## Commercial Cooking

### Sector Description

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.

### Sources of data overview and selection hierarchy

### Spatial coverage and data sources for the sector

### EPA-developed commercial cooking emissions data

The approach to estimating emissions from commercial cooking in 2011 consists of three general steps, as follows:

* Determine county-level activity, i.e., the number of restaurants in each county in 2011 (see Section 1.1.4.1);
* Determine the fraction of restaurants with commercial cooking equipment, the average number of units of each type of equipment per restaurant, and the average amount of food cooked on each type of equipment (see Section 1.1.4.1); and
* Applying emission factors to each type of food for each type of commercial cooking equipment (see Section 1.1.4.2).

For this source category, EPA estimated emissions for the SCCs listed in Table 1.

Table 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 Fying |
| 2302003100 | Commercial Cooking – Frying | Flat Griddle Frying |
| 2302003200 | Commercial Cooking – Frying | Clamshell Griddle Frying |

#### Activity Data

Data on the number of restaurants in each county are available from the U.S. Census Bureau County Business Patterns database, which reports the number of full-service restaurants (NAICS 722110) and limited-service restaurants (722211) in each county. The 2002 NEI, which is the most recent inventory in which the emissions from commercial cooking were estimated using restaurant-level data, rather than population data, used the Dun and Bradstreet industry database, which contains more specific information on the type of restaurant in each county. The documentation from the 2002 NEI identifies five specific categories of restaurants that are likely to have the equipment that matches the source categories for commercial cooking emissions, including: Ethnic food restaurants, Fast food restaurants, Family restaurants, Seafood restaurants, and Steak & Barbecue restaurants (EPA, 2002). Because Dun and Bradstreet data for 2011 were not readily available, the number of restaurants in each county was estimated using a two-step process. First the number of restaurants in 2002 was estimated using the following equation:

|  |  |  |
| --- | --- | --- |
|  |  | (1) |

where:

*RESTi,2002* = the total number of restaurants in county *i* in 2002

*Eijm­,2002 =* the emissions of pollutant *m* from source category *j* in county *i* in 2002, as calculated for the 2002 National Emissions Inventory

*FRACj =* the fraction of restaurants in those categories that have equipment in source ­*j*

*UNITSj* = the average number of units of source category *j* in each restaurant

*AVG\_EMISSIONSjm =* the average emissions of pollutant *m* from food cooked on source category *j*, based on summing the average amount of food cooked on source category *j* multiplied by the emission factor for pollutant *m* from source category *j*

The values of *FRACi,* and *UNITSi,* as well as the average amount of food cooked on each type of source category equipment used to calculate *AVG\_EMISSIONSjm*, came from Potepan (2001). The emission factors used to calculate *AVG\_EMISSIONSjm* are from the 2002 NEI documentation (EPA, 2002; see Section 1.1.4.2).

Next the change in the number of restaurants in each county between 2002 and 2011 was determined using data from the U.S. Census Bureau County Business Patterns database to create a growth factor. For example, if the number of restaurants in a particular county increased from 100 to 125 between 2002 and 2011, the growth factor would be 1.25; in some cases the number of restaurants decreased, and the growth factor was less than 1. This growth factor was multiplied by the number of restaurants in each county in 2002, as shown in equation 2, to estimate the number of restaurants in 2011:

|  |  |  |
| --- | --- | --- |
|  |  | (2) |

where *GFi*is the growth factor for county *i*.

#### Emission Factors

Emission factors for each pollutant for each type of commercial cooking equipment (*EFjmn*)came from the 2002 NEI documentation (EPA 2002). This information remains the most complete catalog of emission factors for commercial cooking; a recent review of the literature on emissions from cooking revealed no new studies with a similar breadth of pollutants analyzed (Abdullahi et al., 2013). The particulate matter (PM) emission factors from the 2002 documentation only contain primary PM. The emission factors for filterable PM were derived by applying ratios to primary PM (Table 2). The condensable particulate matter (PM-CON) emission factors were derived by subtracting PM10-FIL from PM10-PRI.

Table 2. Ratio of filterable particulate matter to primary particulate matter for PM2.5 and PM10 by SCC.

|  |  |  |  |
| --- | --- | --- | --- |
| **Cooking Device** | **SCC** | **PM25-FIL / PM25-PRI** | **PM10-FIL / PM10-PRI** |
| Conveyorized Charbroiling | 2302002100 | 0.00321 | 0.00331 |
| Underfired Charbroiling | 2302002200 | 0.00287 | 0.00297 |
| Flat Griddle Frying | 2302003100 | 0.00201 | 0.00264 |
| Clamshell Griddle Frying | 2302003200 | 0.00241 | 0.00283 |

#### Emissions

After determining the number of establishments in 2011 using Equation 2, the amount of emissions in 2011 was determined by rearranging Equation 1:

|  |  |  |
| --- | --- | --- |
|  |  | (3) |

where *Eijm,*2011 is the emissions of pollutant *m* from commercial equipment *j* in county *i* in 2011.

