CREATION OF UNIT PROCESS DATA FOR LIFE CYCLE ASSESSMENT OF STEAM METHANE REFORMING AND PETROLEUM REFINING

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TABLE OF CONTENTS

1. BACKGROUND 5

2. STANDARDIZED DEFINITIONS 5

3. DATASETS 8

3.1. CRITERIA AIR POLLUTANT EMISSIONS 9

3.2. GREENHOUSE GAS EMISSIONS 10

3.3. SUBPROCESS ACTIVITY LEVELS 11

3.4. FUEL CONSUMPTION 15

3.5. PRODUCT OUTPUTS 16

4. EMISSION FACTORS FOR REFINERY PRODUCTS 23

4.1. ASSIGNING EMISSIONS TO REFINERY SUBPROCESS UNITS 23

4.2. ASSIGNING HEAT RELATED EMISSIONS TO REFINERY SUBPROCESS UNITS FROM UNIT THROUGHPUT 25

4.3. ALLOCATING REFINERY SUBPROCESS UNIT EMISSIONS TO FINAL PRODUCTS 30

4.4. EMISSION FACTORS BY REFINERY PRODUCT 33

4.5. VALIDATING FINAL PRODUCT EMISSION FACTORS 37

5. COMBUSTION-RELATED EMISSION FACTORS BY FUEL TYPE AT REFINERIES 47

5.1. CLASSIFYING COMBUSTION EMISSIONS BY FUEL TYPE 47

5.2. EMISSION FACTORS BY FUEL TYPE 51

5.3. VALIDATING COMBUSTION EMISSION FACTORS 54

6. EMISSION FACTORS FOR HYDROGEN PRODUCTION AT SMR FACILITIES 60

7. REFERENCES 62

APPENDIX A. SUPPORTING INFORMATION 65

ALLOCATION FACTOR VERIFICATION SUPPORTING INFORMATION 95

FIGURES

Figure 2-1. Process diagram of general petroleum refinery showing process options. 6

Figure 4-1. Simplified example of calculating final product allocation factors via PRELIM subprocess output. 31

Figure 4-2. Comparison of PRELIM and EIA estimates of vacuum distillation utilization per bbl of crude input, $[Throughput_{PRELIM} – Throughput_{EIA}]/Throughput_{EIA}$. 38

Figure 4-3. Comparison of PRELIM and EIA estimates of fluid catalytic cracker utilization per bbl of crude input, $[Throughput_{PRELIM} – Throughput_{EIA}]/Throughput_{EIA}$. 39

Figure 4-4. Comparison of PRELIM and EIA estimates of coking utilization per bbl of crude input, $[Throughput_{PRELIM} – Throughput_{EIA}]/Throughput_{EIA}$. 39

Figure 4-5. Comparison of PRELIM and EIA estimates of gas oil catalytic hydrocracking utilization per bbl of crude input, $[Throughput_{PRELIM} – Throughput_{EIA}]/Throughput_{EIA}$. 40

Figure 4-6. Comparison of PRELIM and EIA estimates of total hydrotreating utilization per bbl of crude input, $[Throughput_{PRELIM} – Throughput_{EIA}]/Throughput_{EIA}$. 40

Figure 4-7. Comparison of PRELIM and EIA estimates of catalytic reformer utilization per bbl of crude input, $[Throughput_{PRELIM} – Throughput_{EIA}]/Throughput_{EIA}$. 41

Figure 4-8. Comparison of PRELIM and EIA estimates of isomerization utilization per bbl of crude input, $[Throughput_{PRELIM} – Throughput_{EIA}]/Throughput_{EIA}$. 41

Figure 4-9. Comparison of PRELIM and EIA estimates of alkylation utilization per bbl of crude input, $[Throughput_{PRELIM} – Throughput_{EIA}]/Throughput_{EIA}$. 42

Figure 4-10. Histogram representing the percent difference in EIA reported and PRELIM estimated production of 14 products for each PADD. 44

Figure 4-11. Comparison of refinery final product emission factors. Emissions factors for each pollutant are normalized to the maximum emissions factor for that pollutant. 45

Figure 5-1. Contributions of fuel type to combustion emissions at each PADD. 49

Figure 5-2. Comparing EIA fuel consumption at refineries to estimated fuel consumption calculated from GHGRP reported CO2 emissions. 51

Figure 5-3. Comparison of combustion emission factors. 56

Figure 5-4. Distribution of Fluid Catalytic Cracker CO2 emissions compared to unit throughput. 58

Figure 5-5. Comparing catalyst coke consumption with Fluid Catalytic Cracker unit throughput at each PADD 59

Figure 5-6. Distribution of CO2 emission factors at the Fluid Catalytic Cracker by PADD 59

Figure 6-1. Comparison of emission factors for hydrogen production in 2014. 61

Figure 7-1. Comparison of combustion emission factors.. 94

Figure 7-2. Comparison of emission factors for hydrogen production in 2011. 97

TABLES

Table 2-1. Refinery subprocess presence within datasets. 7

Table 2-2. Overview of flows used to develop life cycle inventory. 8

Table 2-3. Overview of final products for life cycle inventory of refineries. 8

Table 3-1. Data sources for use in creating emission LCIs based on reported releases and emission/activity factors. .8

Table 3-2. Correspondence between NEI source categorization and process diagram unit ID numbers. 10

Table 3-3. Fuel type categories for sources of combustion emissions under GHGRP Subpart C. 11

Table 3-4. Correspondence between GHGRP source categorization and process diagram unit ID numbers. 11

Table 3-5. EIA unit capacity designations. Correspondence to refinery subprocess unit in parenthesis. 12

Table 3-6. PADD level refinery unit throughput (in millions), 2014. 14

Table 3-7. Fuel consumption at refineries, 2014. 15

Table 3-8. Adjusted fuel consumption at refineries for NEI Emissions dataset by PADD, 2014. 15

Table 3-9. Correspondence between refinery products across EIA and PRELIM. 16

Table 3-10. Final product output at refineries by PADD (in thousands), 2014. 18

Table 3-11. Comparison of allocation options for final product output at refineries, 2014. 18

Table 3-12. Comparison of product output at refineries between CDR and EIA datasets in metric tonnes, 2011. 19

Table 3-13. Hydrogen production, metric tonnes, at SMR facilities estimated from three datasets. 21

Table 4-1. National refinery subprocess emission factors (in g / m3 throughput) prior to allocation of facility wide emissions. 24

Table 4-2. Refinery unit energy intensity estimates per barrel of utilized charge capacity 26

Table 4-3. Allocation factors for heaters and boilers by refinery subprocess unit, aggregated nationally. 26

Table 4-4. Allocation method for facility wide emissions sources. 27

Table 4-5. National refinery subprocess emissions, in metric tonnes, following allocation of facility wide emissions. 28

Table 4-6. PADD level energy use by refinery unit, in million mmBTUs. 29

Table 4-7. Comparison of total energy consumption by PADD (million mmBTUs). 30

Table 4-8. Share of total capacity by PRELIM refinery configuration. 31

Table 4-9. Allocation factors from PRELIM refinery units to PRELIM final products, aggregated nationally. 32

Table 4-10. Values for PADD 2 Jet-A/AVTUR splitting factor calculation example 33

Table 4-11. Refinery subprocess allocation factors to refinery final products, aggregated nationally. 34

Table 4-12. Refinery final product emission factors (in g / mmBTU of final product). 35

Table 4-13. EIA total production compared to PRELIM total production estimates, in metric tonnes. 43

Table 5-1. Count of facilities reporting combustion emissions by fuel type. 48

Table 5-2. Results for catalyst coke combustion emission factors. 52

Table 5-3. Results for distillate combustion emission factors. 52

Table 5-4. Results of combined emissions factors for natural gas and refinery gas representing average refinery fuel mix. 53

Table 5-5. Results for residual fuel oil combustion emission factors. 53

Table 5-6. Comparison of combustion emission factors by fuel. 55

Table 6-1. National SMR emission factors in 2014, g/mmBTU 60

Table 7-1. Complete list of refineries and presence within each dataset in 2014. 65

Table 7-2. Complete list of SMR facilities and presence within each dataset. 69

Table 7-3. SubPADD petroleum refinery capacity utilization in 2014. 70

Table 7-4. Lower Heating Values of common fuel types at refineries. 71

Table 7-5. Energy content, density, and value of common refinery products. 71

Table 7-6. Classification of Source Classification Codes (SCC) by combustion source and fuel type. 72

Table 7-7. Results for natural gas combustion emission factors. 92

Table 7-8. Results for refinery gas combustion emission factors. 92

Table 7-9. Results for coal combustion emission factors. 93

Table 7-10. Results for LPG combustion emission factors. 93

Table 7-11. EIA vs PRELIM estimated production comparison 95

Table 7-12. National SMR emission factors in 2011, g/mmBTU 97

1. Background

This study provides detailed, baseline gate-to-gate unit process data for petroleum refining and hydrogen production. The datasets improve the resolution of the environmental releases attributable to specific processes involved in petroleum refining and steam methane reforming (SMR) and the attribution of releases to the products of refineries. These datasets are intended for use in life cycle assessment studies and will be implemented in the GREET software tool. These data are important for understanding the impacts of products and transportation options that use pure hydrogen and the products derived from refined petroleum. It also provides detail to allow resource use and environmental releases to be attributed in a more defensible manner to refinery products and hydrogen produced by SMR.

A distinguishing feature of the approach proposed here is the creation of estimates based on a comprehensive inventory of emissions reported by facilities including subprocess detail. The activity factors provided here allow for the calculation of emissions and resource use associated with individual processes within the steam methane reforming facility and the petroleum refinery, and the use of reported data inclusive of all processes within the refinery provides coverage of all relevant aspects. This approach allows for validation of results by providing comprehensiveness, sub-facility level detail, and proper attribution of releases and resource use to products. The insights and datasets created in this project are useful for considering modifications to the processes used to produce hydrogen and petroleum derived products and for characterizing a wide variety of product and transportation systems.

2. Standardized Definitions

In order to relate the various data used in this analysis to one another, we developed standardized lists of refineries, subprocesses, pollutants, fuels, and final products to which each of the datasets are related in order to facilitate consistent calculations.

A total of 145 unique refineries were present across datasets for the year 2014. Of those, 124 were present across all three relevant datasets (Table 7-1), representing 98% of total operating capacity.

Fifty-three SMR facilities are present across datasets for the years 2011 and 2014. Of those, 32 are present in at least one emissions dataset and one production dataset in 2011, and 42 are present in at least one emissions dataset and one production dataset in 2014 (Table 7-2).

A standard refinery process diagram was created using previous Department of Energy (DOE) research as a starting point (Elgowainy et al., 2014; Forman et al., 2014). The DOE's original process diagram was modified to reflect unit process designations to which emission factors are associated and unit throughput capacity as reported in the EIA Refinery Capacity dataset. Figure 2-1 represents a typical unit process layout for a complex U.S. petroleum refinery.

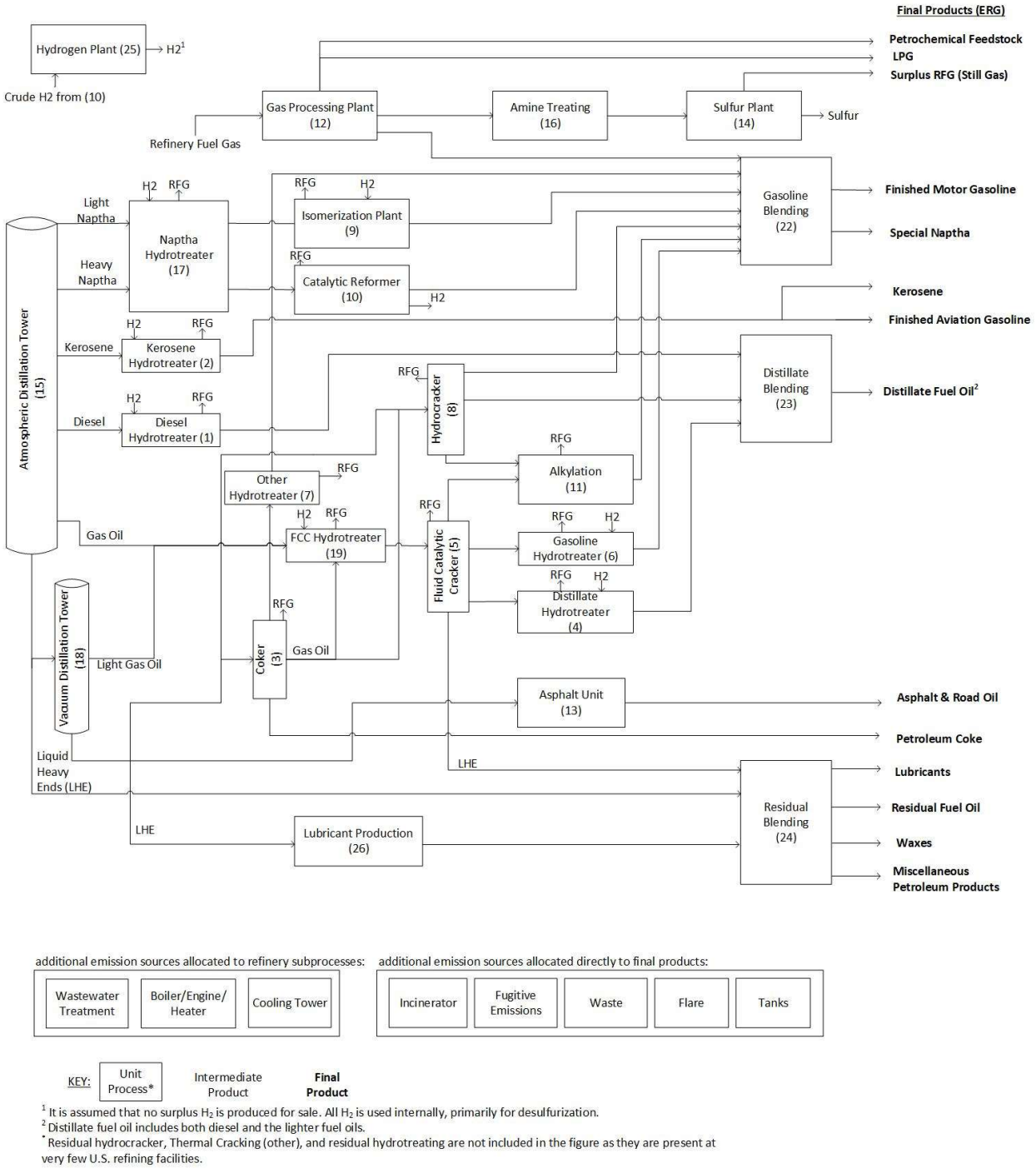


Figure 2-1. Process diagram of general petroleum refinery showing process options.

A full list of refinery subprocess is shown in Table 2-1. Subprocess designations available within each dataset are marked, as is the inclusion of each subprocess within the EIA Refinery Capacity Report. Categorization of emissions by subprocess for each dataset is discussed in chapter 3.

Table 2-1. Refinery subprocess presence within datasets.

Unit ID	*Refinery Subprocess*	*NEI*	*GHGRP*	*EIA*
1	Diesel Hydrotreater	x		x
2	Kerosene Hydrotreater	x		x
3	Coker	x	x	x
4	Distillate Hydrotreater	x		x
5	Fluid Catalytic Cracker	x	x	x
6	Gasoline Hydrotreater	x		x
7	Other Hydrotreater	x		x
8	Hydrocracker	x		x
9	Isomerization Plant			x
10	Catalytic Reformer	x	x	x
11	Alkylation	x		x
12	Gas Processing Plant			
13	Asphalt Unit	x	x	x
14	Sulfur Plant	x	x	x
15	Atmospheric Distillation Tower	x		x
16	Amine Treating	x		
17	Naphtha Hydrotreater	x		x
18	Vacuum Distillation	x		x
19	Gas/Oil Hydrotreater	x		x
20	Residual Hydrotreater	x		x
21	Thermal Cracking	x		x
22	Gasoline Blending	x		
23	Distillate Blending			
24	Residual Blending			
25	Hydrogen Plant	x	x	x
26	Lubricant Production	x		x
	Boiler	x	x	
	Heater	x	x	
	Engine	x		
	Wastewater Treatment	x		
	Cooling Tower	x		
	Flare	x	x	
	Fugitive Emissions	x	x	
	Incinerator	x		
	Other	x	x	
	Tank	x	x	
	Waste	x		

A full list of environmental releases assessed in the inventory is shown in Table 2-2 to match those reported in GREET 2016. Note that the NEI reports all nitrogen oxides as a single total such that no aggregation of individual species needed to be made for this study.

Table 2-2. Overview of flows used to develop life cycle inventory.

Environmental Flow	Data Source
Carbon dioxide (CO_2) (non-biogenic)	GHGRP
Sulfur dioxide (SO_2)	NEI
Nitrogen oxides (NOx)	NEI
Particulates, < 2.5 um (PM2.5)	NEI
Elemental carbon portion of PM2.5 (EC)	NEI
Organic carbon portion of PM2.5 (OC)	NEI
Particulates, < 10 um (PM10)	NEI
Carbon monoxide (CO)	NEI
Methane (CH_4)	GHGRP
Non-methane Volatile organic compounds (VOCs)	NEI
Nitrous Oxide (N_2O)	GHGRP

The list of final products from refineries across which emissions are allocated is shown in Table 2-3.

Table 2-3. Overview of final products for life cycle inventory of refineries.

Environmental Flow
Finished Motor Gasoline
Motor Gasoline Blending Components
Distillate Fuel Oil
Kerosene
Finished Aviation Gasoline
Liquefied Petroleum Gases
Residual Fuel Oil
Special Naphthas
Lubricants
Waxes
Petrochemical Feedstocks
Miscellaneous Petroleum Products
Still Gas
Asphalt and Road Oil
Petroleum Coke

3. Datasets

This section identifies and describes the datasets which are used to characterize the petroleum refinery and steam methane reforming facilities. In Table 3-1, the data year used from each dataset is shown in parentheses where relevant.

