2020 National Emissions Inventory Technical Support Document: Commercial Cooking

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Office of Air Quality Planning and Standards
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19.1 Sector Descriptions and Overview

Commercial cooking refers to the cooking of meat, including steak, hamburger, poultry, pork, and seafood, and french fries on five different cooking devices: chain-driven (conveyorized) charbroilers, underfired charbroilers, deep-fat fryers, flat griddles and clamshell griddles. Table 19-1 lists the SCCs in the commercial cooking sector; EPA estimates emissions for all SCCs in this sector. The SCC level 1 and 2 descriptions are "Industrial Processes; Food and Kindred Products: SIC 20" for all SCCs.

Table 19-1: Source Classification Codes used in the Commercial Cooking sector

SCC	SCC Description, level 3	SCC Descriptions, level 4
2302002100	Commercial Cooking – Charbroiling	Conveyorized Charbroiling
2302002200	Commercial Cooking – Charbroiling	Under-fired Charbroiling
2302003000	Commercial Cooking – Frying	Deep Fat Frying
2302003100	Commercial Cooking – Frying	Flat Griddle Frying
2302003200	Commercial Cooking – Frying	Clamshell Griddle Frying

19.2 EPA-developed estimates

The calculations for estimating the emissions from commercial cooking involve first estimating the amount of meat and french fries cooked on various cooking devices in each county. These data are estimated using the number of restaurants, by specific restaurant type, from the Dun & Bradstreet (D&B) Hoovers Database [ref 1] and assumptions concerning the percent of those restaurants with specific cooking devices, the number of devices per restaurant, and the amount of meat cooked per device from a California Air Resources Board (CARB) sponsored survey [ref 2]. The amount of french fries cooked by the foodservice industry is from a report prepared for Potatoes USA [ref 3]. The total amount of meat or french fries cooked on each device is multiplied by emissions factors for CAPS including, VOC, CO, PM_{10} and $PM_{2.5}$, and various HAPs to estimate emissions of these pollutants from commercial cooking.

19.2.1.1 *Activity data*

The activity data for this source category is the amount of meat and potatoes cooked on each type of cooking device in each county. These amounts are estimated based on the number of restaurants in a county that use commercial cooking equipment, the percent of restaurants with each type of cooking device, the average number of cooking devices per restaurant, and the average amount of meat or potatoes cooked on each device.

Data concerning the number of restaurants in each county are from the Dun & Bradstreet (D&B) Hoovers Database [ref 1]. Hoovers data are proprietary and were purchased by EPA for use in the NEI; EPA provides users with aggregated data on county level restaurants by type. The relevant restaurants pulled from the Hoovers Database and their primary SIC codes are listed in Table 19-2.

Table 19-2: Hoovers database restaurant types

Restaurant Type	Primary SIC Code
Ethnic Food	5812-01
Fast Food	5812-03
Family	5812-05
Seafood	5812-07
Steak & BBQ	5812-08

The number of restaurants by type in each county, pulled from the Hoovers database, is then multiplied by the percentage of restaurants by type with commercial cooking equipment in order to calculate the number of restaurants with the specific cooking devices in each county; these percentages are shown in Table 19-3. The data on cooking devices and meat cooked are from a survey on charbroiling activity in the state of California [ref 2].

Table 19-3: Percent of restaurants with each type of cooking device

Restaurant Type	Conveyorized Char-broilers	Underfired Char-broilers	Deep-Fat Fryers	Flat Griddles	Clamshell Griddles
Ethnic	3.5	47.5	81.9	62.7	4.0
Fast Food	18.6	30.8	96.8	51.9	14.7
Family	10.1	60.9	91.4	82.9	1.4
Seafood	0.0	52.6	100.0	36.8	10.5
Steak & BBQ	6.9	55.2	82.8	89.7	0.0

Source: Reference 2, Table 4

$$R_{t,c,d} = R_{t,c} \times Frac_{t,d} \quad (1)$$

Where:

$R_{t,c,e}$ = Number of type *t* restaurants in county *c* with cooking device *d*
$R_{t,c}$ = Number of type *t* restaurants in county *c*
$Frac_{t,e}$ = Fraction of type *t* restaurants with cooking device *d*

The number of restaurants in each county with cooking devices are then multiplied by the average number of cooking devices by restaurant type shown Table 19-4, from the same California Survey dataset, to calculate the total number of cooking devices.