The fraction of restaurants with commercial cooking equipment (*FRACj*) and the average units of equipment per restaurant (*UNITSj*) were obtained from Potepan (2001). Because Potepan reports the fraction of restaurants with commercial cooking equipment broken down by subcategories of restaurant types (Ethnic food restaurants, Fast food restaurants, Family restaurants, Seafood restaurants, and Steak & Barbecue restaurants), a weighted average of these fractions was calculated to determine an overall fraction of the number of all restaurants across all five subcategories that utilize commercial cooking equipment. Furthermore, because Potepan reports that 31% of all restaurants fall into one of those five subcategories, the weighted averages were multiplied by 0.31 to determine the fraction of all restaurants in each county with commercial cooking equipment. These numbers are reported in Table 3. The percentage of restaurants with under-fired charbroilers (12.5%) is similar to a more recent survey in North Carolina, which found that 13% of surveyed restaurants employed charbroilers (NC Division of Air Quality 2013). The North Carolina survey did not include the other types of commercial cooking equipment reported here.

Table 3. Fraction of restaurants with source category equipment and average number of units per restaurant.

|  |  |  |  |
| --- | --- | --- | --- |
| **Source Category** | **SCC** | **Percent of Restaurants with Equipment (*FRACj*)** | **Average Number of Units Per Restaurant (*UNITSj*)** |
| Conveyorized Charbroiling | 2302002100 | 3.6% | 1.3 |
| Under-fired Charbroiling | 2302002200 | 12.5% | 1.5 |
| Deep Fat Frying | 2302003000 | 28.0% | 2.5 |
| Flat Griddle Frying | 2302003100 | 18.4% | 1.6 |
| Clamshell Griddle Frying | 2302003200 | 2.8% | 1.7 |

The number of restaurants in 2011 estimated using Equation 2 was then used in Equation 3 to determine the amount of emissions in 2011 (Table 4).