Table 3-1. Data sources for use in creating emission LCIs based on reported releases and emission/activity factors.

Data source (year)	*Provider*	*Description*
National Emissions Inventory (2011, 2014)	EPA	Comprehensive inventory of facility (point source) and small, county-level (nonpoint source) air emissions in the U.S. Includes criteria air pollutants (CAPs) and hazardous air pollutants (HAPs). (U.S. EPA, 2016a)
Greenhouse Gas Reporting Program (2011, 2014)	EPA	Greenhouse gas emissions reported by large facilities in the U.S. (U.S. EPA, 2016b)

Data source (year)	*Provider*	*Description*
Chemical Data Reporting (2011)	EPA	Production of qualifying chemicals reported by facilities in regulated industrial sectors. (U.S. EPA, 2012)
AP-42	EPA	Database containing bottom-up emission factors for 420 pollutants to be applied using known or estimated activity factors. (U.S. EPA, 1995)
PRELIM	University of Calgary	Life cycle inventory spreadsheet model capable of modeling energy use and GHG emissions based on customizable crude assays and unit configurations. (Abella, Motazedi, Guo, & Bergerson, 2016)
Petroleum Refinery data:		
Refinery Capacity Report (2014)	EIA	Production capacities reported by U.S. refineries. (U.S. EIA, 2017a)
Refinery Net Production (2014)	EIA	Product outputs from U.S. refineries by PADD. (U.S. EIA, 2016d)
Refinery Net Input (2014)	EIA	Product inputs to U.S. refineries by PADD. (U.S. EIA, 2016c)
Fuel Consumed at Refineries (2014)	EIA	Gross fuel consumption at U.S. refineries by PADD. (U.S. EIA, 2016b)
Natural Gas Used as Feedstocks for Hydrogen Production (2014)	EIA	Natural gas used as feedstocks at U.S. refineries by PADD. (U.S. EIA, 2016a)
Petroleum Refining Sector Information Collection Request (2011)	EPA	The compiled results of an industry-wide information collection request issued in 2011. (U.S. EPA, 2011)
Worldwide Refining Survey	Oil and Gas Journal	Production capacities and other process information reported by refineries worldwide. (Oil & Gas Journal, 2014)
Steam Methane Reformer data:		
Merchant Hydrogen Plant Capacity	PNNL	Compilation of hydrogen production capacities at merchant hydrogen plants from various sources including company statements and reports. (Pacific Northwest National Laboratory, 2016)

3.1. Criteria Air Pollutant Emissions

The National Emissions Inventory (NEI) provides emissions data for criteria air pollutants (CAPs), criteria precursors, and hazardous air pollutants from U.S. point, nonpoint, on-road, off-road, and event sources every 3 years (Table 2-2). For industrial point sources such as petroleum refineries and steam methane reforming facilities, NEI emission records are reported using unit level designations that correspond to eight-digit Source Classification Codes (SCC). 2011 and 2014 are the most recent years for which NEI data is available (U.S. EPA, 2016a). The NEI will serve as a source of top-down emission quantities of CAPs for facilities.

Each NEI record is categorized based on SCC to the appropriate subprocess unit listed in Table 3-2 (full SCC correspondence is provided in a separate file). Some emissions are categorized to subprocesses which are not linked to a specific subprocess chain (Table 2-1).

Table 3-2. Correspondence between NEI source categorization and process diagram unit ID numbers.

NEI Unit Designations	Unit ID Number
Alkylation	11
Amine Treating	16
Asphalt Unit	13
Atmospheric Distillation Tower	15
Catalytic Reformer	10
Coker	3
Fluid Catalytic Cracker	5
Gasoline Blending	22
Hydrocracker	8
Hydrogen Plant	25
Hydrotreater	1,2,4,6,7,17, 19, 20
Lubricant Production	26
Sulfur Plant	14
Thermal Cracking	21
Vacuum Distillation	18

Units with no corresponding NEI emission releases: Isomerization Plant (9), Gas Processing Plant (12), Distillate Blending (23), Residual Blending (24)

3.2. Greenhouse Gas Emissions

The Greenhouse Gas Reporting Program (GHGRP) "collects Greenhouse Gas (GHG) data from large emitting facilities, suppliers of fossil fuels and industrial gases that result in GHG emissions when used, and facilities that inject carbon dioxide underground" (U.S. EPA, 2016b). The program requires businesses operating in certain sectors to report emissions of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and certain fluorinated greenhouse gases annually from specific equipment and processes at their plants (Table 2-2). Different sectors are regulated and report under different Subparts of the GHGRP rule. Petroleum refineries are regulated under Subpart Y, hydrogen facilities are regulated under Subpart P, and combustion emissions from any facility are regulated under Subpart C. The GHGRP datasets do not include SCC codes. Facilities can report emissions using continuous emission monitoring systems (CEMs) or through specific emission calculation methods approved by EPA that vary by industry and process.

GHG emissions are reported at the process level. Process level details provided in each record vary significantly depending on the Subpart, calculation method, and process type. Unlike the NEI, the GHGRP does not generate consistent field names across all records. As a result, a combination of text processing and Subpart specific details are needed to categorize emissions to subprocesses.

Subpart C: Combustion Emissions

Under Subpart C, facilities report combustion emissions and primary fuel type for process heaters, boilers, and most other combustion sources. Fuel types are categorized using one of the

designations shown in Table 3-3. All emissions from Subpart C are categorized under the general subprocess *Combustion Emissions*.

Table 3-3. Fuel type categories for sources of combustion emissions under GHGRP Subpart C.

Fuel Type Designation
Coal
Distillate Fuel Oil
Liquefied Petroleum Gas
Natural Gas
Refinery Gas
Residual Fuel Oil
Other

Subpart Y: Petroleum Refineries

Under Subpart Y, petroleum refineries report emissions from a number of refinery specific processes including asphalt blowing, coking, flaring, storage tanks, and loading operations. Emissions are categorized based on source detail and if applicable, text processing, to the subprocesses in Table 3-4. Additional facility wide subprocesses are shown in Table 2-1.

Table 3-4. Correspondence between GHGRP source categorization and process diagram unit ID numbers.

GHGRP Unit Designations	Unit ID Number
Asphalt Unit	13
Catalytic Reformer	10
Coker	3
Fluid Catalytic Cracker	5
Hydrogen Plant (Subpart P)	25
Sulfur Plant	14

Subpart P: Hydrogen Plants

Under Subpart P, facilities that produce hydrogen report process emissions from hydrogen production units. Both petroleum refineries and steam methane reforming facilities report under this Subpart. All emissions from Subpart P are categorized under the subprocess *Hydrogen Plant*.

3.3. Subprocess Activity Levels

U.S. refinery capacity information is published annually at the facility level in the U.S. Energy Information Administration's Refinery Capacity dataset (U.S. EIA, 2017a). Table 3-5 presents a unique list of production capacity designations available in the EIA Refinery Capacity dataset. The EIA dataset also provides information regarding facility name, location, and its Petroleum Administration for Defense District (PADD) association. Other EIA datasets are available defining refinery capacity utilization for each sub-PADD district (U.S. EIA, 2017b). EIA data will be relied upon as the primary data source for refinery and unit level throughput.

Table 3-5. EIA unit capacity designations. Correspondence to refinery subprocess unit in parenthesis.

Unit Names	Unit Names
Alkylates (11)	Fuels Solvent Deasphalting
Aromatics	Hydrogen (25)
Asphalt & Road Oil (13)	Isomerization (Isobutane) (9)
Cat Cracking: Fresh Feed (5)	Isomerization (Isopentane/Isohexane) (9)
Cat Cracking: Recycled Feed (5)	Isomerization (Isooctane) (9)
Cat Hydrocracking, Distillate (8)	Lubricants (26)
Cat Hydrocracking, Gas Oil (8)	Petcoke,Market
Cat Hydrocracking, Residual (8)	Sulfur (14)
Cat Reforming: High Pressure (10)	Therm Cracking, Delayed Coking (3)
Cat Reforming: Low Pressure (10)	Therm Cracking, Fluid Coking (3)
Desulfurization, Diesel Fuel (1)	Therm Cracking, Other (Incldng Gas Oil) (21)
Desulfurization, Gasoline (6)	Therm Cracking, Visbreaking (21)
Desulfurization, Heavy Gas Oil (19)	Vacuum Distillation (18)
Desulfurization, Kerosene And Jet (2)	Operating Capacity
Desulfurization, Naphtha/Reformer Feed (17)	Total Oper Cap (Projected, Next Year)
Desulfurization, Other (7)	Total Operable Capacity (15)
Desulfurization, Other Distillate (4)	Idle Capacity
Desulfurization, Residual (20)	

Refinery unit throughputs are calculated based on the capacity of each unit provided by the EIA Refinery Capacity dataset. The dataset provides charge capacities for refinery units at all major U.S. refineries in units of *barrels per calendar day* and/or *barrels per stream day*. Refinery units as described by EIA are matched to refinery subprocesses as shown in Table 3-5.

To estimate actual unit level throughput, utilization rates and stream day estimates are needed. Because no data exist as to the utilization rates of individual units or individual refineries, sub-PADD level petroleum refinery capacity utilization factors are used (Table 7-3). The sub-PADD level is a smaller geographic region than the PADD and should provide a more accurate estimation of facility throughput. It is assumed that facility-level capacity utilization also applies at the unit-level. The operable capacity utilization factors provided by EIA are adjusted to enable our calculations to better reflect facility level idle capacity. Total operating capacity at each facility is calculated by subtracting idle capacity from operable capacity. Sub-PADD utilization rates of operating capacity are applied to facility level operating capacities as opposed to applying sub-PADD utilization rates of operable capacity to facility level total operable capacity. Sub-PADD level utilization of operating capacity is calculated using the following formula:

$$\text{Utilization of Operating Capacity (\%)} = \frac{\text{Gross Input to Atmospheric Distillation Unit}}{(\text{Refinery Operable Capacity} - \text{Idle Capacity})}$$

When unit charge capacities are provided in units per stream day (as opposed to units per calendar day), an estimate of the number of active stream days is needed to calculate unit

throughput. The EIA dataset does not provide unit utilization. Stream day estimates are calculated using facility operating capacity data, when available[1], using the following formula:

$$\text{Stream Days} = \frac{\text{Operating Capacity (bbl per calendar day)}}{\text{Operating Capacity (bbl per stream day)}} * 365$$

It is assumed that idle capacity for the atmospheric distillation unit applies to all other refinery units. Therefore, an idle capacity factor adjustment is applied to all unit charge capacities.

$$\text{Idle Cap Factor (\%)} = \frac{\text{Operating Capacity (bbl per calendar day)}}{\text{Total Operable Capacity (bbl per calendar day)}}$$

When charge capacity by calendar day is available, unit throughput (T_U) is calculated using the following equation:

$$T_U = \text{Unit Charge Capacity} \left(\frac{\text{bbl}}{\text{calendar day}}\right) * \text{Idle Capacity Factor} * \text{Utilization of Operating Capacity (RDIST)} * 365$$

If only charge capacity by stream day is available, unit throughput is calculated using the estimate of stream days:

$$T_U = \text{Unit Charge Capacity} \left(\frac{\text{bbl}}{\text{stream day}}\right) * \text{Idle Capacity Factor} * \text{Utilization of Operating Capacity (RDIST)} * \text{Stream Days}$$

Unit throughputs are calculated for each unit at each refinery, and can be aggregated to the national and PADD levels (Table 3-6).

[1] For the few facilities for which operating capacity information is unavailable, stream day estimates are calculated using Total Operable Capacity or an alternate unit with available information on both calendar day and stream day capacities, such as the hydrocracker or the catalytic reformer.

Table 3-6. PADD level refinery unit throughput (in millions), 2014.

Refinery Unit	Units	Dataset[2]	PADD 1	PADD 2	PADD 3	PADD 4	PADD 5	National
Alkylation	m3 alkylate product	P	4.0	14	32	2.3	12	64
Asphalt Unit	m3 asphalt and road oil	P	4.1	13	11	3.8	2.7	34
Atmospheric Distillation Tower	m3	C	64	200	490	33	150	940
Catalytic Reformer	m3	C	12	45	91	6.2	27	180
Coker	m3	C	3.8	28	79	4.3	28	140
Diesel Hydrotreater	m3	C	14	53	110	7.7	25	210
Distillate Hydrotreater	m3	C	8.7	3.9	6.3	2.6	6.1	28
Fluid Catalytic Cracker	m3	C	24	66	160	10	44	300
Gas/Oil Hydrotreater	m3	C	0.31	33	73	4.9	36	150
Gasoline Hydrotreater	m3	C	7.9	21	85	2.2	16	130
Hydrocracker	m3	C	2.1	17	60	1.5	28	110
Hydrogen Plant	m3 hydrogen gas at stp	P	600	4,800	9,400	1,600	11,000	28,000
Isomerization Plant	m3 liquid isomers[1]	P	1.3	8.1	17	0.82	9.8	37
Kerosene Hydrotreater	m3	C	2.5	15	45	2.1	11	76
Lubricant Production	m3 lubricants	P	1.0	0.48	8.3	-	1.9	12
Naphtha Hydrotreater	m3	C	17	60	110	7.4	31	230
Other Hydrotreater	m3	C	-	2.2	11	0.75	3.0	17
Residual Hydrotreater	m3	C	-	-	13	-	-	13
Sulfur Plant	kg sulfur	P	310	2,400	7,100	280	1,700	12,000
Thermal Cracking	m3	C	-	-	0.54	-	0.72	1.3
Vacuum Distillation	m3	C	28	87	240	12	80	450

[1] Isomers include isobutane, isopentane, isohexane, and isooctane.

[2] Unit throughputs are calculated from EIA datasets of charge capacity (C) or production capacity (P). Charge capacity represents the input capacity in liquid volume to the subprocess unit. Production capacity represents product output from a subprocess unit.

Petroleum Refinery Life Cycle Inventory Model (PRELIM)

The Petroleum Refinery Life-cycle Inventory Model (PRELIM) assesses GHG emissions from refineries based on refinery configuration and crude oil characteristics. The presence of specific refinery processes impacts total energy use and final product slate, while crude characteristics such as API gravity and sulfur content impact processing intensity, energy use, and emissions (Abella & Bergerson, 2012). In this project, PRELIM provides estimates of energy use for refinery subprocesses and is used to develop subprocess allocation factors.

3.4. Fuel Consumption

EIA provides petroleum refinery fuel consumption by PADD (U.S. EIA, 2016b). The portion of natural gas used as hydrogen feedstock (U.S. EIA, 2016a) is excluded from total natural gas consumption to derive total natural gas fuel consumption at refineries. Fuel consumption amounts, shown in Table 3-7, are used to calculate combustion emission factors in chapter 5. Fuel amounts are converted to energy basis using the Lower Heating Value (LHV) of fuel provided by GREET 2016 (Argonne National Laboratory, 2017) (see Table 7-4).

Table 3-7. Fuel consumption at refineries, 2014.

EIA Fuel Type	Fuel Consumption		Fuel Consumption (mmBTU)	Percent of Total Consumption
Catalyst petcoke	15,402,363,953	kg	457,552,791	17%
Coal	14,514,956	kg	362,229	<0.1%
Distillate fuel oil	49,126	m3	1,666,974	0.1%
Electricity, purchased	47,224,000,000	kwh	161,134,977	5.9%
Liquefied petroleum gases	366,455	m3	8,223,762	0.3%
Marketable petcoke	115,393,899	kg	3,427,967	0.1%
Natural gas, fuel	20,025,588,959	m3	695,174,651	25%
Other products	183,307	m3	5,767,654	0.2%
Residual fuel oil	65,660	m3	2,434,482	0.1%
Steam, purchased	59,196,023,960	kg	156,538,544	5.7%
Still gas	36,552,941	m3 fuel oil eq.	1,241,669,179	45%

Petcoke is converted from volume to mass using the EIA conversion of 5 barrels per short tons.
Still gas energy basis uses a LHV conversion of 128,950 btu/gal fuel oil eq. based on liquid still gas reported in GREET 2016. EIA reports HHV only for still gas as 142,857 btu/gal fuel oil eq. (U.S. EIA, 2016b).

When fuel consumption statistics are used in conjunction with emissions datasets, fuel consumption by PADD is scaled based on the throughput of those refineries for which emissions data are available. If no record of emissions exists for a facility, that facility's share of total crude throughput in the EIA Refinery Capacity dataset is excluded from the fuel consumption dataset. This calculation is performed separately for each emissions dataset: NEI (Table 3-8), GHGRP Subpart C, and GHGRP Subpart Y. In all cases, the facilities for which emissions data are available account for greater than 95% of the PADD total crude inputs.

Table 3-8. Adjusted fuel consumption at refineries for NEI Emissions dataset by PADD, 2014.

	Adjusted Fuel Consumption (mmBTU)				
EIA Fuel Type	PADD 1	PADD 2	PADD 3	PADD 4	PADD 5
Catalyst petcoke	43,377,800	90,620,461	240,127,784	15,670,466	65,105,909
Coal	362,229	-	-	-	-
Distillate fuel oil	-	177,773	937,686	-	532,509

EIA Fuel Type	Adjusted Fuel Consumption (mmBTU) PADD 1	PADD 2	PADD 3	PADD 4	PADD 5
Electricity, purchased	9,134,303	43,248,727	85,410,485	7,091,818	15,536,148
Liquefied petroleum gases	-	4,802,546	1,500,443	81,565	1,771,225
Marketable petcoke	-	-	-	2,641,207	745,885
Natural gas, fuel	38,610,274	109,983,616	405,866,237	15,105,652	120,897,732
Other products	40,018	269,740	1,788,919	-	3,548,383
Residual fuel oil	17,684	135,384	164,874	76,169	1,973,737
Steam, purchased	5,878,647	15,623,809	117,061,234	1,780,043	15,519,661
Still gas	81,948,970	264,102,953	598,604,220	46,965,432	240,752,701

3.5. Product Outputs

Final refinery products are calculated from the EIA net production at refineries dataset (U.S. EIA, 2016d). Negative net inputs of motor gasoline blending components to refineries, as reported in the EIA net product inputs to refineries dataset (U.S. EIA, 2016c), are considered product outputs. EIA reports blended gasoline products as either "Finished Motor Gasoline" or "Motor Gasoline Blending Components" based on whether the blending takes place within the refinery gate where they are produced. The distinction in these categories is maintained here, but allocation from subprocess to these products is treated as identical. The volume of ethanol included in Finished Motor Gasoline, estimated at 65% for "Greater than Ed55" pool and 10% for all other Finished Motor Gasoline pools, is excluded from the total finished motor gasoline pool. Products reported by EIA are matched to product categories in PRELIM to relate product allocation factors derived for refinery subprocesses within the PRELIM model to EIA product categories (Table 3-9). EIA products are also matched to ERG product categories for which final emission factors and inventories are compiled.