Table 19-4: Average number of devices by restaurant type*

Restaurant Type	Conveyorized Char-broilers	Underfired Char-broilers	Deep-Fat Fryers	Flat Griddles	Clamshell Griddles
Ethnic	1.62	1.54	1.63	1.88	1.80
Fast Food	1.07	1.58	3.10	1.43	2.09
Family	1.71	1.29	2.34	2.03	-
Seafood	-	1.10	2.47	1.11	1.50
Steak & BBQ	-	1.63	2.42	1.35	-

*Only includes restaurants with at least one piece of the equipment. Source: Reference 2, Table 5.

$$D_{t,c,d} = R_{t,c,d} \times E_{t,d} \quad (2)$$

Where:

$D_{t,c,d}$ = Total number of cooking device *d* in county *c* from type *t* restaurants
$R_{t,c,d}$ = Number of type *t* restaurants in county *c* with cooking device *d*
$E_{t,d}$ = Average number of cooking device *d* at type *t* restaurants

The number of cooking devices in each restaurant type from equation 2 are summed across restaurant types to estimate the total number of cooking devices in each county.

$$D_{c,d} = \sum_t D_{t,c,d} \quad (3)$$

Where:

$D_{c,d}$ = Total number of cooking devices *d* from all restaurants in county *c*
$D_{t,c,d}$ = Total number of cooking device *d* in restaurant type *t* in county *c*

The total number of cooking devices in each county is used to determine the amount of meat cooked in that county. The average amount of meat cooked on each cooking device is listed in Table 19-5.

Table 19-5: Average amount of meat cooked per year on each cooking device (tons)

Meat Type	Conveyorized Char-broilers	Underfired Char-broilers	Deep-Fat Fryers	Flat Griddles	Clamshell Griddles
Steak	6.1	4.7	4.7	4.3	2.4
Hamburger	20.7	7.0	7.1	9.4	34.2
Poultry	10.7	8.4	14.9	5.2	5.7
Pork	1.5	3.8	1.5	2.9	3.1
Seafood	3.1	3.7	4.1	2.4	16.4
Other	-	1.1	7.1	1.5	-

Source: Reference 2, Table 13

$$M_{i,d,c} = D_{c,d} \times m_{i,d} \quad (4)$$

Where:

$M_{i,d,c}$ = Total amount of meat type *i* cooked on device *d* in county *c*, in tons
$D_{c,d}$ = Total number of cooking device *d* from all restaurants in county *c*
$m_{i,d}$ = Average amount of meat type *i* cooked on device *d*, in tons

The amount of french fries cooked in each county is calculated based on the amount of frozen potatoes used in the foodservice industry. The total amount of french fries cooked is reported at the national level. The process used to distribute the national amount of french fries cooked to the county-level is discussed in the next section.

19.2.1.2 *Allocation procedure*

In order to allocate the amount of frozen potatoes used in limited and full-service restaurants to the county-level, fractions of the number of limited and full-service restaurants in each county are used. To create these fractions, it is assumed that limited service restaurants are D&B classified fast food restaurants and full services restaurants are represented by all other D&B restaurant codes. County-level fast food and other restaurants are summed, and then divided by the national number of fast food or other restaurants in order to develop the county-level fractions.

$$RFrac_{lim,c} = \frac{R_{lim,c}}{R_{lim,US}} \quad (5)$$

$$RFrac_{full,c} = \frac{R_{full,c}}{R_{full,US}} \quad (6)$$

Where:

$RFrac_{lim,c}$	=	Fraction of limited service restaurants in county *c*
$RFrac_{full,c}$	=	Fraction of full service restaurants in county *c*
$R_{lim,c}$	=	The number of limited service restaurants in county *c*
$R_{full,c}$	=	The number of full service restaurants in county *c*
$R_{lim,US}$	=	The number of limited service restaurants in the U.S.
$R_{full,US}$	=	The number of full service restaurants in the U.S.

