ker,c} = HU_{fo,c} \times R_{dfo/ker,s} \quad (3)$$

Where:

$HU_{dfo/ker,c}$ = housing units in county c using distillate fuel oil or kerosene as the primary heating fuel

$HU_{fo,c}$ = housing units in county c using any fuel oil as primary heating fuel

To distribute the state-level energy consumption data for all fuel types, the ratio of county-level housing units using each fuel type as primary heating fuel to state-level housing units using that fuel type is calculated. This ratio is used to distribute state-level fuel consumption to the county level. The county-level values for housing units using distillate oil and kerosene as primary fuel are calculated in equations 2 and 3 above.

$$R_{f,c} = \frac{HU_{f,c}}{HU_{f,s}} \quad (4)$$

Where:

$R_{f,c}$ = ratio of homes in county c to homes in state s that use fuel f as primary heating fuel

$HU_{f,c}$ = housing units in county c using fuel type f as primary heating fuel

$HU_{f,s}$ = housing units in state s using fuel type f as primary heating fuel

The state-level fuel consumption of each fuel type from SEDS is multiplied by the county-level ratio of homes using each fuel type. State-level fuel consumption of anthracite and bituminous/subbituminous coal is calculated in equation 1 in Section 26.3.1.

$$FC_{f,c} = FC_{f,s} \times R_{f,c} \quad (5)$$

Where:

$FC_{f,c}$ = fuel consumption of fuel type f in county c , in tons, thousand barrels, or thousand cubic feet

$FC_{f,s}$ = fuel consumption of fuel type f in state s , in tons, thousand barrels, or thousand cubic feet, from SEDS

$R_{f,c}$ = ratio of homes in county c to homes in state s that use fuel f as primary heating fuel

Fuel consumption of distillate fuel oil is converted from barrels to gallons using a conversion factor of 42 gallons per barrel.

26.3.3 Emission factors

All emissions factors for CAPs, except ammonia, are from AP-42 [ref 4]. The ammonia emissions factor is from EPA’s Estimating Ammonia Emissions from Anthropogenic Sources, Draft Final Report [ref 5]. In some cases, HAP emissions factors are from a memorandum to EPA called “Baseline Emission Inventory of HAP Emissions from MACT Sources – Interim Final Report” [ref 6].

For many residential heating fuels, the emissions factors for SO2 and PM species are adjusted using sulfur or ash content data for the fuel at the county level. Note that for coal emissions, this step need only be done if a state supplies data on residential coal consumption, because SEDS currently assumes zero residential coal consumption.

$$EF_{f,s,p} = SAC_{f,s} \times EF_{unadj,f} \quad (6)$$

Where:

- $EF_{x,p}$ = emissions factor of pollutant p for fuel type f in state s
- SAC_x = sulfur or ash content for fuel type f in state s
- $EF_{unadj,f}$ = unadjusted emissions factor for fuel type f , from EPA AP-42

A summary of the emissions factors for all fuel types for residential heating: anthracite coal, bituminous/subbituminous coal, distillate fuel oil, kerosene, LPG, and natural gas factors are provided in the “Wagon Wheel Emission Factor Compendium” on the [2020 NEI Supporting Data and Summaries site](#).

For coal combustion, the SO2 emission factors are based on the sulfur content of the coal burned, and some of the PM emission factors for anthracite coal require information on the ash content of the coal. State-specific coal sulfur contents for bituminous coal are obtained from the EIA’s Coal Data Browser and applied at the county level [ref 7]. Bituminous sulfur content data can be found in the Coal Consumption and Quality Data Set, filtered to only account for commercial and institutional sources. For anthracite coal, an ash content value of 13.38% and a sulfur content of 0.89% are applied to all counties except those in New Mexico (ash content 16.61%, sulfur content 0.77%), Washington (ash content 12%, sulfur content 0.9%), and Virginia (ash content 13.38%, sulfur content 0.43%). Table 26-5 shows the coal SO2 and PM emissions factors. Table 26-6 presents the bituminous coal sulfur content values used for each state.

