



2020 National Emissions Inventory Technical Support Document: Miscellaneous Non- Industrial NEC: Residential Charcoal Grilling

EPA-454/R-23-001dd
March 2023

2020 National Emissions Inventory Technical Support Document: Miscellaneous Non-Industrial
NEC: Residential Charcoal Grilling

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30 Miscellaneous Non-Industrial NEC: Residential Charcoal Grilling

30.1 Sector Descriptions and Overview

Residential barbecue grilling emissions include emissions from the burning of charcoal (including the use of lighter fluid) and emissions from all types of meat cooked on charcoal, gas, and electric grills. Combustion emissions from gas barbecue grills are not included. This source category (SCC=2810025000) is one of many components in the Miscellaneous Non-Industrial sector. The SCC description is “Miscellaneous Area Sources; Other Combustion; Charcoal Grilling - Residential (see 23-02-002-xxx for Commercial); Total”.

A list of agencies that submitted residential charcoal grilling emissions is provided in Section 6.2.3.

30.2 EPA-developed estimates

Emissions from this source category include criteria pollutants, (CO, NO_x, PM₁₀-PRI, PM₂₅-PRI and VOC) and HAP emissions from residential barbecue grilling. Sources of emissions include burning charcoal and using lighter fluid in charcoal grills, and cooking meat on charcoal, gas, and electric grills. To perform the relevant calculations data are needed on activities and emissions factors for those activities. Activity data includes information about total charcoal sold, total meat cooked, and total amount of lighter fluid used.

30.2.1 Activity data

There are three types of activity data for this source category: (1) amount of meat cooked on charcoal grills; (2) amount of meat cooked on gas and electric grills; and (3) number of grilling events using lighter fluid. Each of these types of activity data is discussed in the subsections below.

Meat cooked on charcoal grills

This source category includes emissions from the amount of charcoal burned and the amount of meat cooked.

The total amount of charcoal sold in the United States is based on data from the Heath, Patio, and Barbecue Association (HPBA) [ref 1], which is distributed to each county based on the proportion of 1-4 unit homes in each county, from the U.S. Census Bureau [ref 2]. This distribution procedure is discussed in more detail in Section . We assume that all charcoal sold is burned.

The amount of meat cooked is determined based on assumptions about the amount of meat cooked per pound of charcoal sold. This calculation assumes 17.64 charcoal briquettes per pound of charcoal sold [ref 3] and 0.033 pounds of meat cooked per briquette [ref 4]. These numbers are multiplied together to calculate a value of 0.588 pounds of meat cooked per pound of charcoal sold.

$$\begin{aligned} &0.588 \text{ lb. meat cooked per lb. charcoal sold} \\ &= 17.64 \text{ briquettes per lb. charcoal} \\ &\times 0.033 \text{ lb. meat cooked per briquette} \end{aligned} \tag{1}$$

Meat cooked on gas and electric grills

The amount of meat cooked on gas grills is calculated based on assumptions about the ratio of gas grilling to charcoal grilling, including that charcoal grills represent 41% of grills and gas/electric grills represent 59% [ref 4], and that charcoal grills are used 27 times per year and gas/electric grills are used 45 times per year [ref 5]. This calculation results in an estimated ratio of 2.398, meaning that for every pound of meat cooked on a charcoal grill an additional 2.398 pounds of meat are cooked on a gas or electric grill.

$$\begin{aligned} & 2.398 \text{ gas or electric grilling ratio} \\ & = \frac{45 \text{ times per year (gas or electric)} \times 59\% \text{ gas or electric grills}}{27 \text{ times per year (charcoal)} \times 41\% \text{ charcoal grills}} \end{aligned} \quad (2)$$

The values from equations 1 and 2 are used with national data on the amount of charcoal sold from the HPBA [ref 1] to estimate the total amount of meat cooked on charcoal, gas, and electric grills. This national charcoal sales data is distributed to the counties based on the number of homes in each county, as described in the following section.