The fraction of limited and full-service restaurants in each county is then used to distribute the amount of frozen potatoes cooked.

$$F_{lim,c} = RFrac_{lim,c} \times f_{lim,US} \div 2000\ lbs\ per\ ton \quad (7)$$

$$F_{full,c} = RFrac_{full,c} \times f_{full,US} \div 2000\ lbs\ per\ ton \quad (8)$$

Where:

$F_{lim,c}$	=	Amount of french fries cooked in limited service restaurants in county *c,* in tons
$F_{full,c}$	=	Amount of french fries cooked in full service restaurants in county *c,* in ton
$RFrac_{lim,c}$	=	Fraction of limited service restaurants in county *c*
$RFrac_{full,c}$	=	Fraction of full service restaurants in county *c*
$f_{lim,US}$	=	Amount of french fries cooked in limited service restaurants in the U.S., in lbs.
$f_{full,US}$	=	Amount of french fries cooked in full service restaurants in the U.S., in lbs.

The amount of french fries cooked in limited and full-service restaurants are then summed to the county level.

$$F_{all,c} = F_{lim,c} + F_{full,c} \quad (9)$$

Where:

$F_{all,c}$	=	Amount of french fries cooked in county *c*, in tons
$F_{lim,c}$	=	Amount of french fries cooked in limited service restaurants in county *c,* in tons
$F_{full,c}$	=	Amount of french fries cooked in full service restaurants in county *c,* in tons

19.2.1.3 *Emission factors*

Emission factors for these sources are provided in the "Wagon Wheel Emission Factor Compendium" on the 2020 NEI Supporting Data and Summaries site. CAP emissions factors are taken from the article *Emissions from Charbroiling and Grilling of Chicken and Beef* [ref 4], and a South Coast Air Quality Management District Report (SCAQMD) [ref 5]. According to the most recent PM Augmentation tool, Primary PM is equal to Filterable PM and there are assumed to be no condensible PM emissions from commercial cooking.

19.2.1.4 *Controls*

There are no controls assumed for this category.

19.2.1.5 *Emissions*

To calculate emissions of CAPs, the total amount of meat and potatoes cooked on each cooking device in each county is multiplied by the appropriate emissions factor (provided in the "Wagon Wheel Emission Factor Compendium" on the 2020 NEI Supporting Data and Summaries site). The amount of french fries cooked is converted from pounds to tons, and all emissions are converted to tons. Emissions of HAPs are also calculated via HAP augmentation.

$$E_{p,i,d,c} = M_{i,d,c} \times EF_{p,i,d} \div 2000\ lbs\ per\ ton \quad (10)$$

$$E_{p,f,d,c} = F_{all,c} \times EF_{p,f,d} \div 2000\ lbs\ per\ ton \quad (11)$$

Where:

$E_{p,i,d,c}$ = Annual emissions of pollutant *p* from cooking meat type *i* on device *d* in county *c*, in tons
$E_{p,f,d,c}$ = Annual emissions of pollutant *p* from cooking french fries, *f*, on device *d* in county *c*, in tons
$M_{i,d,c}$ = Total amount of meat type *i* cooked on device *d* in county *c*, in tons
$F_{all,c}$ = Total amount of french fries cooked in county *c*, in tons
$EF_{p,i,d}$ = Emissions factor for pollutant *p,* in lbs. of pollutant per ton of meat type *i* cooked on device *d*
$EF_{p,f,d}$ = Emissions factor for pollutant *p,* in lbs. of pollutant per ton of french fries cooked on device *d*

$$E_{p,i,d,c} = M_{i,d,c} \times EF_{p,i,d} \quad (12)$$

Where:

$E_{p,i,d,c}$ = Annual emissions of pollutant *p* from cooking meat type *i* on device *d* in county *c*, in pounds
$M_{i,d,c}$ = Total amount of meat type *i* cooked on device *d* in county *c*, in tons
$EF_{p,i,d}$ = Emissions factor for pollutant *p,* in lbs. of pollutant per ton of meat type *i* cooked on

device *d*

The emissions are summed for all types of meat and french fries to estimate the total emissions from each cooking device type in each county.

$$E_{p,d,c} = \sum_i E_{p,i,d,c} + E_{p,f,d,c} \quad (13)$$

Where:

$E_{p,d,c}$ = Total annual emissions of pollutant *p* from cooking device *d* in county *c*
$E_{p,i,d,c}$ = Annual emissions of pollutant *p* from cooking meat type *i* on device *d* in county *c*
$E_{p,f,d,c}$ = Annual emissions of pollutant *p* from cooking french fries, *f*, on device *d* in county *c*

19.2.1.6 *Example calculations*

Table 19-6 lists sample calculations to determine the VOC emissions from commercial cooking on flat griddles. The first two equations use fast food restaurants as an example, and equations 4 and 10 use hamburgers as an example. However, these calculations would need to be repeated to calculate values for all restaurant and meat types. The values in these equations are demonstrating program logic and are not representative of any specific NEI year or county.