Table 26-5: SO2 and PM Emissions Factors for Residential Anthracite and Bituminous Coal Combustion

Pollutant	Emissions Factor (lb/ton)	Data Source, AP-42 Table No.
Anthracite Emissions Factors (SCC 2104001000)		
PM-CON	0.08 * % Ash	1.2-3 (stoker)
PM10-FIL	10	1.2-3 (hand-fired)
PM25-FIL	4.6	Fig. 1.2-1 (ratio of PM25/PM10=1.25/2.70=0.46) 0.46*10=4.6
PM10-PRI	10 + 0.08 * % Ash	1.2-3
PM25-PRI	4.6 + 0.08 * % Ash	1.2-3 and Fig 1.2-1
Sulfur Dioxide	39 * % Sulfur	1.2-1 (residential space heater)

Pollutant	Emissions Factor (lb/ton)	Data Source, AP-42 Table No.
Bituminous Emissions Factors (SCC 2104002000)		
PM-CON	1.04 ⁺	1.1-5 (stoker)
PM10-FIL	6.2	1.1-4 (hand-fed)
PM25-FIL	3.8	1.1-11 (underfeed stoker)
PM10-PRI	7.24	Sum of FIL and CON
PM25-PRI	4.84	Sum of FIL and CON
Sulfur Dioxide	31 * % Sulfur	1.1-3 (hand-fed)
⁺ Emissions factor provided in AP-42 is 0.04 lb/MMBtu. This is multiplied by the conversion factor of 26 MMBtu/ton provided in AP-42 for bituminous coal.		

Table 26-6: State-Specific Sulfur Content for Bituminous Coal (SCC 2104002000)

State	Percent Sulfur Content	State	Percent Sulfur Content
Alabama	0.00	Montana	0.46
Alaska	0.15	Nebraska	0.00
Arizona	0.00	Nevada	0.00
Arkansas	0.00	New Hampshire	0.00
California	0.00	New Jersey	0.00
Colorado	0.31	New Mexico	0.00
Connecticut	0.00	New York	0.00
Delaware	0.00	North Carolina	1.63
District of Columbia	0.51	North Dakota	0.64
Florida	0.00	Ohio	0.88
Georgia	0.00	Oklahoma	0.00
Hawaii	0.00	Oregon	0.00
Idaho	0.00	Pennsylvania	0.83
Illinois	3.21	Rhode Island	0.00
Indiana	2.95	South Carolina	0.00
Iowa	2.60	South Dakota	0.00
Kansas	0.00	Tennessee	0.00
Kentucky	0.71	Texas	0.00
Louisiana	0.00	Utah	0.00
Maine	0.00	Vermont	0.00
Maryland	0.00	Virginia	1.08
Massachusetts	0.00	Washington	0.00
Michigan	0.00	West Virginia	0.00
Minnesota	0.22	Wisconsin	0.78
Mississippi	0.00	Wyoming	0.44
Missouri	3.03		

The emissions factors for CO, VOC, and some HAPs for anthracite coal factors are available in the “Wagon Wheel Emission Factor Compendium” on the [2020 NEI Supporting Data and Summaries site](#). Emission rates for these pollutants are dependent upon combustion efficiency, with the mass of emissions per unit of heat input generally increasing with decreasing unit size. No anthracite emission rates are provided for residential heaters for these pollutants. Therefore, it was felt that it the AP-42

emission rates from bituminous coal that are derived for smaller hand-fed units, are more appropriate to use than applying anthracite emissions factors derived for much larger boilers.

Note that while AP-42 provides emissions factors for emissions of some metals from coal combustion, these factors are based on tests at controlled and/or pulverized coal boilers. These test conditions are not expected to be a good representation of emission rates for metals from residential heaters, so these pollutants are not included.

For all counties in the United States, the distillate oil consumed by residential combustion is assumed to be No. 2 fuel oil with a heating value of 140,000 Btu per gallon. The SO₂ emissions factor for distillate oil assumes a sulfur content of 500 parts per million (ppm) and is calculated at the county level [ref 8].

Emissions factors for kerosene are based on the emissions factors for distillate oil, which are multiplied by a factor of 135/140 to convert them for this use. This factor is based on the ratio of the heat content of kerosene (135,000 Btu/gallon) to the heat content of distillate oil (140,000 Btu/gallon) [ref 4]. Criteria pollutant and HAP emissions factors are from the same sources discussed above for distillate fuel oil. The distillate sulfur content (500 ppm) is used for kerosene as well [ref 8].