Grilling events using lighter fluid

This calculation is based on the percentage of homes that have a grill (80%) [ref 6], the percentage of grills that are charcoal grills (41%) [ref 5], the percentage of charcoal grills that use lighter fluid (37%) [ref 7], and the number of times per year that charcoal grills are used (27) [ref 6]. This results in a value of approximately 3.28 grilling events per household per year where lighter fluid is used.

$$\begin{aligned} & 3.28 \text{ grilling events with lighter fluid} \\ & = 80\% \text{ homes with a grill} \times 41\% \text{ grills that are charcoal} \\ & \quad \times 37\% \text{ charcoal grills that use lighter fluid} \\ & \quad \times 27 \text{ times per year charcoal grills are used} \end{aligned} \quad (3)$$

This number is multiplied by the number of occupied homes in each county to determine the total number of grilling events in each county where lighter fluid is used. See Section on allocation procedure for information on calculating the number of occupied 1-4-unit households.

$$n_{LF,c} = H_{c,o} \times 3.28 \quad (4)$$

Where:

- $n_{LF,c}$ = Number of grilling events in county c where lighter fluid is used
- $H_{c,o}$ = Total occupied households of 1-4 units in county c
- 3.28 = Number of grilling events with lighter fluid per home, from equation 3

30.2.2 Allocation procedure

National data on the amount of charcoal sold is distributed to the counties based on the proportion of occupied 1-4-unit homes in each county. It is assumed that households in larger apartment buildings would not have the space to have or use an outdoor grill. The data on the number of occupied 1-4 unit homes in each county is from the U.S. Census Bureau American Community Survey [ref 2]. Occupied

households between 1 and 4 units are estimated using the sum of total 1-4-unit households and the fraction of total occupied households in the US.

$$H_{c,o} = \sum_{units=1}^{units=4} H_{c,t} \times \frac{H_{US,o}}{H_{US,t}} \quad (5)$$

$$HR_c = \frac{H_{c,o}}{\sum_c H_o} \quad (6)$$

Where:

- $H_{c,o}$ = Total occupied households of 1-4 units in county c
- $H_{c,t}$ = Total households in county c
- $H_{US,o}$ = Total occupied households in the United States
- $H_{US,t}$ = Total households in the United States
- HR_c = Ratio of occupied households of 1-4 units in county c to total households of 1-4 units in United States

The national-level data on charcoal sales is distributed to the counties using the ratio from equation 6.

$$Charcoal_c = HR_c \times Charcoal_{US} \times 2000 \text{ lbs. per ton} \quad (7)$$

Where:

- $Charcoal_c$ = Amount of charcoal sold in county c , in pounds
- HR_c = Ratio of households of 1-4 units in county c to total households of 1-4 units in United States
- $Charcoal_{US}$ = Amount of charcoal sold in the United States, in tons

The amount of charcoal sold in each county (from equation 7) is multiplied by the amount of meat cooked per pound of charcoal (from equation 1) to estimate the amount of meat cooked on charcoal grills in each county.

$$Meat_{charcoal,c} = Charcoal_c \times 0.588 \quad (8)$$

Where:

- $Meat_{charcoal,c}$ = Amount of meat cooked on charcoal grills in county c , in pounds
- $Charcoal_c$ = Amount of charcoal sold in county c , in pounds
- 0.588 = Pounds of meat cooked per pound of charcoal, from equation 1

The amount of meat cooked on charcoal grills is used with the ratio from equation 2 to estimate the amount of meat cooked on gas or electric grills.

$$Meat_{gas/elec,c} = Meat_{charcoal,c} \times 2.398 \quad (9)$$

Where:

- $Meat_{gas/elec,c}$ = Amount of meat cooked on gas or electric grills in county c , in pounds

$Meat_{charcoal,c}$ = Amount of meat cooked on charcoal grills in county c , in pounds
 2.398 = Ratio of meat cooked on gas or electric grills to charcoal grills, from equation 2

The amount of meat cooked on charcoal and on gas or electric grills is added together to determine the total amount of meat cooked on grills in each county.