Table 3-9. Correspondence between refinery products across EIA and PRELIM.

Product Category (ERG)	PRELIM Product	EIA Product
Asphalt and Road Oil	Asphalt	Asphalt and Road Oil
Distillate Fuel Oil	ULSD	Distillate Fuel Oil, 0 to 15 ppm Sulfur
Distillate Fuel Oil	ULSD	Distillate Fuel Oil, Greater than 15 to 500 ppm Sulfur
Distillate Fuel Oil	ULSD	Distillate Fuel Oil, Greater than 500 ppm Sulfur
Distillate Fuel Oil	Liquid Heavy Ends	-
Finished Motor Gasoline	Blended Gasoline	Motor Gasoline, Finished, Conventional, Ed55 and Lower
Finished Motor Gasoline	Blended Gasoline	Motor Gasoline, Finished, Conventional, Greater Than Ed55
Finished Motor Gasoline	Blended Gasoline	Other Conventional Motor Gasoline
Finished Motor Gasoline	Blended Gasoline	Reformulated Motor Gasoline with Fuel Alcohol
Motor Gasoline Blending Components	Blended Gasoline	Motor Gasoline Blending Components
Finished Aviation Gasoline	Jet-A/AVTUR	Aviation Gasoline
Kerosene	Jet-A/AVTUR	Commercial Kerosene-Type Jet Fuel
Kerosene	Jet-A/AVTUR	Kerosene
Kerosene	Jet-A/AVTUR	Military Kerosene-Type Jet Fuel
Special Naphthas	Jet-A/AVTUR	Special Naphthas
Liquefied Petroleum Gas (LPG)	LPG	Ethane
LPG	LPG	Ethylene
LPG	LPG	Isobutane
LPG	LPG	Isobutylene
LPG	LPG	Normal Butane
LPG	LPG	Normal Butylene

Product Category (ERG)	PRELIM Product	EIA Product
LPG	LPG	Propane
LPG	LPG	Propylene
Lubricants	Liquid Heavy Ends	Naphthenic Lubricants
Lubricants	Liquid Heavy Ends	Paraffinic Lubricants
Miscellaneous Petroleum Products	Liquid Heavy Ends	Miscellaneous Petroleum Products for Fuel Use
Miscellaneous Petroleum Products	Liquid Heavy Ends	Miscellaneous Petroleum Products for Nonfuel Use
Residual Fuel Oil	Liquid Heavy Ends	Residual Fuel Oil, 0.31 to 1.00 Percent Sulfur
Residual Fuel Oil	Liquid Heavy Ends	Residual Fuel Oil, Greater Than 1.00 Percent Sulfur
Residual Fuel Oil	Liquid Heavy Ends	Residual Fuel Oil, Less Than 0.31 Percent Sulfur
Waxes	Liquid Heavy Ends	Waxes
Petrochemical Feedstocks	Petrochemical Feedstocks	Naphtha For Petrochemical Feedstock Use
Petrochemical Feedstocks	Petrochemical Feedstocks	Other Oils for Petrochemical Feedstock Use
Petroleum Coke	Coke	Petroleum Coke, Catalyst
Petroleum Coke	Coke	Petroleum Coke, Marketable
Still Gas	Surplus RFG	Still Gas

National product output at refineries is shown in Table 3-10. As in the EIA fuel consumption dataset, product output by PADD is scaled based on the throughput of those refineries for which emissions data are available. If no record of emissions exists for a facility, that facility's share of total crude throughput in the EIA Refinery Capacity dataset is excluded from the product output dataset. The energy basis, mass basis, and economic basis of all refinery product outputs in 2014 is shown Table 3-11 (see conversions in Table 7-5).

The U.S. EPA Chemical Data Reporting (CDR) database provides information on chemicals domestically manufactured or imported by industrially facilities under the Toxic Substances Control Act (U.S. EPA, 2012). The 2011 dataset, the most recent available, contains production records for 130 unique refineries across 464 products. A majority of refineries withhold production data on at least some products as confidential business information (CBI). Aggregate reported manufactured and consumed quantities by product category are found in Table 3-12.

Reported production as a percentage of total mass from the CDR provides evidence that the EIA list of reported products is comprehensive. Some intermediate products reported in the CDR can be converted or blended into a variety of final products depending on refinery configuration and market conditions, so exact comparisons between datasets is not possible. However, 99% of reported products by mass in the CDR are represented in the EIA production dataset.

EIA reports hydrogen production capacity as a subprocess activity but does not report net hydrogen output at refineries or by PADD. Instead, the U.S. EPA Chemical Data Reporting (CDR) database can be used, which provides information on chemicals domestically manufactured or imported by industrially facilities under the Toxic Substances Control Act (U.S. EPA, 2012). In the 2011 dataset, the most recent available, only 23 refineries report gross production of hydrogen. Of those, 17 report consuming all hydrogen that is manufactured, while five report no use at all. The use of hydrogen within the refinery is tracked and allocated to final products via the *hydrogen plant* subprocess unit. However, given the lack of production data, no emissions are allocated to hydrogen as a final net product from refineries.

Table 3-10. Final product output at refineries by PADD (in thousands), 2014.

Product	Units	PADD 1	PADD 2	PADD 3	PADD 4	PADD 5	National
Asphalt and Road Oil	m3	2,927	8,203	4,278	1,936	1,203	18,548
Finished Motor Gasoline[1]	m3	3,492	22,719	48,162	11,780	11,319	97,471
Motor Gasoline Blending Components	m3	28,248	84,551	180,108	4,318	60,978	358,202
Petroleum Coke	kg	2,152,749	11,572,774	32,925,544	1,548,746	9,926,053	58,125,866
Finished Aviation Gasoline	m3	-	109	488	13	104	714
Kerosene	m3	5,689	13,436	45,522	1,725	24,841	91,213
Special Naphthas	m3	37	73	2,266	-	66	2,442
Lubricants	m3	749	462	7,274	-	1,161	9,647
Miscellaneous Petroleum Products[2]	m3	179	834	3,106	198	756	5,073
Residual Fuel Oil	m3	3,240	3,000	10,867	690	7,425	25,221
Waxes	m3	11	64	336	-	-	411
Liquefied Petroleum Gases	m3	2,314	6,869	24,646	608	3,479	37,916
Petrochemical Feedstocks[3]	m3	187	1,819	16,107	-	11	18,125
Still Gas	m3 fuel oil eq	2,348	7,514	21,876	1,364	7,094	40,196
Distillate Fuel Oil	m3	19,389	63,033	157,705	11,261	33,337	284,725

[1] An estimate of ethanol content has been excluded from the finished motor gasoline pool. See explanation in text.

[2] "Includes all finished products not classified elsewhere (e.g., petrolatum, lube refining byproducts (aromatic extracts and tars), absorption oils, ram-jet fuel, petroleum rocket fuels, synthetic natural gas feedstocks, and specialty oils)" (U.S. EIA, 2016d).

[3] "Chemical feedstocks derived from petroleum principally for the manufacture of chemicals, synthetic rubber, and a variety of plastics. The categories reported are "Naphtha Less Than 401º F" and "Other Oils Equal to or Greater Than 401º F" (U.S. EIA, 2016d).

Table 3-11. Comparison of allocation options for final product output at refineries, 2014.

Product Category (ERG)	Amount (ERG)	Unit (ERG)	Energy Content	Mass	Value
Asphalt and Road Oil	18,547,776	m3	2.1%	2.3%	1.4%
Finished Motor Gasoline	97,471,366	m3	9.0%	8.7%	11%
Motor Gasoline Blending Components	358,202,350	m3	33%	32%	40%
Petroleum Coke	58,125,866,409	kg	5.2%	7.0%	0.6%
Finished Aviation Gasoline	713,853	m3	< 0.1%	< 0.1%	< 0.1%
Kerosene	91,213,078	m3	9.0%	8.8%	9.3%
Special Naphthas	2,441,568	m3	0.2%	0.2%	0.2%
Lubricants	9,647,031	m3	1.0%	1.2%	0.6%
Miscellaneous Petroleum Products	5,072,808	m3	0.5%	0.4%	0.3%
Residual Fuel Oil	25,221,268	m3	2.8%	3.0%	1.5%
Waxes	411,459	m3	< 0.1%	< 0.1%	< 0.1%
Liquefied Petroleum Gases	37,916,085	m3	2.6%	2.3%	3.8%
Petrochemical Feedstocks	18,124,711	m3	1.7%	1.6%	1.1%
Still Gas	40,195,804	m3 fuel oil eq.	4.1%	3.4%	1.6%
Distillate Fuel Oil	284,725,100	m3	29 %	29%	29%

Table 3-12. Comparison of product output at refineries between CDR and EIA datasets in metric tonnes, 2011.

				Net Output by Category		Percent of Total		
Product, CDR	**Matched Product Category, EIA**	**Manufactured**	**Used**	**CDR**	**EIA**	**CDR**	**EIA**	**Difference**
asphalt	Asphalt and Road Oil	14,699,499	2,418,297	12,281,202	21,988,509	2.8%	2.8%	0.0%
distillates	Distillate Fuel Oil	338,504,397	168,615,390	169,889,007	218,681,268	39.3%	27.7%	12%
kerosene	Kerosene & Aviation Gasoline	108,949,513	79,608,647	29,340,866	69,286,710	6.8%	8.8%	-2.0%
butane	Liquefied Petroleum Gases	12,321,028	7,916,302	12,655,331	18,252,470	2.9%	2.3%	0.6%
butylene	Liquefied Petroleum Gases	735,431	541,080					
ethane	Liquefied Petroleum Gases	756,985	344,731					
ethylene	Liquefied Petroleum Gases	2,723,955	1,814,372					
propane	Liquefied Petroleum Gases	9,278,991	4,841,663					
propylene	Liquefied Petroleum Gases	3,265,142	968,055					
lubricant	Lubricants	3,093,301	2,335,801	2,556,332	9,771,154	0.6%	1.2%	-0.6%
paraffin oil	Lubricants	1,798,831	-					
benzenes	Miscellaneous Petroleum Products & Petrochemical Feedstocks	28,731,370	6,598,613	57,323,092	16,269,379	13.2%	2.1%	11%
clarified oils	Miscellaneous Petroleum Products & Petrochemical Feedstocks	11,537,045	6,043,717					
gas oils	Miscellaneous Petroleum Products & Petrochemical Feedstocks	139,341,402	127,086,968					
petroleum extracts	Miscellaneous Petroleum Products & Petrochemical Feedstocks	3,411,940	1,018,318					
petroleum residues	Miscellaneous Petroleum Products & Petrochemical Feedstocks	185,360,064	175,679,169					
sulfur	Miscellaneous Petroleum Products & Petrochemical Feedstocks	5,684,294	316,239					
gasoline	Motor Gasoline Blending Components & Finished Gasoline	12,659,204	8,796,700	117,510,013	318,830,259	27.2%	40.4%	-13.2%
hydrocarbons	Motor Gasoline Blending Components & Finished Gasoline	32,009,226	23,010,595					
naphthas	Motor Gasoline Blending Components & Finished Gasoline	379,249,618	274,600,740					
coke	Petroleum Coke	25,255,477	1,486,787	23,768,690	55,822,343	5.5%	7.1%	-1.6%
residual oil	Residual Fuel Oil	8,732,743	5,604,098	3,128,644	30,486,989	0.7%	3.9%	-3.2%
special naphthas	Special Naphthas	1,065,623	545,321	520,303	1,587,313	0.1%	0.2%	-0.1%
petroleum gases	Still Gas	103,217,816	104,687,315	(566,885)	27,668,981	-0.1%	3.5%	-3.6%

Product, CDR	Matched Product Category, EIA	Manufactured	Used	Net Output by Category		Percent of Total		
				CDR	EIA	CDR	EIA	Difference
refinery fuel gas	Still Gas	24,823,020	23,884,204					
tail gas	Still Gas	1,355,658	1,391,861					
waxes	Waxes	221,288	132,030	89,258	478,740	0.0%	0.1%	0.0%
hydrogen	No match	2,393,434	2,027,519	4,312,478	n.a.	1.0%	n.a.	1.0%
waste	No match	3,268,339	3,210,989					
other	No match	14,415,239	10,526,026					
Total		**1,478,859,875**	**1,046,051,545**	**432,808,330**	**801,440,415**	**100%**	**100%**	

Hydrogen production at SMR facilities is calculated from one of three datasets, the CDR, the GHGRP, and a capacity report compiled by Pacific Northwest National Laboratory (PNNL) (Pacific Northwest National Laboratory, 2016). A 90% capacity utilization factor is assumed for capacities reported by PNNL. Hydrogen production is estimated from the GHGRP Subpart P under the assumption that 8 kg of CO2 is released per kg of hydrogen produced. The three datasets combined provide estimates of annual hydrogen production for 52 SMR facilities (Table 3-13). Bolded values highlight the preferred production estimate (see discussion in Chapter 6).

Table 3-13. Hydrogen production, metric tonnes, at SMR facilities estimated from three datasets.

Facility ID	Facility Name	CDR 2011	PNNL	GHGRP 2011	GHGRP 2014
201	Air Liquide, El Segundo	-	**72,040**	73,451	76,932
202	Air Liquide, Corpus Christi	-	**41,884**	48,040	49,804
203	Air Liquide, Freeport	-	**58,637**	-	1,405
204	Air Liquide, Longview	-	-	**48,730**	**51,786**
205	Air Liquide, Anacortes	-	**6,283**	7,892	8,014
206	Air Liquide, Pasadena	-	**83,768**	61,715	79,910
207	Air Liquide, Rodeo	-	**100,521**	80,667	101,541
209	Air Products, Westlake	-	**92,144**	103,740	108,989
210	Air Products, Catlettsburg	-	**28,481**	26,066	23,918
211	Air Products, Convent	-	**92,144**	92,234	82,703
212	Air Products, Geismar	-	-	**6,398**	**16,405**
213	Air Products, New Orleans	-	**83,768**	36,300	24,768
214	Air Products, Martinez	-	**103,034**	94,539	86,594
215	Air Products Tesoro, Martinez	-	-	32,312	31,881
216	Air Products, Norco	-	**125,651**	-	105,529
217	Air Products, Garyville	-	**100,521**	116,349	103,961
218	Air Products, Luling	-	**83,768**	-	103,358
219	Air Products, Detroit	-	**50,261**	-	46,953
220	Air Products, Sacramento	-	-	**5,645**	**5,603**
221	Air Products, Cincinnati	-	**1,927**	1,979	2,244
222	Air Products, Baton Rouge	-	**100,521**	100,870	113,420
223	Air Products, Baytown	-	**104,709**	52,044	28,423
224	Air Products, Carson	-	**83,768**	77,006	85,280
225	Air Products, Corpus Christi	-	-	**28,283**	**20,924**
226	Air Products, Pasadena	-	**67,014**	79,800	69,520
227	Air Products, Port Arthor	-	**180,100**	210,461	242,596
228	Air Products, Wilmington	-	-	**84,754**	**96,065**
229	Ascend, Decatur	-	-	**5,728**	**4,762**
230	Ascend, Cantonment	-	-	**14,915**	**21,215**
234	Evonik Corporation, Mapleton	-	-	**1,221**	**2,200**
235	Air Liquide, La Porte	-	101,359	-	90,555
236	Linde Gas, Decatur	**7,716**	8,377	11,536	10,779
237	Linde Gas, Anacortes	-	5,864	-	6,719

Facility ID	Facility Name	CDR 2011	PNNL	GHGRP 2011	GHGRP 2014
238	Linde Gas, Pasadena	**46,830**	-	73,804	91,523
239	Linde Gas, La Porte	**65,763**	-	140,913	150,658
240	Linde Gas, Romeoville	**39,620**	50,261	46,613	45,022
241	Linde Gas, Lima	**19,286**	50,261	30,399	30,657
243	Linde Gas, Salt Lake City	**12,529**	25,968	17,415	17,629
244	Linde Gas, Saraland	**5,752**	8,377	6,981	7,639
245	Linde Gas, Toldeo	**13,973**	100,521	84,067	55,939
246	Motiva, Norco	-	-	**18,149**	-
247	Praxair Whiting, East Chicago	-	**184,925**	83,655	190,611
249	Praxair Shell, Carneys Point	-	-	**5,330**	**5,719**
251	Praxair, Geismar	-	**155,221**	74,080	71,912
252	Praxair, Hemlock	-	-	3,353	3,119
253	Praxair, Ontario	-	**10,052**	4,933	4,850
254	Praxair, Port Arthur	-	**196,854**	95,335	226,245
256	Praxair, Texas City	-	**221,984**	48,459	43,876
257	Praxair Hydrogen, Texas City	-	-	**132,304**	**158,654**
258	Praxair, Sulphur	-	**105,547**	56,520	74,106
259	Praxair, Norco	-	**113,086**	-	92,705
260	Solvay Chemicals, Longview	-	-	**5,700**	**5,869**

4. Emission Factors for Refinery Products

A key outcome of this project is to assign emissions to the final products produced by refineries. Final refinery products are connected to the process chains used to produce them in the unit processes described above. Emissions from individual refinery subprocesses are a combination of combustion and non-combustion emissions. Non-combustion-related emissions are assigned to individual refinery subprocess units based on details provided in the GHGRP and NEI. Combustion-related emissions are allocated to refinery subprocesses on the basis of unit heat intensity and throughput. Emissions from refinery units are allocated to final products according to the process flow relationships shown in the refinery process diagram. The following section describes the calculation of refinery unit throughputs, the mapping of emissions to refinery units from both combustion and non-combustion sources, and the allocation of emission from refinery units to final products.