Table 4. National Emissions Summary

| **SCC** | **Cooking Device** | **Pollutant Description** | **Pollutant Code** | **Emission Factor (lb/ton)** | **Annual Activity (ton)a** | **National Emissions (tons)** |
| --- | --- | --- | --- | --- | --- | --- |
| 2302002100 | Conveyorized Charbroiling | 4-NITROPHENOL | 100027 | 0.003826 | 1,186,515 | 2.27 |
| 2302002100 | Conveyorized Charbroiling | ACENAPHTHENE | 83329 | 0.000415 | 1,314,996 | 0.27 |
| 2302002100 | Conveyorized Charbroiling | ACENAPHTHYLENE | 208968 | 0.007423 | 1,138,964 | 4.23 |
| 2302002100 | Conveyorized Charbroiling | ACETALDEHYDE | 75070 | 0.163475 | 1,167,190 | 95.40 |
| 2302002100 | Conveyorized Charbroiling | ACETOPHENONE | 98862 | 0.001409 | 1,213,196 | 0.85 |
| 2302002100 | Conveyorized Charbroiling | ANTHRACENE | 120127 | 0.001669 | 1,220,561 | 1.02 |
| 2302002100 | Conveyorized Charbroiling | BENZ[A]ANTHRACENE | 56553 | 0.000477 | 1,260,448 | 0.30 |
| 2302002100 | Conveyorized Charbroiling | BENZENE | 71432 | 0.292169 | 1,181,225 | 172.56 |
| 2302002100 | Conveyorized Charbroiling | BENZO[A]PYRENE | 50328 | 0.000275 | 1,711,082 | 0.24 |
| 2302002100 | Conveyorized Charbroiling | BENZO[G,H,I,]PERYLENE | 191242 | 0.000256 | 1,666,792 | 0.21 |
| 2302002100 | Conveyorized Charbroiling | BIPHENYL | 92524 | 0.003623 | 1,201,044 | 2.18 |
| 2302002100 | Conveyorized Charbroiling | Carbon Monoxide | CO | 13.364824 | 1,089,326 | 7,279.32 |
| 2302002100 | Conveyorized Charbroiling | DIBUTYL PHTHALATE | 84742 | 0.001113 | 1,269,288 | 0.71 |
| 2302002100 | Conveyorized Charbroiling | ETHYL BENZENE | 100414 | 0.023188 | 1,131,442 | 13.12 |
| 2302002100 | Conveyorized Charbroiling | ETHYLENE DICHLORIDE | 107062 | 0.008116 | 1,129,399 | 4.58 |
| 2302002100 | Conveyorized Charbroiling | FLUORANTHENE | 206440 | 0.001863 | 1,192,078 | 1.11 |
| 2302002100 | Conveyorized Charbroiling | FLUORENE | 86737 | 0.001806 | 1,215,340 | 1.10 |
| 2302002100 | Conveyorized Charbroiling | FORMALDEHYDE | 50000 | 0.227822 | 1,174,580 | 133.80 |
| 2302002100 | Conveyorized Charbroiling | INDENO[1,2,3-C,D]PYRENE | 193395 | 0.000162 | 2,505,188 | 0.20 |
| 2302002100 | Conveyorized Charbroiling | NAPHTHALENE | 91203 | 0.034368 | 1,129,988 | 19.42 |
| 2302002100 | Conveyorized Charbroiling | O-CRESOL | 95487 | 0.000974 | 1,219,919 | 0.59 |
| 2302002100 | Conveyorized Charbroiling | O-XYLENE | 95476 | 0.01913 | 1,103,135 | 10.55 |
| 2302002100 | Conveyorized Charbroiling | PAH, TOTAL | 130498292 | 0.081077 | 1,143,526 | 46.36 |
| 2302002100 | Conveyorized Charbroiling | P-CRESOL | 106445 | 0.001988 | 1,205,754 | 1.20 |
| 2302002100 | Conveyorized Charbroiling | PHENANTHRENE | 85018 | 0.008221 | 1,152,312 | 4.74 |
| 2302002100 | Conveyorized Charbroiling | PHENOL | 108952 | 0.013333 | 1,135,211 | 7.57 |
| 2302002100 | Conveyorized Charbroiling | PM10-PRI | PM10-PRI | 15.996058 | 1,172,362 | 9,376.58 |
| 2302002100 | Conveyorized Charbroiling | PM25-PRI | PM25-PRI | 15.506208 | 1,172,415 | 9,089.85 |
| 2302002100 | Conveyorized Charbroiling | PROPIONALDEHYDE | 123386 | 0.044057 | 1,138,496 | 25.08 |
| 2302002100 | Conveyorized Charbroiling | PYRENE | 129000 | 0.002508 | 1,208,724 | 1.52 |
| 2302002100 | Conveyorized Charbroiling | STYRENE | 100425 | 0.110143 | 1,160,333 | 63.90 |
| 2302002100 | Conveyorized Charbroiling | TOLUENE | 108883 | 0.11594 | 1,065,825 | 61.79 |
| 2302002100 | Conveyorized Charbroiling | Volatile Organic Compounds | VOC | 4.002084 | 1,034,572 | 2,070.22 |
| 2302002100 | Conveyorized Charbroiling | XYLENES | 1330207 | 0.016232 | 16,657 | 0.14 |
| 2302002200 | Under-fired Charbroiling | 4-NITROPHENOL | 100027 | 0.005624 | 3,898,031 | 10.96 |
| 2302002200 | Under-fired Charbroiling | ACENAPHTHENE | 83329 | 0.000219 | 4,311,998 | 0.47 |
| 2302002200 | Under-fired Charbroiling | ACENAPHTHYLENE | 208968 | 0.005542 | 3,946,813 | 10.94 |
| 2302002200 | Under-fired Charbroiling | ACETALDEHYDE | 75070 | 0.340875 | 4,283,828 | 730.12 |
| 2302002200 | Under-fired Charbroiling | ACETOPHENONE | 98862 | 0.002804 | 3,975,221 | 5.57 |
| 2302002200 | Under-fired Charbroiling | ANTHRACENE | 120127 | 0.001622 | 4,048,828 | 3.28 |
| 2302002200 | Under-fired Charbroiling | BENZ[A]ANTHRACENE | 56553 | 0.000441 | 4,217,480 | 0.93 |
| 2302002200 | Under-fired Charbroiling | BENZENE | 71432 | 0.586544 | 4,312,337 | 1,264.69 |
| 2302002200 | Under-fired Charbroiling | BENZO[A]PYRENE | 50328 | 0.000187 | 4,228,673 | 0.40 |
| 2302002200 | Under-fired Charbroiling | BENZO[G,H,I,]PERYLENE | 191242 | 0.000196 | 4,389,774 | 0.43 |