$$Meat_{t,c} = Meat_{gas/elec,c} + Meat_{charcoal,c} \quad (10)$$

Where:

$Meat_{t,c}$ = Total amount of meat cooked on grills in county c , in pounds
 $Meat_{gas/elec,c}$ = Amount of meat cooked on gas or electric grills in county c , in pounds
 $Meat_{charcoal,c}$ = Amount of meat cooked on charcoal grills in county c , in pounds

30.2.3 Emission factors

The emissions factors are shown in Table 30-1, including the actual emissions factor used in the calculations, and the original emissions factor from the reference if it is different from the actual factor. These emission factors for CAPs are also provided in the “Wagon Wheel Emission Factor Compendium” on the [2020 NEI Supporting Data and Summaries site](#). The emissions factors for CO, NOX, PM10-PRI, PM25-PRI, and VOC are from EPA’s report, *Emissions from Street Vendor Cooking Devices (Charcoal Grilling)* [ref 8]. There is also a separate emissions factor for VOC from lighter fluid, from the South Coast Air Quality Management District, Rule 1174 [ref 9]. The HAP emission factors (also available in the zip file “HAPAugmentation_Nonpoint_28jan2023”, on the [2020 NEI Supplemental data FTP site](#)) are speciation factors from the EPA SPECIATE database [ref 10], which are speciation factors for charbroiling meat.

Table 30-1: Emissions Factors for Residential Grilling (2810025000)

Pollutant	Pollutant Code	Emissions Factor (original)	Emissions Factor Units (original)	Emissions Factor (actual)	Emissions Factor Units (actual)	Emissions Factor Reference
CO	CO	162.97a	g/kg meat	325.93	lbs./ton meat	6, Table E-2
NOX	NOX	3.37a		6.74		
PM10-PRI	PM10-PRI	9.10a		18.19		
PM25-PRI	PM25-PRI	n/a		14.56b		
		0.94a		1.88		
VOC	VOC			0.02	lbs./grilling event	6, section (c)(1)
1,3-Butadiene	106990			1.04E-02	lbs./lb. VOC	6
2,2,4-Trimethylpentane	540841			1.12E-03		
Acetaldehyde	75070			1.09E-01		
Anthracene	120127			1.09E-05		
Benzene	71432			8.26E-03		
Ethyl Benzene	100414			1.09E-03		
Fluoranthene	206440			3.98E-05		
Formaldehyde	50000			1.38E-01		

Pollutant	Pollutant Code	Emissions Factor (original)	Emissions Factor Units (original)	Emissions Factor (actual)	Emissions Factor Units (actual)	Emissions Factor Reference
Hexane	110543			4.38E-03		
m-Xylene	108383			5.97E-04		
Naphthalene	91203			8.94E-04		
o-Xylene	95476			1.09E-03		
Phenanthrene	85018			1.20E-04		
Propionaldehyde	123386			5.01E-02		
p-Xylene	106423			5.97E-04		
Pyrene	129000			5.67E-05		
Toluene	108883			3.98E-03		

- Based on average of test numbers MC1, MC2, MC3, MC6, MC7, and MC8 from the table showing emissions factors for emissions per kg meat cooked. See Table E-2 in Reference 9.
- PM25-PRI emission factor is based on assumption that PM25-PRI = PM10-PRI × 0.8.

30.2.4 Controls

There are no controls assumed for this category.

30.2.5 Emissions

The emissions of PM10-PRI, PM25-PRI, and VOC for residential barbecue grilling are calculated by multiplying the amount of meat grilled in each county (from equation 10) by the emissions factors from Table 30-1.

$$E_{p,c} = \frac{Meat_{t,c}}{2000 \text{ lbs. per ton}} \times EF_{p,meat} \quad (11)$$

Where:

- $E_{p,c}$ = Emissions of pollutant p from grilling meat in county c , in pounds
- $Meat_{t,c}$ = Total amount of meat cooked on grills in county c , in pounds
- $EF_{p,meat}$ = Emissions factor for pollutant p from grilling meat