4.1. Assigning emissions to refinery subprocess units

Emissions from the NEI and GHGRP are assigned to refinery subprocess units. These emissions represent both non-combustion (process) and combustion emissions. Total combustion and non-combustion emissions for each refinery subprocess at each refinery are calculated. These emissions are divided by refinery unit throughput to develop refinery subprocess emission factors per unit throughput. Emission factors aggregated at the PADD or National level include emissions and throughput only from those facilities found within both the emissions dataset (NEI or GHGRP) and the production dataset (EIA). National emission factors for all refinery subprocess units, prior to allocation of facility wide emissions sources such as boilers and heaters, are shown in Table 4-1.

Table 4-1. National refinery subprocess emission factors (in g / m3 throughput) prior to allocation of facility wide emissions.

Refinery Subprocess	carbon monoxide	nitrogen oxides	particulates, < 2.5 um	particulates, < 10 um	sulfur dioxide	VOC, volatile organic compounds	elemental carbon portion of PM2.5	organic carbon portion of PM2.5	carbon dioxide	methane	nitrous oxide
Alkylation	0.52	0.15	0.051	0.051	0.032	0.37	2.3E-3	4.5E-3	-	-	-
Asphalt Unit	-	-	-	-	-	6.3E-3	-	-	3,300	8.2	-
Atmospheric Distillation Tower	2.4E-5	2.4E-5	3.4E-4	9.5E-4	2.4E-5	0.17	1.5E-5	3.0E-5	-	-	-
Catalytic Reformer	0.43	0.75	0.019	0.019	0.039	0.28	-	6.5E-4	330	0.77	3.2E-3
Coker	3.8	4.3	1.4	2.3	3.7	4.7	0.046	0.095	9,800	9.1	0.074
Diesel Hydrotreater	0.011	2.2E-3	4.0E-5	4.0E-5	4.6E-6	0.19	-	1.4E-6	-	-	-
Distillate Hydrotreater	-	-	-	-	-	0.045	-	-	-	-	-
Fluid Catalytic Cracker	26	27	18	21	25	4.3	0.52	0.33	150,000	4.8	0.94
Gas/Oil Hydrotreater	0.013	2.6E-3	-	-	5.3E-6	0.24	-	-	-	-	-
Gasoline Hydrotreater	-	-	-	-	-	0.047	-	-	-	-	-
Hydrocracker	0.55	0.41	0.019	0.27	0.23	0.36	-	6.8E-4	-	-	-
Hydrogen Plant	2.4E-3	3.7E-3	1.5E-3	1.5E-3	4.1E-5	2.9E-3	-	2.0E-6	620	-	-
Kerosene Hydrotreater	0.013	2.5E-3	1.6E-5	1.6E-5	5.1E-6	0.14	-	5.7E-7	-	-	-
Lubricant Production	0.45	0.044	0.034	0.034	1.8E-3	18	-	1.2E-3	-	-	-
Naphtha Hydrotreater	0.010	2.0E-3	4.6E-5	4.6E-5	4.1E-6	0.15	-	1.6E-6	-	-	-
Other Hydrotreater	-	-	3.8E-5	3.8E-5	-	0.069	-	1.3E-6	-	-	-
Sulfur Plant* (g / kg)	0.088	0.033	0.014	0.014	0.15	0.023	7.4E-11	3.5E-4	210	1.2E-3	6.7E-5
Thermal Cracking	8.4	18	39	61	28	7.2	0.028	5.4E-3	-	-	-
Vacuum Distillation	4.8E-3	0.017	0.012	0.017	0.14	0.48	-	4.3E-4	-	-	-

*Sulfur plant emission factors in units of g / kg throughput

4.2. Assigning heat related emissions to refinery subprocess units from unit throughput

Emissions associated with heat use are assigned to refinery units, and ultimately to final products. As the datasets do not specify where the heat from each heat process is used, emissions associated with heat production are assigned to other refinery subprocesses according to their heat requirements. Table 4-2 provides an average of energy intensities per barrel of utilized charge capacity for refinery units. In the NEI dataset, the *heater* and *boiler* subprocesses are associated with the generation of direct heat and steam, respectively, that are used throughout the refinery. In the GHGRP, emissions from Subpart C (combustion emissions) are allocated in this manner.

Refinery subprocess unit energy intensities

Energy intensity values were developed based on values reported in the PRELIM model and documentation and Pellegrino and colleagues (2007). PRELIM documentation reports energy intensities as fuel use, electricity, and steam use. Fuel use is interpreted to correspond to process heater use, as confirmed by implementation of these values in the PRELIM model. Steam use, as reported in PRELIM documentation, is used to allocate boiler emissions reported in the NEI. A boiler efficiency of 80% is assumed. Information from Pellegrino et al. (2007) provides values for additional units not included within PRELIM and provides a confirmation of reported energy demand. The range of energy intensity values reported in Table 4-2 for refinery unit heater demand indicates that significant variation in heat demand exists between refineries. The range in unit heat demand estimates is attributable to variation in feedstock characteristics, process configuration and management both within and between facilities.

From these unit energy estimates, energy use allocations for each refinery subprocess unit can be calculated as a percent share of total energy use at each refinery (Table 4-3). Emissions from *heaters* and *boilers* are allocated to refinery units based on their respective shares of each energy source. Combustion emissions from the GHGRP and other facility wide emissions from the NEI are allocated to refinery units based on boilers and heaters *combined* (Table 4-4). This allocation is performed at each individual refinery to better reflect unit throughput at each refinery.

Table 4-2. Refinery unit energy intensity estimates per barrel of utilized charge capacity

Refinery Unit	U.S. Throughput (million bbl) (T_U)	Energy Use (MJ / bbl) Direct Heat ($I_{U,h}$)	Energy Use (MJ / bbl) Steam ($I_{U,b}$)	Energy Use (million mmBTU) Heater	Energy Use (million mmBTU) Boiler[1]
Alkylation	401	0	227	-	110
Asphalt Unit	215	0	0	-	-
Atmospheric Distillation Tower	5,932	96	8	540	59
Catalytic Reformer	1,141	293	38	320	51
Coker	896	154	4	130	4.4
Diesel Hydrotreater	1,339	126	10	160	16
Distillate Hydrotreater	173	126	10	21	2.1
Fluid Catalytic Cracker[2]	1,902	0	0	-	-
Gas/Oil Hydrotreater	926	126	10	110	11
Gasoline Hydrotreater	832	126	10	99	10
Hydrocracker (Distillate)	212	157	2		
Hydrocracker (Gas Oil)	433	139	95	94	49
Hydrocracker (Residual)	35	157	2		
Isomerization Plant	235	271	0	60	-
Kerosene Hydrotreater	480	126	10	57	5.8
Lubricant Production	73	695	695	48	60
Naphtha Hydrotreater	1,438	126	10	170	17
Other Hydrotreater	108	126	10	13	1.3
Residual Hydrotreater	79	126	10	9.5	0.95
Thermal Cracking	8	159	4	1.2	0.04
Vacuum Distillation	2,809	57	7	150	24
Hydrogen Plant (mil kg)	2,479	154 MJ/kg	(34) MJ/kg	360	(100)
Sulfur Plant (mil short tons)	13	0 MJ/ton	(1538) MJ/ton	-	(24)
				2,400	**300**

[1] Energy use at boiler accounts for an 80% boiler efficiency rating

[2] FCC is treated as self-contained; no additional facility heat is supplied outside of catalyst coke combustion

Table 4-3. Allocation factors for heaters and boilers by refinery subprocess unit, aggregated nationally.

Refinery Unit	Heater	Boiler	Combined
Alkylation	-	26%	4.0%
Asphalt Unit	-	-	-
Atmospheric Distillation Tower	23%	14%	22%
Catalytic Reformer	13%	12%	14%
Coker	5.6%	1.1%	5.1%
Diesel Hydrotreater	6.8%	3.8%	6.6%
Distillate Hydrotreater	0.9%	0.5%	0.9%
Fluid Catalytic Cracker	-	-	-
Gas/Oil Hydrotreater	4.7%	2.6%	4.6%
Gasoline Hydrotreater	4.2%	2.4%	4.1%
Hydrocracker	4.0%	12%	5.4%
Isomerization Plant	2.6%	-	2.3%
Kerosene Hydrotreater	2.4%	1.4%	2.4%
Lubricant Production	2.1%	14%	4.1%
Naphtha Hydrotreater	7.3%	4.1%	7.1%
Other Hydrotreater	0.6%	0.3%	0.5%
Residual Hydrotreater	0.4%	0.2%	0.4%
Thermal Cracking	0.1%	0.0%	0.0%
Vacuum Distillation	6.5%	5.8%	6.6%
Hydrogen Plant	15%	-	9.8%
Sulfur Plant	-	-	-

Table 4-4. Allocation method for facility wide emissions sources.

Refinery Subprocess	Emissions Dataset	Allocation Approach
Boiler / Heater	NEI	Allocated to refinery units based on the steam / heat intensity of that unit
Combustion Emissions	GHGRP	Allocated to refinery units based on the combined energy intensity of that unit
Engine	NEI	
Cooling Tower	NEI	
Wastewater Treatment	NEI	
Fugitive Emissions	NEI & GHGRP	Allocated to final products based on product energy content
Flare	NEI & GHGRP	
Incinerator	NEI	
Other	NEI & GHGRP	
Tank	NEI & GHGRP	
Waste	NEI	

Subprocess emissions following allocation of facility wide emissions to refinery subprocesses are shown in Table 4-5.

Table 4-5. National refinery subprocess emissions, in metric tonnes, following allocation of facility wide emissions.

Refinery Subprocess	carbon monoxide	nitrogen oxides	particulates, < 2.5 um	particulates, < 10 um	sulfur dioxide	VOC, volatile organic compounds	elemental carbon portion of PM2.5	organic carbon portion of PM2.5	carbon dioxide	methane	nitrous oxide
Alkylation	1,900	4,200	740	900	710	610	210	140	4,800,000	270	52
Amine Treating	76	47	2.5	2.5	40	27	0.017	0.51	-	-	-
Asphalt Unit	-	-	-	-	-	0.21	-	-	110,000	280	-
Atmospheric Distillation Tower	8,000	15,000	2,600	3,000	3,100	3,000	420	590	28,000,000	1,500	300
Catalytic Reformer	5,100	9,500	1,600	1,900	1,900	1,800	270	360	17,000,000	1,100	180
Coker	1,800	3,400	680	900	1,200	1,200	82	130	7,500,000	1,600	78
Diesel Hydrotreater	2,300	4,200	690	820	870	810	120	160	7,800,000	440	87
Distillate Blending	-	-	-	-	-	-	-	-	-	-	-
Distillate Hydrotreater	530	530	170	180	54	160	24	36	1,100,000	57	11
Fluid Catalytic Cracker	7,900	8,200	5,500	6,200	7,600	1,300	160	99	45,000,000	1,400	280
Gas Processing Plant	-	-	-	-	-	-	-	-	-	-	-
Gas/Oil Hydrotreater	1,200	2,500	530	580	510	590	92	120	5,100,000	280	54
Gasoline Blending	-	-	-	-	-	47	-	-	-	-	-
Gasoline Hydrotreater	1,300	2,700	520	580	630	550	73	110	5,300,000	300	58
Hydrocracker	1,300	3,300	470	550	670	620	95	100	5,700,000	340	65
Hydrogen Plant	2,700	6,300	1,100	1,300	1,500	1,200	160	260	27,000,000	540	100
Isomerization Plant	630	1,300	220	230	220	240	34	51	2,500,000	140	26
Kerosene Hydrotreater	550	1,400	260	280	310	240	44	58	3,000,000	170	32
Lubricant Production	860	1,600	270	290	780	610	52	53	4,000,000	200	38
Naphtha Hydrotreater	2,400	4,700	800	920	890	910	130	180	8,500,000	480	93
Other Hydrotreater	180	360	53	58	78	64	9.2	12	660,000	36	7.0
Residual Blending	-	-	-	-	-	-	-	-	-	-	-
Residual Hydrotreater	40	140	29	38	11	24	5.9	7.5	440,000	31	6.2
Sulfur Plant	1,000	390	160	170	1,800	260	8.7E-7	4.1	2,500,000	14	0.78
Thermal Cracking	26	67	54	81	47	12	0.89	0.83	51,000	2.5	0.50
Vacuum Distillation	2,000	4,300	750	870	960	1,000	130	160	7,900,000	440	85
Total	42,000	74,000	17,000	20,000	24,000	15,000	2,100	2,600	180,000,000	9,600	1,600

Validating energy consumption at refineries

Total energy use for a specific refinery unit is calculated from unit throughput and energy intensity. Energy intensity estimates include heater and boiler energy use (Table 4-2), as well as estimates of engine and electricity use. Engine and electricity use are included to better reflect the granularity of data provided in the EIA fuel consumption dataset (Table 3-7).

$$E_U = \left(I_{U,h} + I_{U,b} + I_{U,o}\right) * T_U$$

where, E_U represents the total energy used for refinery unit U,

I represents the average energy intensity required from heaters, boilers, and other energy sources respectively for each unit U (in MJ/ bbl unit throughput),

T represents the estimated unit throughput for each unit U at each facility.

Refinery energy use can be estimated for individual units at individual facilities and aggregated to national or PADD levels (Table 4-6).

Table 4-6. PADD level energy use by refinery unit, in million mmBTUs.

Refinery Unit	PADD 1	PADD 2	PADD 3	PADD 4	PADD 5	National
Alkylation	7.4	25	59	4.1	21	120
Asphalt Unit	-	-	-	-	-	-
Atmospheric Distillation Tower	46	150	350	24	110	680
Catalytic Reformer	27	100	200	14	60	400
Coker	4.0	29	82	4.5	29	150
Diesel Hydrotreater	13	51	110	7.4	24	210
Distillate Hydrotreater	8.5	3.8	6.2	2.6	6.0	27
Fluid Catalytic Cracker	-	-	-	-	-	-
Gas/Oil Hydrotreater	0.31	32	72	4.8	35	140
Gasoline Hydrotreater	7.6	20	82	2.1	16	130
Hydrocracker	3.2	27	98	2.0	47	180
Hydrogen Plant	6.2	50	97	16	120	280
Isomerization Plant	2.2	14	30	1.4	17	66
Kerosene Hydrotreater	2.4	15	45	2.1	11	75
Lubricant Production	10	4.8	82	-	19	120
Naphtha Hydrotreater	16	58	110	7.2	30	220
Other Hydrotreater	-	2.2	11	0.74	2.9	17
Residual Hydrotreater	-	-	12	-	-	12
Sulfur Plant	(0.30)	(2.3)	(6.8)	(0.26)	(1.6)	(11)
Thermal Cracking	-	-	0.58	-	0.78	1.4
Vacuum Distillation	13	39	110	5.2	35	200
Total	170	620	1,500	98	580	3,000

Total energy use at refineries, as estimated using this method, indicates that approximately 9% of energy embodied in incoming crude is consumed during the refining process.[2] Total energy use estimated by subprocess is approximately 10% greater than fuel consumption as reported by EIA (Table 4-7; see Table 3-7 for fuel consumption breakout at refineries by fuel type). More

[2] Assumes 5745.8 MJ / bbl crude oil

efficient recycling of internal heat at refineries than what is assumed in Table 4-2 may account for this difference.

Table 4-7. Comparison of total energy consumption by PADD (million mmBTUs).

	PADD 1	PADD 2	PADD 3	PADD 4	PADD 5	National
Sum of Subprocess Heat Requirements	170	620	1,500	98	580	3,000
Fuel Inputs by PADD (EIA)	180	530	1,500	90	480	2,700
Crude Input	2,200	7,000	17,000	1,100	5,200	32,000

4.3. Allocating refinery subprocess unit emissions to final products

Refinery subprocess emissions are allocated to final products based on the energy content of intermediate and final product outputs as specified in the PRELIM refinery model. Each U.S. refining facility is associated with a PRELIM refinery configuration as described in the SI of Cooney et al. (2016) (Table 7-1). Refinery subprocess allocation factors are calculated for each PRELIM configuration and are aggregated at the PADD or national level based on a production weighted average. Intermediate product flows are allocated to final products based on product allocation factors of downstream subprocesses.