Table 19-6: Sample VOC emissions calculations from commercial cooking on flat griddles

Eq. #	Equation	Values	Result
1	$R_{t,c,d} = R_{t,c} \times Frac_{t,d}$	$6\ fast\ food\ rest.$ $\times\ 51.9\%\ with\ flat\ griddles$	3.114 fast food restaurants with flat griddles
2	$D_{t,c,d} = R_{t,c,d} \times E_{t,d}$	$3.114\ fast\ food\ rest.with\ flat\ griddles$ $\times\ 1.43\ flat\ griddles\ per\ rest.$	4.45 flat griddles in fast food restaurants
3	$D_{c,d} = \sum_t D_{t,c,d}$	$\sum Flat\ griddles$	9.5 flat griddles in all restaurants
4	$M_{i,d,c} = D_{c,d} \times m_{i,d}$	$9.5\ flat\ griddles$ $\times\ 9.4\ tons\ of\ hamburger\ cooked\ on\ flat\ griddles$	89.3 tons of hamburger cooked on flat griddles
5	$RFrac_{lim,c} = \frac{R_{lim,c}}{R_{lim,US}}$	N/A	Equation is for deep-fat fryers; example is for flat griddles
6	$RFrac_{full,c} = \frac{R_{full,c}}{R_{full,US}}$	N/A	Equation is for deep-fat fryers; example is for flat griddles
7	$F_{lim,c}$ $= RFrac_{lim,c} \times f_{lim,US}$ $\div\ 2000\ lbs\ per\ ton$	N/A	Equation is for deep-fat fryers; example is for flat griddles

Eq. #	Equation	Values	Result
8	$F_{full,c} = RFrac_{full,c} \times f_{full,US} \div 2000\ lbs\ per\ ton$	N/A	Equation is for deep-fat fryers; example is for flat griddles
9	$F_{all,c} = F_{lim,c} + F_{full,c}$	N/A	Equation is for deep-fat fryers; example is for flat griddles
10	$E_{p,i,d,c} = M_{i,d,c} \times EF_{p,i,d} \div 2000\ lbs\ per\ ton$	$89.3\ tons\ of\ hamburger\ cooked \times 0.14\ lbs.VOC\ per\ ton\ hamburger \div 2000\ lbs.per\ ton$	0.00625 tons VOC emissions from cooking hamburgers on flat griddles
11	$E_{p,f,d,c} = F_{all,c} \times EF_{p,f,d} \div 2000\ lbs\ per\ ton$	N/A	Equation is for deep-fat fryers; example is for flat griddles
12	$E_{p,i,d,c} = M_{i,d,c} \times EF_{p,i,d}$	NA	Equation is for HAPs; example is for VOC
13	$E_{p,d,c} = \sum_i E_{p,i,d,c} + E_{p,f,d,c}$	$\sum VOC\ emissions$	0.04 tons VOC emissions from flat griddles

19.2.2 Improvements/Changes in the 2020 NEI

There are no major changes to the methodology used to calculate commercial cooking emissions for the 2020 NEI aside from updates to activity data. However, significant changes in restaurant counts between 2017 and 2020 led to significant increases in commercial cooking emission for the 2020 NEI. The Hoovers database reported approximately 77% more restaurants nationally between 2017 and 2020. An analysis comparing County Business Patterns reported by the US Census and the Hoovers database shows that 2017 restaurant counts were underestimated by Hoovers.

19.3 References

1. Dun and Bradford Hoovers database, 2020.
2. Public Research Institute, 2001. Charbroiling Activity Estimation. Prepared for the California Air Resources Board and California EPA.
3. Technomic, 2020. Domestic Sales and U.S. Potato Utilization Report. Prepared for Potatoes USA.
4. McDonald, J., B. Zielinska, E. Fujita, J. Sagebiel, J. Chow, and J. Watson, 2003. "Emissions from Charbroiling and Grilling of Chicken and Beef." *Journal of Air & Waste Management Association*. 53:185-194.
5. Norbeck, Joseph, 1997. *Further Development of Emission Test Methods and Development of Emission Factors for Various Commercial Cooking Operations.* Prepared for the South Coast Air Quality Management District.

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