| 2302002200 | Under-fired Charbroiling | BIPHENYL | 92524 | 0.002233 | 4,013,540 | 4.48 |
| 2302002200 | Under-fired Charbroiling | Carbon Monoxide | CO | 12.81754 | 3,626,640 | 23,242.30 |
| 2302002200 | Under-fired Charbroiling | DIBUTYL PHTHALATE | 84742 | 0.002049 | 4,038,808 | 4.14 |
| 2302002200 | Under-fired Charbroiling | ETHYL BENZENE | 100414 | 0.044503 | 4,106,897 | 91.38 |
| 2302002200 | Under-fired Charbroiling | ETHYLENE DICHLORIDE | 107062 | 0.018742 | 4,002,626 | 37.51 |
| 2302002200 | Under-fired Charbroiling | FLUORANTHENE | 206440 | 0.002287 | 3,964,213 | 4.53 |
| 2302002200 | Under-fired Charbroiling | FLUORENE | 86737 | 0.001698 | 4,043,879 | 3.43 |
| 2302002200 | Under-fired Charbroiling | FORMALDEHYDE | 50000 | 0.46992 | 4,303,258 | 1,011.09 |
| 2302002200 | Under-fired Charbroiling | INDENO[1,2,3-C,D]PYRENE | 193395 | 0.000115 | 5,083,385 | 0.29 |
| 2302002200 | Under-fired Charbroiling | NAPHTHALENE | 91203 | 0.022748 | 4,002,990 | 45.53 |
| 2302002200 | Under-fired Charbroiling | Nitrogen Oxides | NOX | 0 | 0 | 0 |
| 2302002200 | Under-fired Charbroiling | O-CRESOL | 95487 | 0.001799 | 4,022,665 | 3.62 |
| 2302002200 | Under-fired Charbroiling | O-XYLENE | 95476 | 0.037336 | 4,045,133 | 75.51 |
| 2302002200 | Under-fired Charbroiling | PAH, TOTAL | 130498292 | 0.066015 | 4,126,651 | 136.21 |
| 2302002200 | Under-fired Charbroiling | P-CRESOL | 106445 | 0.003632 | 3,983,808 | 7.23 |
| 2302002200 | Under-fired Charbroiling | PHENANTHRENE | 85018 | 0.00746 | 3,979,410 | 14.84 |
| 2302002200 | Under-fired Charbroiling | PHENOL | 108952 | 0.02601 | 4,046,610 | 52.63 |
| 2302002200 | Under-fired Charbroiling | PM10-PRI | PM10-PRI | 32.666124 | 4,261,149 | 69,597.61 |
| 2302002200 | Under-fired Charbroiling | PM25-PRI | PM25-PRI | 31.577929 | 4,266,629 | 67,365.65 |
| 2302002200 | Under-fired Charbroiling | PROPIONALDEHYDE | 123386 | 0.092009 | 4,168,855 | 191.79 |
| 2302002200 | Under-fired Charbroiling | PYRENE | 129000 | 0.003087 | 3,987,378 | 6.15 |
| 2302002200 | Under-fired Charbroiling | STYRENE | 100425 | 0.222409 | 4,253,927 | 473.06 |
| 2302002200 | Under-fired Charbroiling | Sulfur Dioxide | SO2 | 0 | 0 | 0.00 |
| 2302002200 | Under-fired Charbroiling | TOLUENE | 108883 | 0.232132 | 3,713,794 | 431.05 |
| 2302002200 | Under-fired Charbroiling | Volatile Organic Compounds | VOC | 3.918318 | 3,647,168 | 7,145.38 |
| 2302002200 | Under-fired Charbroiling | XYLENES | 1330207 | 0.033076 | 14,729 | 0.24 |
| 2302003000 | Deep Fat Frying | Carbon Monoxide | CO | 0 | 0 | 0 |
| 2302003000 | Deep Fat Frying | PM10-PRI | PM10-PRI | 0 | 0 | 0 |
| 2302003000 | Deep Fat Frying | PM25-PRI | PM25-PRI | 0 | 0 | 0 |
| 2302003000 | Deep Fat Frying | Volatile Organic Compounds | VOC | 0.129029 | 33,174,687 | 2,140.25 |
| 2302003100 | Flat Griddle Frying | ACENAPHTHENE | 83329 | 0.000055 | 8,279,238 | 0.23 |
| 2302003100 | Flat Griddle Frying | ACENAPHTHYLENE | 208968 | 0.000271 | 6,182,290 | 0.84 |
| 2302003100 | Flat Griddle Frying | ANTHRACENE | 120127 | 0.000478 | 6,090,935 | 1.46 |
| 2302003100 | Flat Griddle Frying | BENZ[A]ANTHRACENE | 56553 | 0.000158 | 6,261,442 | 0.49 |
| 2302003100 | Flat Griddle Frying | BENZO[A]PYRENE | 50328 | 0.00003 | 12,337,940 | 0.19 |
| 2302003100 | Flat Griddle Frying | BIPHENYL | 92524 | 0.000153 | 6,203,735 | 0.47 |
| 2302003100 | Flat Griddle Frying | Carbon Monoxide | CO | 0.733239 | 5,937,814 | 2,176.92 |
| 2302003100 | Flat Griddle Frying | FLUORANTHENE | 206440 | 0.001409 | 5,765,254 | 4.06 |
| 2302003100 | Flat Griddle Frying | FLUORENE | 86737 | 0.000362 | 6,147,778 | 1.11 |
| 2302003100 | Flat Griddle Frying | NAPHTHALENE | 91203 | 0.007855 | 5,714,108 | 22.44 |
| 2302003100 | Flat Griddle Frying | PAH, TOTAL | 130498292 | 0.015412 | 5,766,864 | 44.44 |
| 2302003100 | Flat Griddle Frying | PHENANTHRENE | 85018 | 0.003628 | 5,694,533 | 10.33 |
| 2302003100 | Flat Griddle Frying | PM10-PRI | PM10-PRI | 5.922517 | 6,023,278 | 17,836.48 |
| 2302003100 | Flat Griddle Frying | PM25-PRI | PM25-PRI | 4.501113 | 6,021,778 | 13,552.35 |
| 2302003100 | Flat Griddle Frying | PYRENE | 129000 | 0.001878 | 5,728,770 | 5.38 |
| 2302003100 | Flat Griddle Frying | Volatile Organic Compounds | VOC | 0.35508 | 5,751,517 | 1,021.12 |
| 2302003200 | Clamshell Griddle Frying | Carbon Monoxide | CO | 0 | 0 | 0 |
| 2302003200 | Clamshell Griddle Frying | PM10-PRI | PM10-PRI | 1.006137 | 2,386,729 | 1,200.69 |
| 2302003200 | Clamshell Griddle Frying | PM25-PRI | PM25-PRI | 0.852257 | 2,381,432 | 1,014.80 |
| 2302003200 | Clamshell Griddle Frying | Volatile Organic Compounds | VOC | 0.036472 | 2,179,244 | 39.74 |