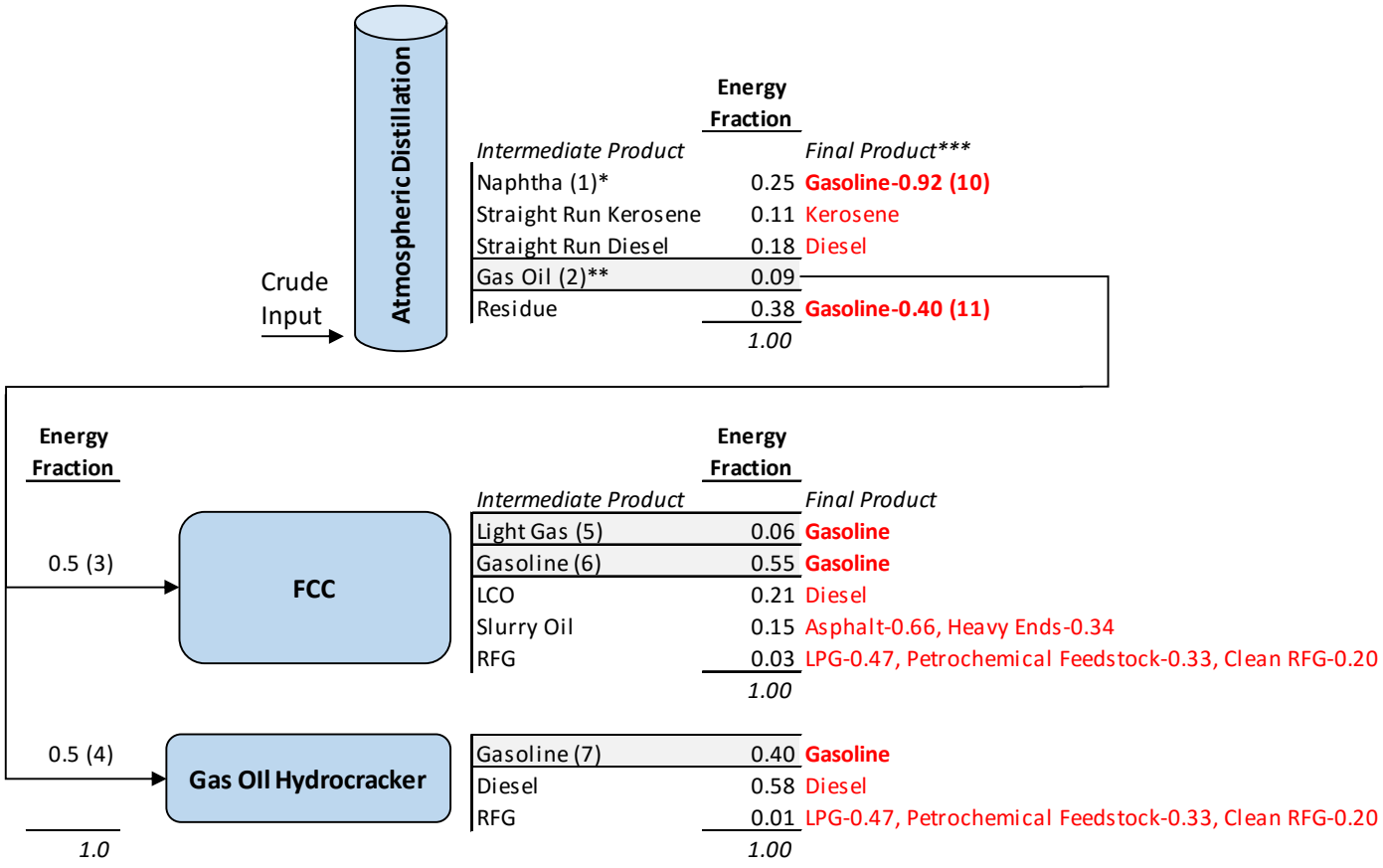
Allocation factors for subprocess units to final products

Figure 4-1 shows a subset of a generalized petroleum refinery. The full crude input to the refining facility first flows to the atmospheric distillation tower where it is separated into five intermediate product flows, with production fractions based on product energy content. Total output of each unit process sums to one, ignoring process gain or loss, which is calculated relative to volumetric input flow and will not typically sum to one. Some intermediate product flows map directly to a final product. Flow (6), FCC Gasoline, provides an example where 100 percent of the intermediate product is allocated to the gasoline final product pool. The figure demonstrates the calculation of a final product allocation factor for gasoline from the atmospheric distillation tower that takes into consideration the flows through downstream FCC and Gas Oil Hydrocracking subprocesses. Approximately 9 percent of distillation tower output is classified as gas oil based on energy content. In the example refinery configuration, 50 percent of gas oil flows to the FCC and the remaining 50 percent to the Gas Oil Hydrocracker. Equation 1 demonstrates the calculation of the gasoline allocation factor using the flow number labels in the figure. Equation 2 demonstrates the same calculation substituting the energy fractions that correspond to the labeled flows. In the included example, 43% of atmospheric distillation emissions are allocated to finished gasoline.

The same general calculation procedure is carried out for each subprocess unit, final product, and refinery configuration included in PRELIM. PADD and national throughput capacity weighted average subprocess allocation factors are calculated based on the relative share of configurations within each PADD (Table 4-8). These initial allocation factors represent PADD or national average allocation according to the slate of final products within PRELIM (Table 4-9).

Table 4-8. Share of total capacity by PRELIM refinery configuration.

	PRELIM Configuration							
		Medium Conversion			Deep Conversion			
PADD	0	1	2	3	4	5	6	7
1	6%	67%	-	-	13%	-	15%	-
2	11%	17%	-	2%	47%	-	24%	-
3	5%	8%	1%	3%	45%	0%	35%	3%
4	27%	18%	-	-	56%	-	-	-
5	8%	10%	6%	9%	37%	12%	19%	-
U.S.	8%	15%	2%	3%	42%	2%	27%	1%



Atmospheric Distillation Final Product Allocation	
Gasoline	0.43
Kerosene	0.11
Diesel	0.31
Asphalt	0.07
Coke	0.04
Liquid Heavy Ends	8.7E-3
LPG	0.02
Petrochemical Feedstock	0.01
Clean RFG	8.0E-3
	1.00

Final Product Allocation Factor Calculation Example: Gasoline

Equation 1: [(1)*(10)]+[(2)*(3)*(5)]+[(2)*(3)*(6)]+[(2)*(4)*(7)]+[(9)*(11)] = 0.43

Equation 2: (0.25*0.92)+(0.09*0.5*0.06)+(0.09*0.5*0.55)+
(0.09*0.5*0.40)+(0.38*0.40) = 0.43

* Numbered flows are used in equation 1

** Grey color is used to highlight product flows used in the example calculation

*** Labels in red refer to PRELIM final products

Figure 4-1. Simplified example of calculating final product allocation factors via PRELIM subprocess output.

Table 4-9. Allocation factors from PRELIM refinery units to PRELIM final products, aggregated nationally.

PRELIM Unit	Blended Gasoline	ULSD	Jet-A/AVTUR	Fuel Oil	Liquefied Petroleum Gas (LPG)	Liquid Heavy Ends	Petrochemical Feedstocks	Asphalt	Coke	Clean RFG	HC Resid
Atmospheric Tower	42%	25%	11%	1%	2%	7%	1%	7%	3%	1%	<0.1%
Naphtha Hydrotreater	92%	<0.1%	<0.1%	<0.1%	4%	-	3%	-	-	1%	<0.1%
Isomerization Unit	99%	-	-	-	1%	-	0.4%	-	-	0.2%	-
Catalytic Naphtha Reformer	90%	<0.1%	<0.1%	<0.1%	5%	-	3%	-	-	2%	<0.1%
Gas Oil Hydrocracker	41%	58%	-	<0.1%	1%	-	0.4%	-	-	0.2%	-
Kerosene Hydrotreater	-	-	100%	-	0.1%	-	0.1%	-	-	<0.1%	-
Kerosene Merox	-	-	100%	-	-	-	-	-	-	-	-
Diesel Hydrotreater	-	100%	-	-	0.1%	-	<0.1%	-	-	<0.1%	-
Vacuum Tower	41%	18%	-	0.0%	2%	11%	1%	18%	8%	1%	0.1%
Fluid Catalytic Cracking Feed Hydrotreater	61%	21%	-	-	2%	8%	1%	7%	-	1%	-
Fluid Catalytic Cracker	61%	21%	-	-	1%	8%	1%	7%	-	1%	-
Coker and Coker Fractionator	45%	13%	-	-	5%	3%	3%	3%	26%	2%	-
Alkylation Unit	100%	-	-	-	-	-	-	-	-	-	-
Residue Hydrocracker	28%	39%	-	-	2%	2%	2%	2%	-	1%	24%
Coker/HC Naphtha Hydrotreater	100%	-	-	-	<0.1%	-	<0.1%	-	-	<0.1%	-
Fuel Gas Treatment and Sulphur Recovery	-	-	-	-	48%	-	35%	-	-	18%	-
Steam-Methane Reformer	61%	32%	3%	<0.1%	1%	0.4%	1%	1%	-	0.5%	0.1%

Subprocess allocation factors developed using PRELIM require a correspondence to EIA final products that serve as the basis for calculated emission factors. This correspondence is reported in Table 3-9. Where a single PRELIM final product (e.g. Jet-A/AVTUR) is matched to multiple EIA products, further allocation (splitting) is required to complete the allocation to EIA final products. Splitting factors are developed for each PADD and are calculated as the PADD level production ratio of EIA final products to which a given PRELIM final product category is matched. For example, emissions allocated to the PRELIM product category Jet-A/AVTUR are split between EIA products finished aviation gasoline, kerosene, and special naphtha based on the relative production volume of these three fuels as reported by EIA and demonstrated as follows.

$$Kerosene\ Splitting\ Factor = \frac{13{,}436{,}334}{109{,}224+13{,}436{,}334+\quad{,}452}\ (m^3) = 98.7\%$$

Table 4-10. Values for PADD 2 Jet-A/AVTUR splitting factor calculation example

PADD	PRELIM Product Category	EIA Product Category	Quantity (m^3-eq)	Splitting Factor
2	Jet-A/AVTUR	Finished Aviation Gasoline	109,224	0.8%
2	Jet-A/AVTUR	Kerosene	13,436,334	98.7%
2	Jet-A/AVTUR	Special Naphthas	73,452	0.5%

Further adjustments were made to the liquid heavy ends splitting factors to minimize the percent difference between EIA reported production and the corresponding quantities estimated using PRELIM as described in Section 4.5 and reported in Table 7-11. First, a fraction of residual fuel oils original splitting factor was allocated to distillate fuel oil bringing both estimates into better alignment. Next, an additional fraction of lubricants, miscellaneous petroleum products, and waxes liquid heavy ends splitting factors were allocated to distillate fuel oil such that PRELIM estimates for these product categories demonstrate between 0 and 9% difference with EIA reported production (Table 7-11).

Emissions from a subset of refinery subprocess (Table 4-4) are allocated directly to final products, independent of PRELIM, based on energy content of products at each PADD (Table 3-11). Subprocess to final product allocation factors are shown in Table 4-11.

4.4. Emission factors by refinery product

Emission factors for final refinery products are calculated by dividing total product emissions, as allocated above, by total product output at each PADD (Table 3-10). Emission factors by PADD for each final product are shown in Table 4-12.

Table 4-11. Refinery subprocess allocation factors to refinery final products, aggregated nationally.

Refinery Subprocess Unit	Finished Motor Gasoline	Motor Gasoline Blending Components	Distillate Fuel Oil	Kerosene	Finished Aviation Gasoline	Special Naphthas	Liquefied Petroleum Gases	Lubricants	Miscellaneous Petroleum Products	Residual Fuel Oil	Waxes	Petrochemical Feedstocks	Petroleum Coke	Asphalt and Road Oil	Still Gas
Alkylation	25%	75%	-	-	-	-	-	-	-	-	-	-	-	-	-
Amine Treating	-	-	-	-	-	-	48%	-	-	-	-	34%	-	-	18%
Asphalt Unit	-	-	-	-	-	-	-	-	-	-	-	-	-	100%	-
Atmospheric Distillation Tower	11%	33%	29%	10%	<0.1%	0.5%	1.8%	1.1%	0.6%	3.1%	<0.1%	1.3%	3.3%	4.6%	0.7%
Catalytic Reformer	23%	68%	<0.1%	<0.1%	<0.1%	<0.1%	4.4%	-	-	-	-	3.1%	-	-	1.7%
Coker	12%	34%	15%	-	-	-	4.7%	0.7%	0.3%	1.3%	<0.1%	3.2%	25%	2.3%	1.8%
Diesel Hydrotreater	-	-	100%	-	-	-	0.1%	-	-	-	-	<0.1%	-	-	<0.1%
Distillate Blending	-	-	100%	-	-	-	-	-	-	-	-	-	-	-	-
Distillate Hydrotreater	25%	75%	-	-	-	-	<0.1%	-	-	-	-	<0.1%	-	-	<0.1%
Fluid Catalytic Cracker	15%	46%	25%	-	-	-	1.4%	1.8%	0.7%	3.8%	<0.1%	1.0%	-	4.5%	0.5%
Gas Processing Plant	-	-	-	-	-	-	48%	-	-	-	-	34%	-	-	18%
Gas/Oil Hydrotreater	10%	31%	57%	-	-	-	0.6%	-	-	-	-	0.4%	-	-	0.2%
Gasoline Blending	100%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gasoline Hydrotreater	23%	70%	<0.1%	<0.1%	<0.1%	<0.1%	3.5%	-	-	-	-	2.5%	-	-	1.3%
Hydrocracker	10%	31%	57%	-	-	-	0.6%	-	-	-	-	0.4%	-	-	0.2%
Hydrogen Plant	16%	47%	31%	2.4%	<0.1%	<0.1%	1.3%	0.2%	0.2%	0.3%	<0.1%	0.9%	-	0.3%	0.5%
Isomerization Plant	26%	73%	-	-	-	-	0.5%	-	-	-	-	0.3%	-	-	0.2%
Kerosene Hydrotreater	-	-	-	95%	0.9%	4.3%	<0.1%	-	-	-	-	<0.1%	-	-	<0.1%
Lubricant Production	-	-	-	-	-	-	-	100%	-	-	-	-	-	-	-
Naphtha Hydrotreater	23%	70%	<0.1%	<0.1%	<0.1%	<0.1%	3.5%	-	-	-	-	2.5%	-	-	1.3%
Other Hydrotreater	15%	46%	25%	-	-	-	1.5%	1.8%	0.7%	3.8%	<0.1%	1.1%	-	4.5%	0.6%
Residual Hydrotreater	25%	75%	-	-	-	-	<0.1%	-	-	-	-	<0.1%	-	-	<0.1%
Sulfur Plant	-	-	-	-	-	-	48%	-	-	-	-	34%	-	-	18%
Thermal Cracking	12%	34%	15%	-	-	-	4.7%	0.7%	0.3%	1.3%	<0.1%	3.2%	25%	2.3%	1.8%
Vacuum Distillation	11%	32%	24%	-	-	-	2.3%	1.9%	1.0%	5.2%	<0.1%	1.7%	9.0%	12%	0.9%

Table 4-12. Refinery final product emission factors (in g / mmBTU of final product).

PADD	Final Product	CO2	CH4	N2O	CO	NOx	PM10	PM2.5	SO2	VOC	PM2.5 - EC	PM2.5 - OC
1	Asphalt and Road Oil	4,100	0.37	0.035	1.0	1.7	0.55	0.48	0.66	0.91	0.053	0.059
2	Asphalt and Road Oil	4,600	1.2	0.037	1.6	1.9	0.78	0.67	1.1	1.6	0.047	0.069
3	Asphalt and Road Oil	5,600	1.9	0.046	1.3	1.7	0.61	0.55	0.81	1.5	0.044	0.055
4	Asphalt and Road Oil	2,900	1.8	0.025	1.5	1.6	0.73	0.46	1.3	2.6	0.025	0.030
5	Asphalt and Road Oil	8,300	0.94	0.053	1.8	2.8	0.65	0.56	1.6	2.0	0.060	0.067
US	Asphalt and Road Oil	4,800	1.3	0.038	1.4	1.8	0.69	0.58	1.0	1.6	0.046	0.060
1	Distillate Fuel Oil	4,700	0.39	0.038	0.95	1.7	0.51	0.44	0.70	0.94	0.052	0.050
2	Distillate Fuel Oil	4,500	0.83	0.038	1.7	2.2	0.68	0.58	1.0	1.7	0.058	0.083
3	Distillate Fuel Oil	4,300	0.77	0.041	1.1	1.7	0.43	0.39	0.59	1.5	0.045	0.060
4	Distillate Fuel Oil	5,000	1.9	0.042	2.4	2.5	1.1	0.61	1.7	3.0	0.046	0.059
5	Distillate Fuel Oil	9,500	0.93	0.056	2.0	3.4	0.78	0.70	1.3	2.1	0.090	0.12
US	Distillate Fuel Oil	5,000	0.82	0.042	1.4	2.0	0.56	0.48	0.82	1.6	0.053	0.071
1	Finished Aviation Gasoline	-	-	-	-	-	-	-	-	-	-	-
2	Finished Aviation Gasoline	3,000	0.78	0.030	1.5	1.9	0.46	0.40	0.82	1.5	0.055	0.082
3	Finished Aviation Gasoline	2,500	0.67	0.027	0.71	1.2	0.24	0.21	0.40	1.4	0.033	0.046
4	Finished Aviation Gasoline	4,800	1.9	0.048	2.7	2.9	0.61	0.28	1.3	2.9	0.059	0.077
5	Finished Aviation Gasoline	1,600	0.68	0.011	0.53	0.78	0.21	0.19	0.29	1.5	0.019	0.030
US	Finished Aviation Gasoline	2,500	0.71	0.025	0.83	1.3	0.28	0.24	0.47	1.4	0.035	0.050
1	Finished Motor Gasoline	7,700	0.53	0.064	2.0	3.4	1.1	0.93	1.1	2.9	0.13	0.13
2	Finished Motor Gasoline	6,400	0.93	0.055	2.4	3.2	1.0	0.86	1.3	3.2	0.093	0.12
3	Finished Motor Gasoline	7,400	0.97	0.070	1.6	2.9	0.74	0.67	0.91	2.9	0.081	0.10
4	Finished Motor Gasoline	8,600	2.0	0.072	4.0	4.3	1.7	1.0	2.5	5.0	0.087	0.10
5	Finished Motor Gasoline	10,000	0.97	0.062	2.2	4.0	0.87	0.78	1.5	5.1	0.11	0.13
US	Finished Motor Gasoline	7,600	1.1	0.066	2.2	3.3	0.95	0.78	1.3	3.4	0.089	0.11
1	Kerosene	2,100	0.29	0.020	0.42	0.82	0.19	0.17	0.18	0.94	0.027	0.034
2	Kerosene	3,000	0.78	0.030	1.5	1.9	0.46	0.40	0.82	1.7	0.055	0.082
3	Kerosene	2,500	0.67	0.027	0.71	1.2	0.24	0.21	0.40	1.5	0.033	0.046
4	Kerosene	4,800	1.9	0.048	2.7	2.9	0.61	0.28	1.3	3.8	0.059	0.077
5	Kerosene	1,600	0.68	0.011	0.53	0.78	0.21	0.19	0.29	1.5	0.019	0.030
US	Kerosene	2,300	0.69	0.023	0.79	1.2	0.27	0.23	0.44	1.5	0.033	0.047
1	LPG	5,700	0.54	0.049	2.7	1.8	0.57	0.50	0.85	0.91	0.061	0.071
2	LPG	6,100	0.89	0.043	2.4	3.0	0.78	0.65	2.5	2.0	0.065	0.093
3	LPG	4,700	0.80	0.034	1.5	1.7	0.45	0.41	1.1	1.6	0.037	0.056
4	LPG	17,000	2.4	0.14	7.9	8.6	4.4	2.8	21	4.8	0.16	0.24
5	LPG	11,000	1.0	0.060	2.8	4.1	0.91	0.79	3.5	2.1	0.094	0.12
US	LPG	5,800	0.84	0.040	2.0	2.2	0.62	0.53	1.9	1.7	0.051	0.073
1	Lubricants	22,000	1.3	0.22	6.7	19	1.4	1.4	22	1.6	0.29	0.22
2	Lubricants	17,000	1.3	0.13	13	10	2.3	1.4	1.4	5.6	0.35	0.30
3	Lubricants	15,000	1.3	0.14	2.9	4.8	1.3	1.2	1.5	3.1	0.17	0.19
4	Lubricants	-	-	-	-	-	-	-	-	-	-	-