Pollutant emissions factors for residential LPG are based on the residential natural gas emissions factors. The natural gas emissions factors [ref 9] are converted to LPG emissions factors by multiplying by 96,750 Btu/gallon.

26.3.4 Controls

There are no controls assumed for this category.

26.3.5 Emissions

The criteria pollutant and HAP emissions from residential heating are calculated by multiplying the distributed county-level residential fuel consumption by the corresponding emissions factor for each pollutant. The adjusted emissions factors for SO₂ and PM for anthracite and bituminous/subbituminous coal are calculated above in equation 6 in Section 4.14.3.3.

$$E_{f,c,p} = FC_{f,c} \times EF_{f,p} \times \frac{1 \text{ ton}}{2000 \text{ lb}} \quad (7)$$

Where:

- $E_{f,c,p}$ = annual emissions of pollutant p from combustion of fuel type f in county c , in tons
- $FC_{f,c}$ = fuel consumption of fuel type f in county c , in tons, thousand barrels, or thousand cubic feet, from equation 5
- $EF_{f,p}$ = emissions factor pollutant p and fuel type f , in pounds of emissions per unit (tons, thousand barrels, or thousand cubic feet) of fuel consumption, are available in the Wagon Wheel Emission Factor Compendium.

26.3.6 Example calculations

Table 26-7 provides sample calculations for CO emissions from residential heating from distillate fuel oil. The values in these equations are demonstrating program logic and are not representative of any specific NEI year or county.

Table 26-7: Sample calculations for CO emissions from residential heating from distillate fuel oil

Eq. #	Equation	Values	Result
1	$FC_{anth/bit,s}$ $= FC_{coal,s} \times R_{anth/bit}$	N/A	This example is for distillate. Equation 1 is for coal.
2	$R_{dfo/ker,s}$ $= \frac{FC_{dfo/ker,s}}{FC_{dfo,s} + FC_{ker,s}}$	$\frac{15,062 \text{ thousand barrels}}{(15,062 \text{ thousand barrels} + 238 \text{ thousand barrels})}$	0.9844 ratio of DFO to total fuel oil
3	$HU_{dfo/ker,c}$ $= HU_{fo,c} \times R_{dfo/ker,s}$	8,081 houses × 0.9844	7,955.30 houses using DFO
4	$R_{f,c} = \frac{HU_{f,c}}{HU_{f,s}}$	$\frac{7,955.30 \text{ houses}}{916,301.2 \text{ houses}}$	0.0086 county housing allocation ratio
5	$FC_{f,c}$ $= FC_{f,s} \times R_{f,c}$ $\times 42 \text{ gal. per barrel}$	15,062 thous. barrels × 0.0086 × 42 gal. per barrel	5,492.25 thousand gallons DFO consumed
6	$EF_{anth/bit,s,p}$ $= SAC_{f,s} \times EF_{unadj,f}$	N/A	This example is for distillate. Equation 6 is for coal.
7	$E_{f,c,p}$ $= FC_{f,c} \times EF_{f,p}$ $\times \frac{1 \text{ ton}}{2000 \text{ lb}}$	5,492.25 thous. gal. × 5 lbs. per thous. gal × $\frac{1 \text{ ton}}{2000 \text{ lb}}$	13.7 tons CO from DFO

26.3.7 Improvements/Changes in the 2020 NEI

There were no changes in methodology from the 2017 NEI. Activity data was updated to reflect the most recent, best available data at the time of the NEI.

26.3.8 Puerto Rico and U.S. Virgin Islands

Since insufficient data exist to calculate emissions for the counties in Puerto Rico and the US Virgin Islands, emissions are based on two proxy counties in Florida: 12011, Broward County for Puerto Rico and 12087, Monroe County for the US Virgin Islands. The total emissions in tons for these two Florida counties are divided by their respective populations creating a tons per capita emissions factor. For each Puerto Rico and US Virgin Island county, the tons per capita emissions factor is multiplied by the county population (from the same year as the inventory's activity data) which served as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are "EACH".

26.4 References

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