a The annual activity differs across pollutants because the calculation takes into account the fact that different types of meat are cooked on each SCC, some of which do not emit each type of pollutant.

#### Sample Calculations

Determining the Number of Restaurants in Autauga County, AL in 2002

|  |  |  |
| --- | --- | --- |
|  |  |  |

Emissions of PM2.5 from underfired charbroilers in county Autauga County, ALin 2002 were 8.76 tons. To determine the number of restaurants that generated these emissions in 2002, the emissions are divided by the fraction of restaurants that use underfired charbroilers (0.125), the average number of underfired charbroilers used at each restaurant (1.54), and the average emissions from each establishment from underfired charbroilers (0.454 tons PM2.5). The result shows that there were approximately 100 restaurants in Autauga County, ALin 2002. This process is repeated for each SCC (Table 1) across all counties.

Determining the Number of Restaurants in Each County in 2011

Using the estimated number of restaurants in 2002, the number of restaurants in 2011 was determined by employing a growth factor based on the change in the number of restaurants between 2002 and 2011 as determined by the U.S. Census Bureau County Business Statistics Database.

|  |  |  |
| --- | --- | --- |
|  |  |  |

There were 100 restaurants estimated to be in Autauga County, AL in 2002. Data from the U.S. Census Bureau show that there was a 38% increase in the number of restaurants in Autauga between 2002 and 2011. The growth factor (1.38) was multiplied by 100 to estimate that there were 138 restaurants in Autauga in 2011. Note that the actual number of restaurants in 2011 as determined from the U.S. Census Bureau County Business Statistics database is not equal to *RESTi,*2011as determined by the equation above because the emissions from the 2002 NEI were calculated using activity data from the Dun and Bradstreet database, rather than the U.S. Census Bureau County Business Statistics database.

Determining the Emissions in 2011

The emissions in 2011 were determined using the following equation:

|  |  |  |
| --- | --- | --- |
|  |  |  |

There were 138 restaurants in Autauga County, AL in 2011. This was multiplied by the fraction of restaurants that use underfired charbroilers (0.125), the average number of underfired charbroilers used at each restaurant (1.54),and the average emissions from each establishment from underfired charbroilers (0.454 tons PM2.5). The result shows that the emissions of PM2.5 in Autauga County, AL were 12.06 tons in 2011.

### Summary of quality assurance methods

### References

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