PADD	Final Product	CO2	CH4	N2O	CO	NOx	PM10	PM2.5	SO2	VOC	PM2.5 - EC	PM2.5 - OC
5	Lubricants	15,000	1.3	0.12	1.9	4.0	0.84	0.79	1.0	3.8	0.13	0.18
US	Lubricants	16,000	1.3	0.15	3.6	6.0	1.3	1.2	3.0	3.2	0.19	0.20
1	Misc Petroleum Products	3,000	0.32	0.025	0.80	1.3	0.41	0.36	0.53	0.82	0.039	0.042
2	Misc Petroleum Products	2,700	0.75	0.023	1.1	1.2	0.50	0.42	0.87	1.4	0.026	0.038
3	Misc Petroleum Products	4,600	0.76	0.038	1.1	1.4	0.51	0.46	0.69	1.4	0.037	0.047
4	Misc Petroleum Products	3,200	1.8	0.028	1.6	1.6	0.85	0.55	1.5	2.5	0.028	0.034
5	Misc Petroleum Products	3,700	0.76	0.025	0.99	1.5	0.36	0.32	0.76	1.6	0.033	0.042
US	Misc Petroleum Products	4,100	0.78	0.033	1.1	1.4	0.50	0.43	0.76	1.5	0.034	0.044
1	Motor Gasoline Blending Components	7,700	0.53	0.064	2.0	3.4	1.1	0.93	1.1	1.0	0.13	0.13
2	Motor Gasoline Blending Components	6,400	0.93	0.055	2.4	3.2	1.0	0.86	1.3	1.8	0.093	0.12
3	Motor Gasoline Blending Components	7,400	0.97	0.070	1.6	2.9	0.74	0.67	0.91	1.7	0.081	0.10
4	Motor Gasoline Blending Components	8,600	2.0	0.072	4.0	4.3	1.7	1.0	2.5	3.5	0.087	0.10
5	Motor Gasoline Blending Components	10,000	0.97	0.062	2.2	4.0	0.87	0.78	1.5	2.1	0.11	0.13
US	Motor Gasoline Blending Components	7,700	0.94	0.065	2.0	3.2	0.87	0.76	1.1	1.7	0.092	0.11
1	Petrochemical Feedstocks	38,000	2.6	0.33	18	12	3.7	3.2	5.3	2.0	0.41	0.47
2	Petrochemical Feedstocks	12,000	1.1	0.083	4.5	5.7	1.5	1.3	4.4	2.8	0.13	0.18
3	Petrochemical Feedstocks	3,700	0.74	0.027	1.3	1.3	0.36	0.33	0.92	1.5	0.029	0.045
4	Petrochemical Feedstocks	-	-	-	-	-	-	-	-	-	-	-
5	Petrochemical Feedstocks	1,700,000	61	9.4	410	620	130	110	530	130	15	18
US	Petrochemical Feedstocks	6,000	0.84	0.042	2.0	2.3	0.59	0.52	1.6	1.7	0.052	0.074
1	Petroleum Coke	4,100	0.37	0.032	0.28	0.52	0.25	0.22	0.14	0.77	0.020	0.022
2	Petroleum Coke	1,700	0.82	0.018	0.86	1.2	0.36	0.23	0.71	1.6	0.030	0.044
3	Petroleum Coke	2,100	0.92	0.025	0.72	1.1	0.23	0.20	0.38	1.4	0.027	0.042
4	Petroleum Coke	2,500	1.8	0.024	1.7	1.8	0.85	0.41	2.2	2.7	0.026	0.035
5	Petroleum Coke	2,800	0.85	0.023	1.3	1.7	0.40	0.36	0.72	1.7	0.036	0.055
US	Petroleum Coke	2,300	0.89	0.024	0.85	1.2	0.30	0.24	0.54	1.5	0.029	0.044
1	Residual Fuel Oil	2,200	0.28	0.018	0.63	0.98	0.31	0.27	0.41	0.79	0.029	0.032
2	Residual Fuel Oil	2,700	0.74	0.023	1.1	1.2	0.52	0.45	0.87	1.7	0.027	0.039
3	Residual Fuel Oil	3,400	0.70	0.028	0.94	1.0	0.40	0.36	0.57	1.5	0.026	0.033
4	Residual Fuel Oil	2,700	1.8	0.023	1.4	1.4	0.70	0.45	1.3	2.9	0.023	0.028
5	Residual Fuel Oil	3,700	0.76	0.025	0.98	1.5	0.36	0.32	0.75	1.7	0.033	0.042
US	Residual Fuel Oil	3,200	0.70	0.025	0.94	1.2	0.40	0.35	0.66	1.5	0.028	0.036
1	Special Naphthas	2,300	0.30	0.021	0.44	0.86	0.20	0.18	0.18	0.82	0.029	0.036
2	Special Naphthas	3,200	0.79	0.032	1.5	2.0	0.49	0.42	0.84	1.5	0.058	0.086
3	Special Naphthas	2,600	0.68	0.029	0.73	1.2	0.25	0.23	0.42	1.4	0.035	0.049
4	Special Naphthas	-	-	-	-	-	-	-	-	-	-	-
5	Special Naphthas	1,700	0.68	0.011	0.55	0.82	0.22	0.20	0.30	1.5	0.020	0.031
US	Special Naphthas	2,600	0.67	0.028	0.75	1.2	0.26	0.23	0.43	1.4	0.035	0.049
1	Still Gas	1,300	0.27	0.011	0.70	0.50	0.15	0.13	0.25	0.77	0.014	0.018

PADD	Final Product	CO2	CH4	N2O	CO	NOx	PM10	PM2.5	SO2	VOC	PM2.5 - EC	PM2.5 - OC
2	Still Gas	1,400	0.69	0.010	0.77	0.78	0.21	0.17	0.95	1.3	0.016	0.024
3	Still Gas	1,400	0.61	0.010	0.68	0.56	0.16	0.14	0.45	1.3	0.012	0.018
4	Still Gas	1,900	1.7	0.015	1.2	1.2	0.45	0.29	2.6	2.4	0.017	0.025
5	Still Gas	1,400	0.67	8.0E-3	0.56	0.64	0.19	0.17	0.55	1.4	0.013	0.022
US	Still Gas	1,400	0.65	0.010	0.69	0.64	0.18	0.15	0.62	1.3	0.013	0.020
1	Waxes	2,900	0.32	0.025	0.79	1.3	0.40	0.35	0.52	0.82	0.038	0.042
2	Waxes	2,700	0.74	0.022	1.1	1.2	0.49	0.42	0.87	1.4	0.026	0.037
3	Waxes	4,000	0.73	0.033	1.0	1.2	0.47	0.42	0.64	1.4	0.031	0.038
4	Waxes	-	-	-	-	-	-	-	-	-	-	-
5	Waxes	-	-	-	-	-	-	-	-	-	-	-
US	Waxes	3,800	0.72	0.031	1.0	1.2	0.47	0.42	0.68	1.4	0.030	0.038

4.5. Validating final product emission factors

Final product allocation factors are used to assign subprocess emissions reported in the NEI and GHGRP to EIA final refinery products. Allocation factors do not affect the quantity of emissions included in the LCI at a facility, PADD, or national level. Allocation factors do affect the distribution of those emissions to individual products, which ultimately determines the relative environmental impacts of each. Several validations have been performed to provide confidence that process flows represented in the PRELIM model provide a reasonable representation of the U.S. petroleum refining sector. The first validation step compares subprocess throughput information from the EIA refinery capacity dataset to estimates derived via PRELIM for each facility. The second validation step uses PRELIM final production estimates for each configuration to calculate PADD and national level final production estimates based on crude input quantities estimated using the EIA refinery capacity dataset and comparing them to EIA reported production. The final validation step compares refinery final product emission factors to existing emission factors from other data sources.

Validation of refinery unit process throughput values by comparing to PRELIM results

The comparison between PRELIM and the EIA refinery capacity dataset is made based on ratios between subprocess throughput and facility crude input. The value that is compared between PRELIM and EIA reflects the fraction of crude input at each facility that is subject to processing in each subprocess unit. Using this metric, a comparison can be made that is independent of facility size, which allows facilities to be compared directly and is required by PRELIM as it does not allow specification of facility crude throughput capacity. PRELIM provides results for a facility with approximately 100,000 barrels per day of utilized processing capacity. The exact throughput varies slightly depending on crude type selected. Percent difference between EIA and PRELIM estimates for each facility are calculated using the equation below:

$$\text{Percent Difference Validation: } \frac{\text{PRELIM throughput ratio} - \text{EIA throughput ratio}}{\text{EIA throughput ratio}}$$

The comparison is performed for the 130 U.S. petroleum refineries that demonstrate both a reasonable match with the nine available PRELIM refinery configurations as reported in Cooney et al. (2016) and have the necessary EIA information. The results of the percent difference validation are presented in a series of histograms: Figure 4-2 through Figure 4-9. Seven quantitative bins are defined along the x-axis of each figure; negative percent difference values indicate PRELIM throughputs less than those reported by EIA. Two additional bins indicate that the assigned PRELIM configuration predicts the presence (or absence) of a subprocess unit that is absent (or present) in the petroleum refining facility as reflected in the EIA refinery capacity dataset. Presence of a significant number of added or missing units in PRELIM directly affects the calculation of allocation factors, particularly for process units that produce multiple product outputs such as FCC, hydrocracking, and coking subprocess units. No validation is performed for atmospheric distillation capacity. It is assumed that 100 percent of crude inputs are treated in the atmospheric distillation subprocess.

Figure 4-2 describes the validation comparison for facility level vacuum distillation capacity. The figure indicates that PRELIM tends to underestimate vacuum distillation capacity at facilities that include this unit process. Seventeen of the 130 facilities reflected in the figure have vacuum distillation towers as indicated by the EIA refinery capacity datasets, which are not recognized by the assigned PRELIM configuration. PRELIM assumes that simple hydroskimming facilities do not include vacuum distillation capacity, which is not always the case as indicated by EIA. The consequence of missing vacuum distillation units will be an under representation of vacuum distillation products in the final product allocation factors.

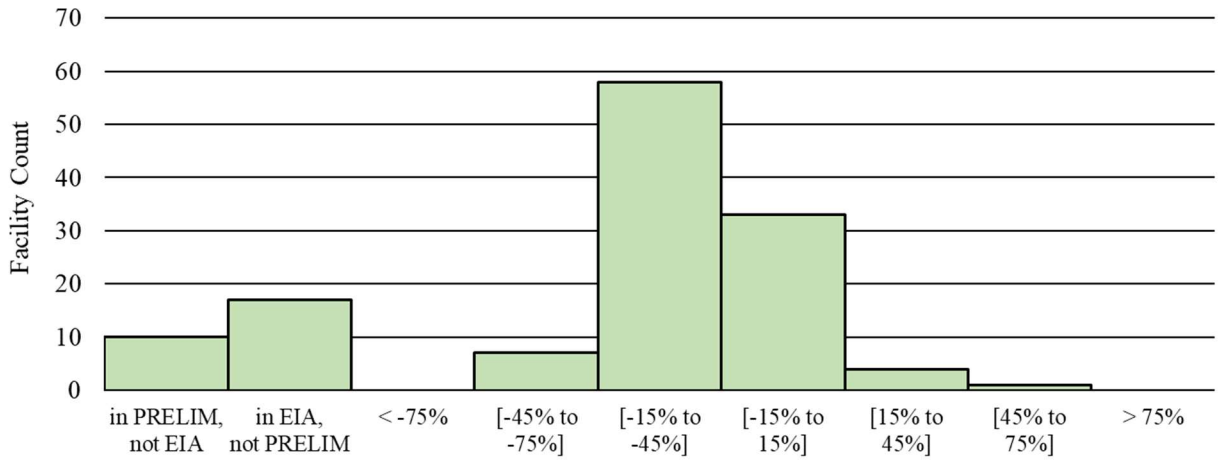


Figure 4-2. Comparison of PRELIM and EIA estimates of vacuum distillation utilization per bbl of crude input, [Throughput$_{PRELIM}$–Throughput$_{EIA}$]/Throughput$_{EIA}$.

Figure 4-3 describes the validation comparison at a facility level for the FCC subprocess. Sixty-seven of the 130 refining facilities generate a percent difference value of between negative and positive 15%. This bin includes facilities that do not include an FCC unit, and for which there is agreement on this determination between EIA and PRELIM. The figure indicates that more FCC capacity is present in U.S. refining facilities than is estimated using PRELIM with the described settings.

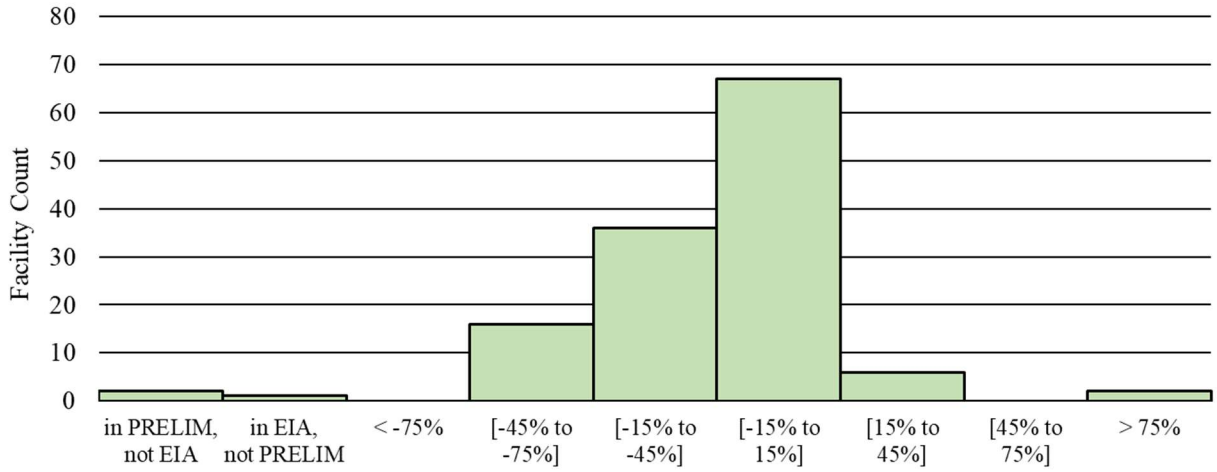


Figure 4-3. Comparison of PRELIM and EIA estimates of fluid catalytic cracker utilization per bbl of crude input, [Throughput$_{PRELIM}$–Throughput$_{EIA}$]/Throughput$_{EIA}$.

Figure 4-4 describes the validation comparison at a facility level for aggregated coking capacity utilization. The figure combines EIA reported charge capacities for delayed and fluid coking. Seventy-eight of the refining facilities demonstrate a percent difference value of less than 15%. The histogram indicates that PRELIM tends to underestimate utilization of coking units at the facility level for refineries that including coking capacity, causing coking products to be underrepresented within the PRELIM based allocation factors.

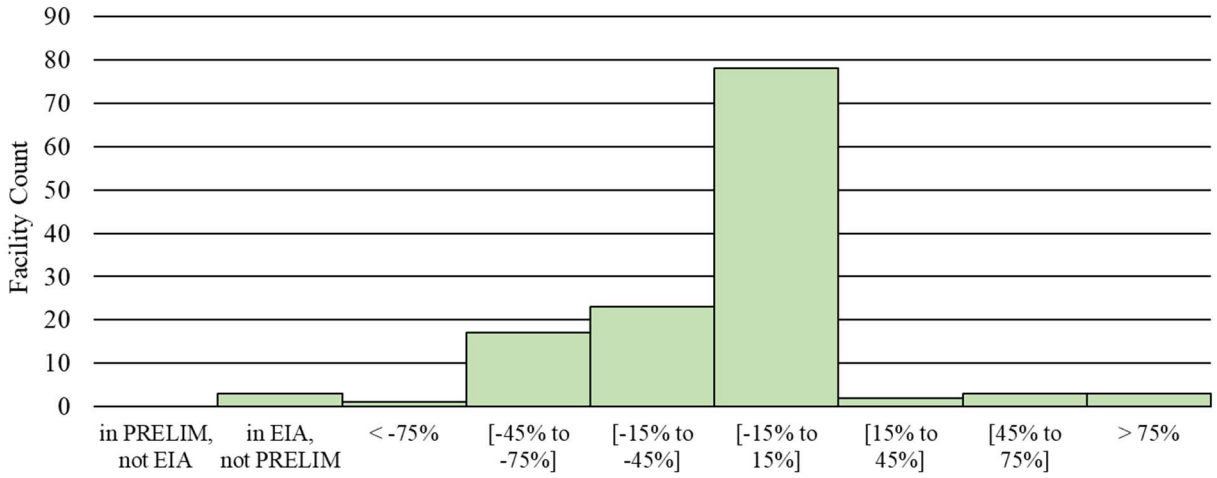


Figure 4-4. Comparison of PRELIM and EIA estimates of coking utilization per bbl of crude input, [Throughput$_{PRELIM}$–Throughput$_{EIA}$]/Throughput$_{EIA}$.