It is assumed that CO and NOX emissions are from charcoal combustion, and there are no significant emissions of these pollutants from gas or electric grills. Therefore, to estimate CO and NOX emissions, the emissions factors for these pollutants are multiplied by the amount of meat cooked on charcoal (from equation 8), rather than the total amount of meat cooked.

$$E_{CO/NOX,c} = \frac{Meat_{charcoal,c}}{2000 \text{ lbs. per ton}} \times EF_{CO/NOX} \quad (11a)$$

Where:

- $E_{CO/NOX,c}$ = Emissions of pollutant CO or NOX from grilling meat in county c , in pounds
- $Meat_{charcoal,c}$ = Total amount of meat cooked on charcoal grills in county c , in pounds
- $EF_{CO/NOX}$ = Emissions factor for CO or NOX from grilling meat

For VOC, there is a separate calculation to account for emissions from lighter fluid use, in which the number of grilling events per year where lighter fluid is used (from equation 4) is multiplied by an emissions factor of 0.02 lbs. VOC/grilling event (Table 30-1).

$$E_{VOC,LF,c} = n_{LF,c} \times EF_{VOC,LF} \quad (12)$$

Where:

- $E_{VOC,LF,c}$ = Emissions of VOC from lighter fluid use in county c , in pounds
- $n_{LF,c}$ = Number of grilling events in county c where lighter fluid is used
- $EF_{VOC,LF}$ = Emissions factor for VOC from lighter fluid use

These VOC emissions are added to the VOC emissions from grilling meat to determine the total VOC emissions from residential grilling.

$$E_{VOC,c} = E_{VOC,LF,c} + E_{VOC,meat,c} \quad (13)$$

Where:

- $E_{VOC,c}$ = Total emissions of VOC from residential grilling in county c , in pounds
- $E_{VOC,LF,c}$ = Emissions of VOC from lighter fluid use in county c , in pounds
- $E_{VOC,meat,c}$ = Emissions of VOC from grilling meat in county c , in pounds

Emissions of HAPs are calculated by multiplying the total VOC emissions by the speciation factors in Table 30-1.

$$E_{h,c} = E_{VOC,c} \times EF_h \quad (14)$$

Where:

- $E_{h,c}$ = Emissions of HAP h in county c , in pounds
- $E_{VOC,c}$ = Total emissions of VOC from residential grilling in county c , in pounds
- EF_h = Emissions factor for HAP h

30.2.6 Example calculations

Sample calculations for estimating VOC emissions from residential grilling in Ada County, ID, are shown in Table 30-2. Note that equations 1, 2, and 3 result in constant values for each county, so these calculations are not repeated here. See Section 30.2.1 for more information about these equations.

Table 30-2: Sample calculations for VOC emissions from residential grilling in Ada County, Idaho

Eq. #	Equation	Values for Ada County, ID	Result
5	$H_{c,o} = \sum_{units=1}^{units=4} H_{c,t} \times \frac{H_{US,o}}{H_{US,t}}$	138,929 1 – 4 unit homes in Ada County × (154,408 occupied homes in Ada County) /(162,766 Total homes in Ada County)	131,795 occupied homes in Ada County, ID