Figure 4-5 describes the validation comparison at a facility level for gas oil catalytic hydrocracking. Very few added or missing units between PRELIM and EIA reflects well on representation of this unit process within PRELIM and the resulting allocation factors.

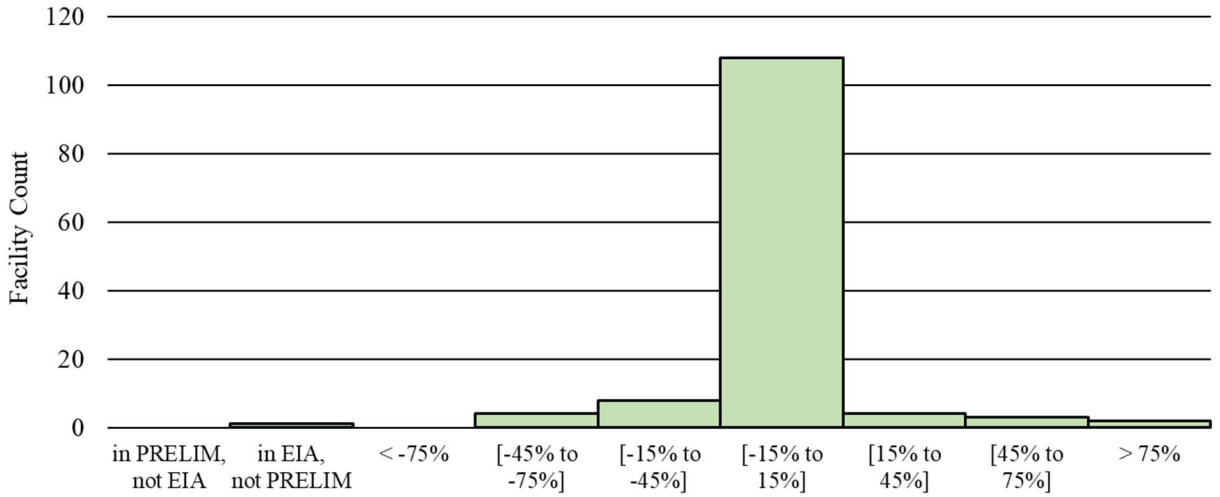


Figure 4-5. Comparison of PRELIM and EIA estimates of gas oil catalytic hydrocracking utilization per bbl of crude input, [Throughput$_{PRELIM}$–Throughput$_{EIA}$]/Throughput$_{EIA}$.

Figure 4-6 describes the validation comparison for aggregated hydrotreating capacity utilization at each refinery. Both EIA and PRELIM report hydrotreater use for specific intermediate product categories. These categories are not in alignment between the two datasets necessitating the aggregation to cumulative hydrotreating capacity. All PRELIM configurations include the presence of hydrotreating. EIA data indicates that 17 of the 130 refineries do not hydrotreat product flows. For those refineries that do hydrotreat product flows, the figure indicates that PRELIM overestimates hydrotreating throughput.

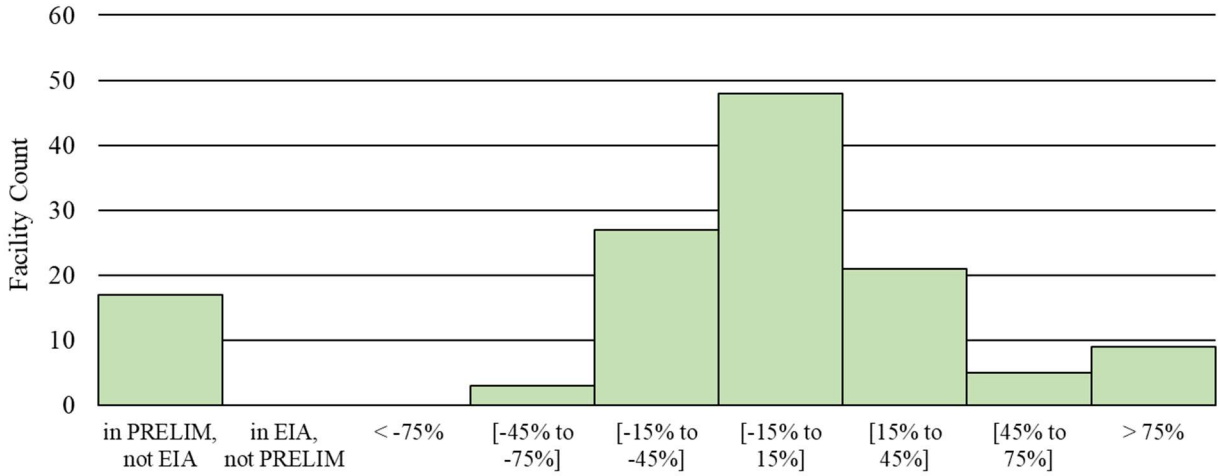


Figure 4-6. Comparison of PRELIM and EIA estimates of total hydrotreating utilization per bbl of crude input, [Throughput$_{PRELIM}$–Throughput$_{EIA}$]/Throughput$_{EIA}$.

Figure 4-7 describes the validation comparison at a facility level for the catalytic reforming subprocess. Calculated validation numbers are roughly centered around no percent difference indicating that on average the PRELIM model should not skew results for this unit process. All PRELIM configurations reflect the presence of a catalytic reforming unit. The EIA refinery capacity dataset indicates that 25 of the 130 represented facilities do not include a catalytic

reformer. This discrepancy between EIA reported capacity and the PRELIM capacity estimate for this subprocess does not have a material effect on product allocation given that catalytic reforming both accepts and produces products destined for the gasoline blending pool.

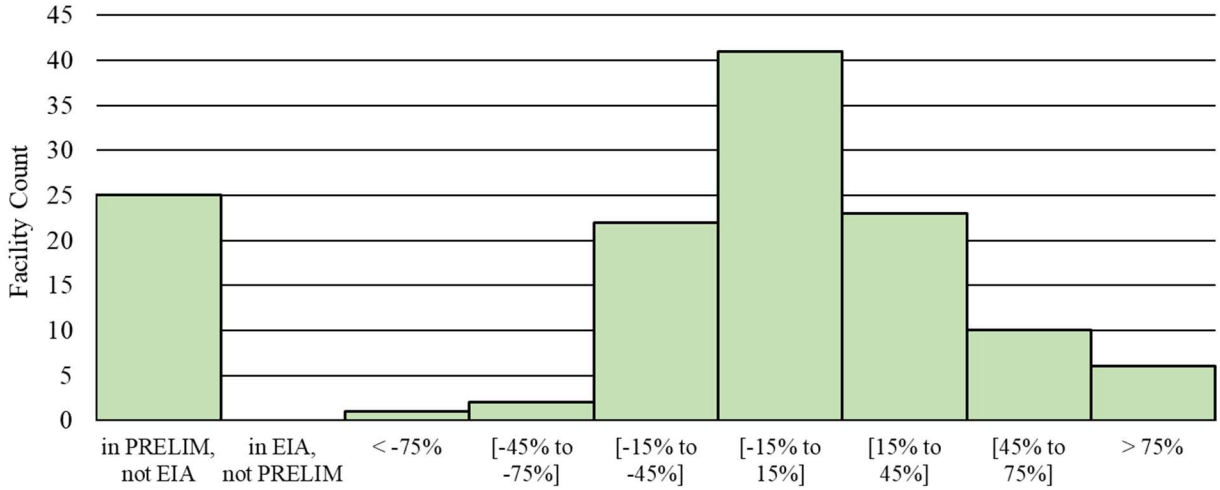


Figure 4-7. Comparison of PRELIM and EIA estimates of catalytic reformer utilization per bbl of crude input, [Throughput$_{PRELIM}$–Throughput$_{EIA}$]/Throughput$_{EIA}$.

Figure 4-8 describes the validation comparison at a facility level for the aggregated isomerization subprocess, which includes EIA estimates for isobutane, isooctane, and isopentane. The presence of isomerization units is significantly overestimated based on PRELIM, which assumes that isomerization is present in all refinery configurations. Isomerization is not a defining unit process in refineries however, and given that both the inputs and outputs of this subprocess are destined for the gasoline blending pool there is minimal effect on final product allocation factors.

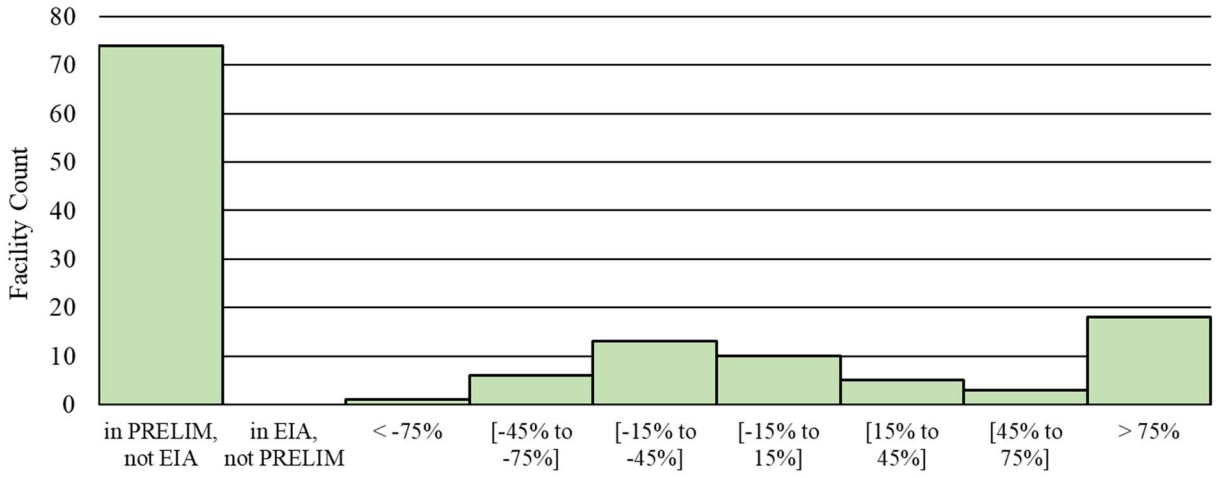


Figure 4-8. Comparison of PRELIM and EIA estimates of isomerization utilization per bbl of crude input, [Throughput$_{PRELIM}$–Throughput$_{EIA}$]/Throughput$_{EIA}$.

Figure 4-9 describes the validation comparison at a facility level for the alkylation subprocess. The figure indicates that PRELIM tends to underestimate alkylation capacity at refineries. This is exacerbated by the small fraction of facility crude input capacity that is typically processed by the alkylation unit. Underrepresentation of alkylation within PRELIM will contribute to lower estimates of products within the gasoline blending pool.

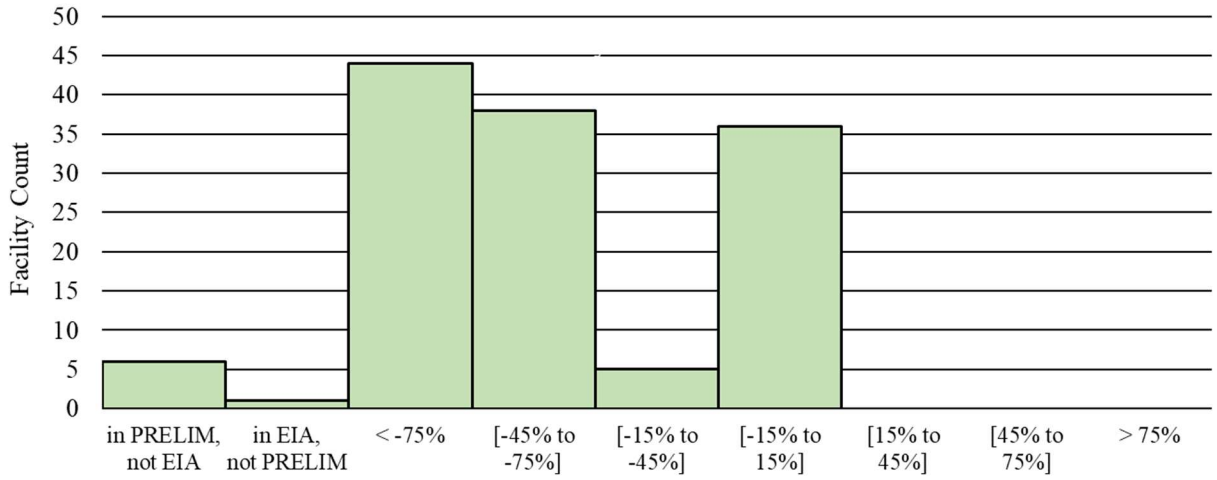


Figure 4-9. Comparison of PRELIM and EIA estimates of alkylation utilization per bbl of crude input, [Throughput$_{PRELIM}$–Throughput$_{EIA}$]/Throughput$_{EIA}$.

Validation of assumed PRELIM refinery configurations by comparing product slates at the PADD level

A further validating check has been performed to see how PADD level production estimates based on PRELIM product allocations and EIA estimates of crude input capacity approximate EIA records of PADD level final product production. Mass based production fractions are extracted from PRELIM for each refinery configuration according to the PRELIM settings described in Section 4.3. These fractions are applied to facility crude throughput capacity calculated from the 2014 EIA refinery capacity dataset to estimate refinery production in the year 2014 based on a facility's assigned PRELIM configuration. PRELIM final products are matched to EIA final products as reported in Table 3-9. In cases where a PRELIM product category is matched to multiple EIA products, the splitting factors described in Section 4.3 are used to disaggregate PRELIM product estimates into the corresponding EIA product categories.

The sum of all facility production estimates is compared between EIA and PRELIM. The results of that comparison are detailed in Table 4-13. The percent difference of total product by PADD between the two sets of values ranges between -6 and -9%, giving high confidence in the capacity utilization calculations performed to convert capacity records present in the EIA refinery capacity dataset to estimates of annual crude input to each facility.

Table 4-13. EIA total production compared to PRELIM total production estimates, in metric tonnes.

PADD	EIA production	PRELIM production	Percent Difference
1	56,690,289,906	53,144,011,954	-6%
2	177,801,379,434	168,352,602,309	-5%
3	437,964,540,736	400,964,360,170	-8%
4	28,455,221,053	27,193,447,347	-4%
5	128,772,225,235	120,350,698,859	-7%
US	829,683,656,364	770,005,120,639	-7%

Product	EIA production	PRELIM production	Percent Difference
Asphalt and Road Oil	19,242,543	16,727,264	-13%
Distillate Fuel Oil	238,210,383	244,949,754	3%
Finished Aviation Gasoline	572,510	691,634	21%
Finished Motor Gasoline	72,577,093	71,241,915	-2%
Kerosene	73,152,873	85,043,963	16%
Liquefied Petroleum Gases	19,261,480	16,076,129	-17%
Lubricants	9,561,882	7,910,301	-17%
Miscellaneous Petroleum Products	3,678,558	4,144,625	13%
Motor Gasoline Blending Components	266,753,654	260,782,258	-2%
Petrochemical Feedstocks	13,143,175	11,258,341	-14%
Petroleum Coke	58,125,866	26,950,189	-54%
Residual Fuel Oil	24,998,653	21,593,155	-14%
Special Naphthas	1,770,509	2,295,249	30%
Still Gas	28,226,650	-	-100%
Waxes	407,827	340,341	-17%

Percent difference between EIA and PRELIM estimates for 14 EIA product categories are listed in Appendix Table 7-11. Figure 4-10 shows a summary of this comparison. The histogram counts the number of PADD-product pairs (70 in total) that fall into each of the defined bins. Fifty-seven percent of product estimates are within 20% of the EIA reported value, while 80% of product estimates are within 50% of the EIA reported value. The largest differences often occur only in a single PADD for any given product, and are more commonly associated with more marginal refinery products that have lower production volumes and tend to vary more significantly in production between refineries.

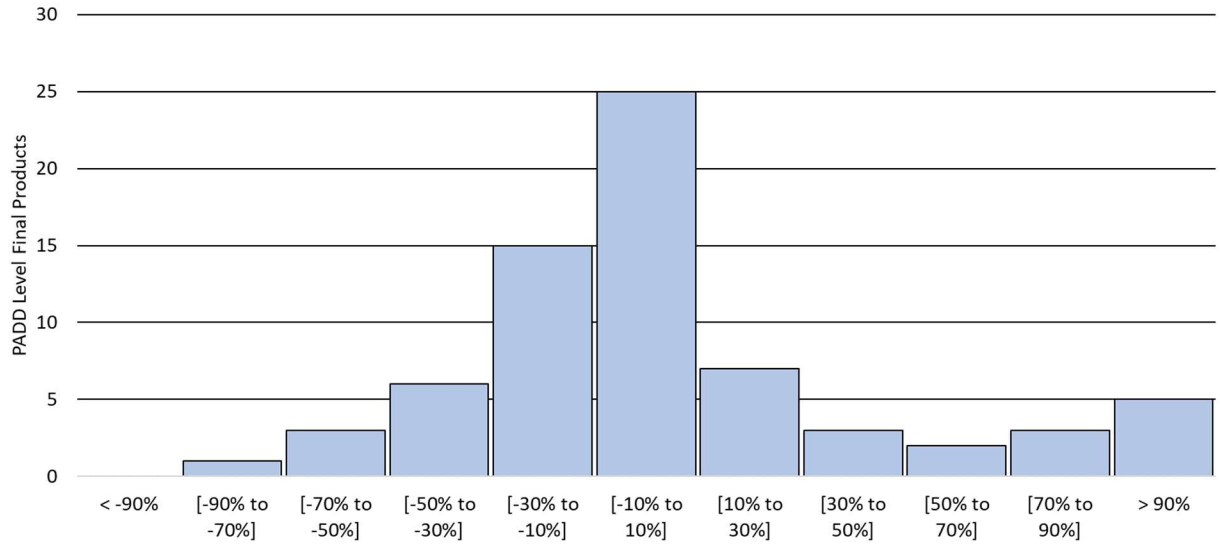


Figure 4-10. Histogram representing the percent difference in EIA reported and PRELIM estimated production of 14 products for each PADD.