Eq. #	Equation	Values for Ada County, ID	Result
4	$n_{LF,c} = H_{c,o} \times 3.28$	131,795 occupied homes in Ada County $\times 3.28$ grilling events per home	432,287 grilling events in Ada County, ID
6	$HR_c = \frac{H_{c,o}}{\sum_c H_o}$	$\frac{131,795 \text{ occupied homes in Ada County}}{89,010,502 \text{ homes in U.S.}}$	0.00148 ratio of homes in Ada County, ID
7	$Charcoal_c = HR_c \times Charcoal_{US} \times 2000 \text{ lbs. per ton}$	$0.00148 \times 890,910 \text{ tons charcoal} \times 2000 \text{ lbs. per ton}$	2,638,284.3 pounds charcoal in Ada County, ID
8	$Meat_{charcoal,c} = Charcoal_c \times 0.588$	$2,638,284.3 \text{ lbs. charcoal} \times 0.588$	1,551,311 lbs. meat grilled on charcoal grills in Ada County, ID
9	$Meat_{gas/elec,c} = Meat_{charcoal,c} \times 2.398$	$1,551,311 \text{ lbs. meat} \times 2.398$	3,720,044 lbs. meat grilled on gas or electric grills in Ada County, ID
10	$Meat_{t,c} = Meat_{gas/elec,c} + Meat_{charcoal,c}$	$1,551,311 \text{ lbs. meat} + 3,720,044 \text{ lbs. meat}$	5,271,355 lbs. meat grilled in Ada County, ID
11	$E_{p,c} = \frac{Meat_{t,c}}{2000 \text{ lbs. per ton}} \times EF_{p,meat}$	$\frac{5,271,355 \text{ lbs. meat}}{2000 \text{ lbs. per ton}} \times 1.88 \text{ lbs. per ton}$	4,955 lbs. VOC from grilling meat in Ada County, ID
12	$E_{VOC,LF,c} = n_{LF,c} \times EF_{VOC,LF}$	$432,287 \text{ grilling events} \times 0.02 \text{ lb. per grilling event}$	8,645 lbs. VOC from lighter fluid in Ada County, ID
13	$E_{VOC,c} = E_{VOC,LF,c} + E_{VOC,meat,c}$	$4,955 \text{ lbs. VOC} + 8,645 \text{ lbs. VOC}$	13,601 lbs. VOC from residential grilling in Ada County, ID

30.2.7 Improvements/Changes in the 2020 NEI

There are no significant changes from the methodology used to calculate the 2020 NEI emissions.

30.2.8 Puerto Rico and U.S. Virgin Islands

Emissions from Puerto Rico are calculated using the same method described above. Insufficient data exists to calculate emissions for the counties in the US Virgin Islands, so emissions are based on a proxy county in Florida: 12087, Monroe County. The total emissions in lbs. for this Florida County is divided by its population creating a lbs.-per-capita emission factor. For each US Virgin Island County, the lbs. per capita emission factor is multiplied by the county population (from the same year as the inventory's activity data) which serves as the activity data. In these cases, the throughput (activity data) unit and the emissions factor denominator unit are "EACH".

30.3 References

1. Hearth, Patio and Barbecue Association (HPBA), [Statistics/Barbecue Statistics/Charcoal Shipments for 2013](#), accessed April 2015.
2. U.S. Census Bureau. Community Facts, Housing, [Selected Housing Characteristics](#), Table DP04, American Community Survey 5-Year Estimates, 2020.
3. Kingsford email on the weight of their charcoal briquettes 4/11/2015.
4. Hearth, Patio and Barbecue Association (HPBA), [Statistics, BBQ Grill Shipments](#), accessed April 2015.
5. Hearth, Patio & Barbecue Association (HPBA), [2011 State of the Barbecue Industry Report](#), accessed April 2015.
6. Hearth, Patio & Barbecue Association (HPBA), [2014 State of the Barbecue Industry Report](#).
7. Hearth, Patio and Barbecue Association (HPBA) 3/23/2015 email from Jessica Boothe on how many people with charcoal grills use lighter fluid.
8. U.S. Environmental Protection Agency. 1999. [Emissions from Street Vendor Cooking Devices \(Charcoal Grilling\)](#), EPA/600/SR-99/048.
9. South Coast Air Quality Management District. October 5, 1990. "Rule 1174. [Control of Volatile Organic Compound Emissions from the Ignition of Barbecue Charcoal](#)" accessed May 2015.
10. U.S. Environmental Protection Agency. 2014. SPECIATE Database, version 4.4. Speciation profile 4553, meat charbroiling. Speciation profile was adjusted to be based on VOC, rather than total organic gases (TOG), by removing methane from the profile.

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Publication No. EPA-454/R-23-001dd
March 2023