Comparison to existing emission factors

Emission factors for refinery final products are compared to existing emission factors from Cooney et al. (2017), PRELIM, and the Argonne Linear Programming Model (unpublished) in Figure 4-11. To enable comparisons across sources, some final product categories used in this study are combined and reflect a production weighted average. Emission factors are not available for all products from all sources. Error bars on emission factors sourced from PRELIM represent ranges based on refinery configuration. Difference in allocation method likely explain discrepancies between emission factors from this study and the Argonne model; higher emission factors for one refinery product are offset by lower emission factors for another.

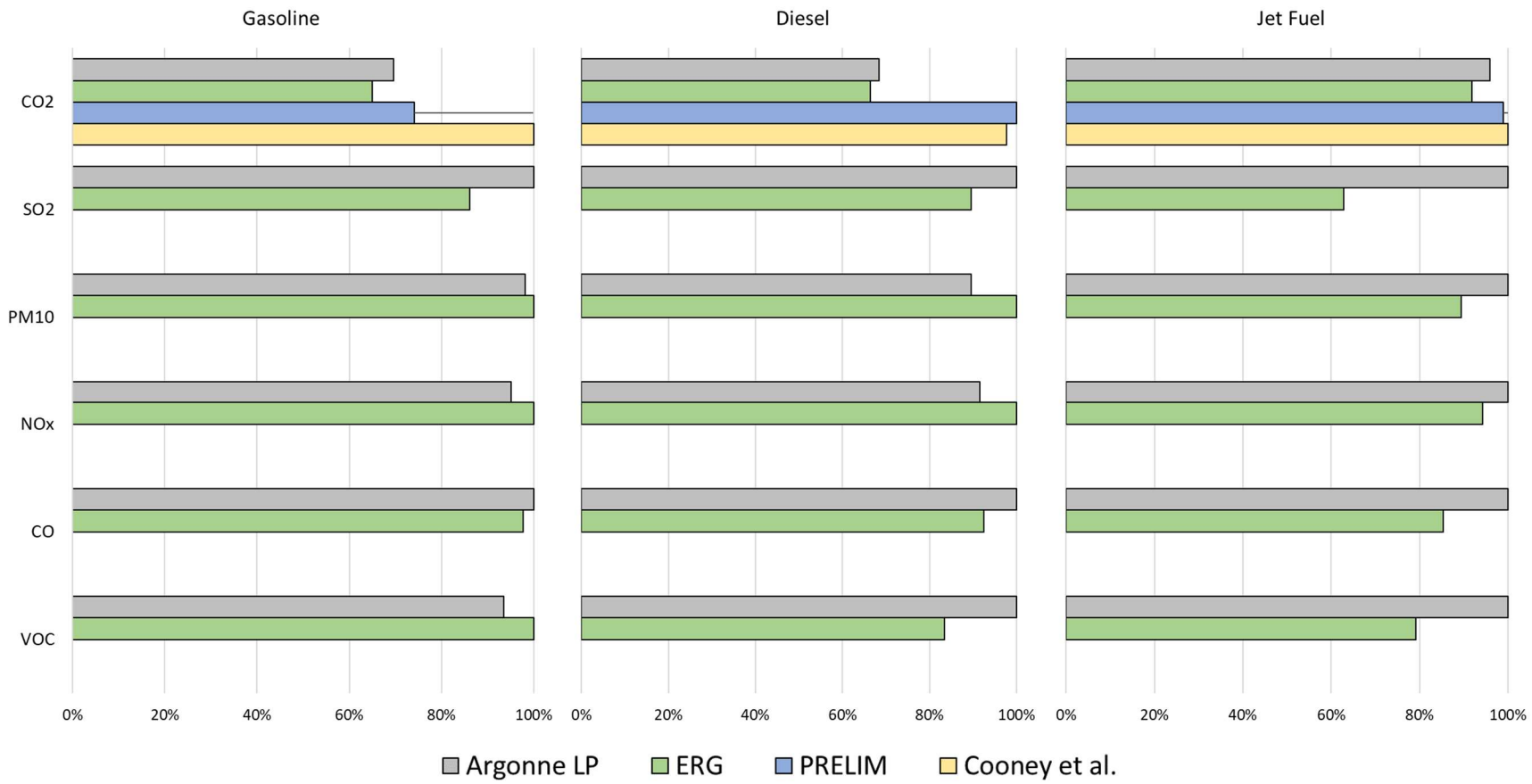


Figure 4-11. Comparison of refinery final product emission factors. Emissions factors for each pollutant are normalized to the maximum emissions factor for that pollutant.

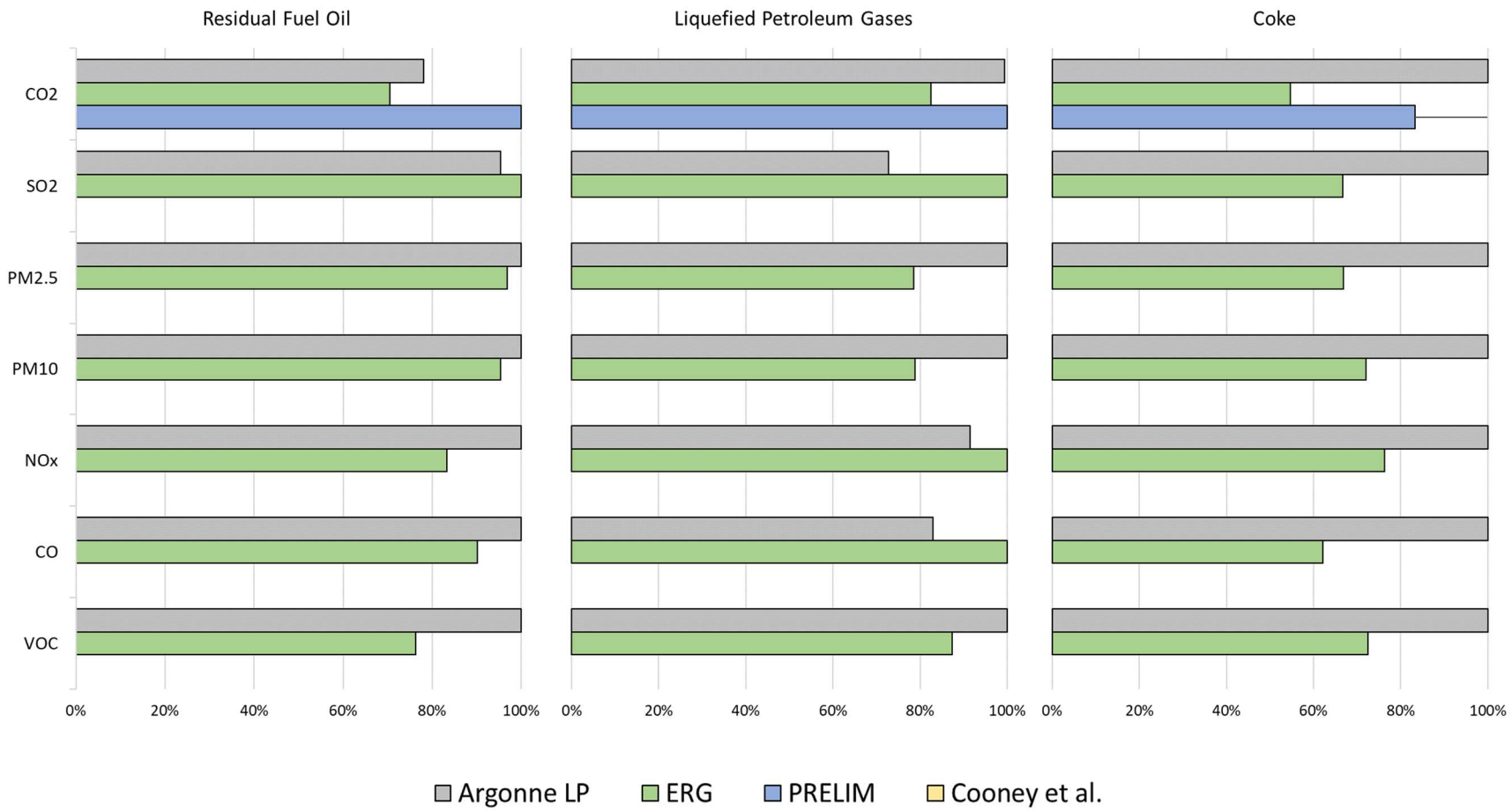


Figure 4-11 (cont'd). Comparison of refinery final product emission factors. Emissions factors for each pollutant are normalized to the maximum emissions factor for that pollutant.

5. Combustion-related Emission Factors by fuel type at Refineries

This section describes the creation of greenhouse gas and criteria pollutant emission factors for combustion of various fuels used at refineries. Combustion processes drive a significant portion of refinery emissions. In this section, fuel combustion related emissions are normalized to fuel use to develop fuel-specific combustion emission factors. The NEI and GHGRP emission datasets are used to update and/or validate current combustion emission factors at refineries by fuel type in GREET.

5.1. Classifying combustion emissions by fuel type

A subset of emissions from each dataset are categorized as combustion emissions and categorized by fuel type. In the NEI, the descriptions of combustion-related SCCs also provide information regarding the fuel used including: coal, distillate, liquefied petroleum gases (LPG), residual fuel oil, natural gas, refinery gas, and other combustion fuels. *Other* combustion fuels are an aggregation of gasoline, jet fuel, and combustion of waste products (U.S. EPA, 2016c). Emissions from combustion for heat at specific refinery units such as the coker (coker blast furnace) or Fluid Catalytic Cracker (CO boilers) are also categorized by fuel type. Direct emissions from the FCC are from catalytic coke combustion. Combustion emissions from flares are excluded as they are not a source of energy at the refinery. A full list of combustion related SCCs classified by fuel type can be found in the Appendix (Table 7-6).

Combustion emissions for each fuel are summed to the national or PADD level. Only facilities that have been matched across NEI and EIA datasets are included in the emission aggregation. If no record of emissions exists for a facility, that facility's share of total crude throughput in the EIA Refinery Capacity dataset is excluded from the fuel consumption amount used to calculate the emissions factor (Table 3-8).

In the GHGRP Subpart C, facilities report combustion emissions of greenhouse gases and fuel type for all combustion units (i.e. boilers and process heaters) (Table 3-3). Emissions related to coke burn-off from the fluid catalytic converter are reported separately under Subpart Y. Combustion emissions for each fuel are summed to the national or PADD level (Figure 5-1). Only facilities that have been matched across the GHGRP and EIA datasets are included in the emission aggregation.

The number of facilities within each dataset that report any emissions from combustion of a given fuel type is shown in Table 5-1. Combustion of natural gas, refinery gas, and refinery catalyst coke is common across refineries, while combustion of coal, LPG, and residual oil is more rare.

Table 5-1. Count of facilities reporting combustion emissions by fuel type.

	Facilities Reporting			
Combustion Fuel	**NEI**		**GHGRP**	
Coal	3	(2%)	1	(1%)
Coke	74	(58%)	93	(72%)
Distillate	89	(70%)	50	(39%)
LPG	10	(8%)	3	(2%)
Residual Oil	29	(23%)	9	(7%)
Natural Gas	95	(74%)	113	(88%)
Refinery Gas	98	(77%)	124	(96%)
Other	32	(25%)	51	(40%)
Any Combustion Type	123	(96%)	129	(100%)
Total Facility Count	*128*		*129*	

At the national level, most combustion related emissions from refineries are from the use of refinery gas and natural gas, followed by refinery catalyst coke, together accounting for between 91% and 100% of emissions across pollutant species tracked here (Figure 5-1). Together these three fuel sources produce 99% of total energy generated on-site. The use of other fuels such as coal, distillate, and residual fuel oils varies across PADDs but is only a minor contributor to emissions totals.

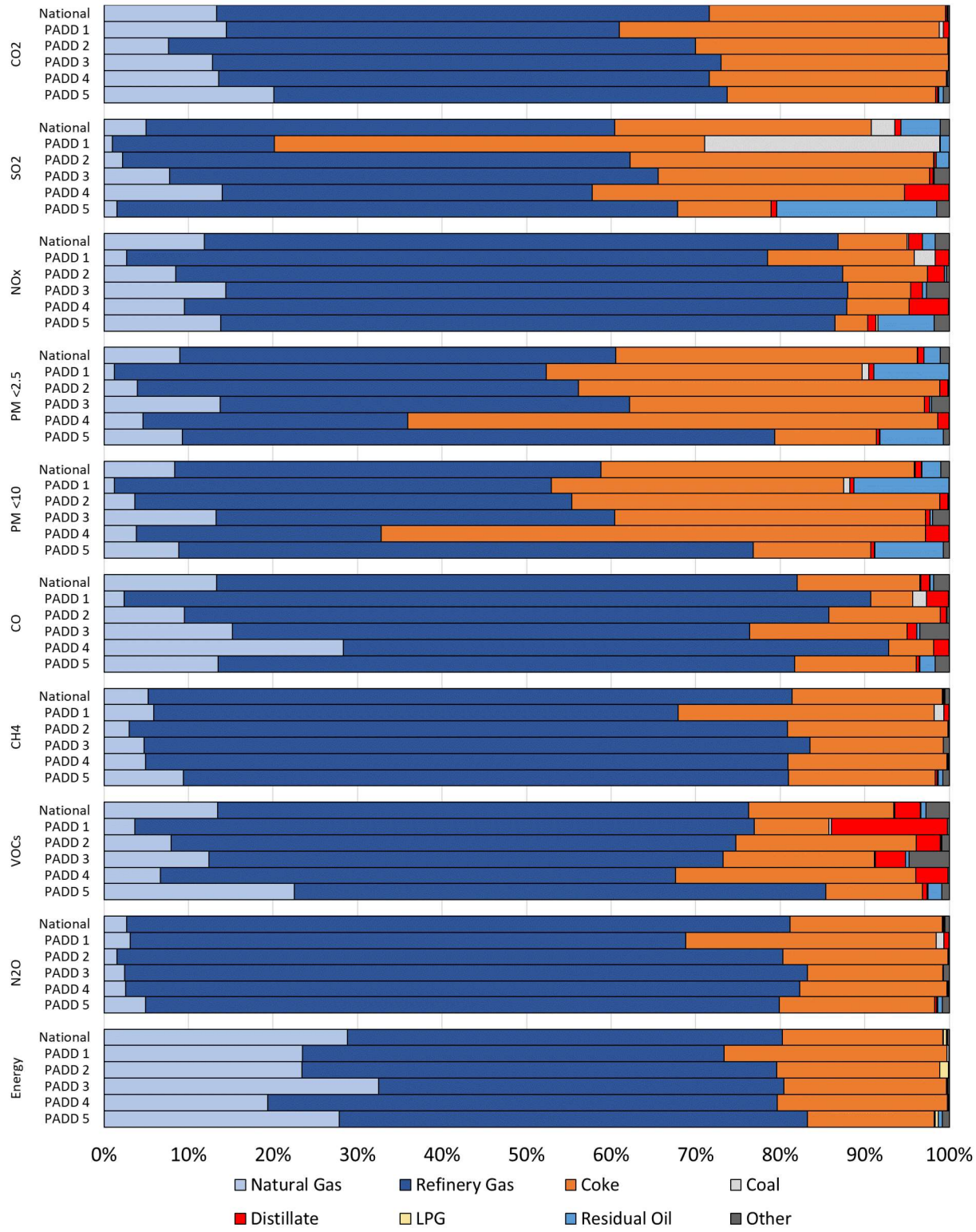


Figure 5-1. Contributions of fuel type to combustion emissions at each PADD.

Rationale for a combined emissions factor for natural gas and refinery gas

Because refinery gas and natural gas are often used in the same combustion units at refineries, emissions reported for each of these fuels include emissions associated with combustion of both fuels. Refinery operators likely adjust the gas supply to heaters and boilers depending on current refinery and market conditions. Based on discussions with experts familiar with GHGRP Subpart C at petroleum refineries, we expect that facilities are likely reporting the fuel type that is most common at a given heater or boiler, while calculating emissions based on the actual fuel mix. A number of individual facilities report no refinery gas consumption or no natural gas consumption, both of which are unlikely. An expert involved in the compilation of the GHGRP confirmed limited quality assurance is performed for the "fuel type" field in the GHGRP dataset (J. Crenshaw, personal communication, 6/8/2017). For this reason, we determined it is best to create emissions factors reflective of the mix of refinery gas and natural gas used nationally and in each PADD.

The decision not to create separate emissions factors for natural gas and refinery gas was made when we found that carbon dioxide emissions factor estimates from reported natural gas combustion are significantly lower than expected, while emissions from reported refinery gas consumption are significantly higher than expected. Carbon dioxide releases from fuel combustion should be consistent across combustion technologies, depending predominantly on the carbon content of the fuel. The GHGRP does not release fuel consumption amounts. However, we can estimate fuel consumption at individual refineries using the GHGRP default emission factors by fuel type (Natural gas: 53,060 g CO_2 / mmBTU; Refinery gas: 59,000 g CO_2 / mmBTU; U.S. EPA, 2017). Figure 5-2 shows that estimates of natural gas consumption based on the default are lower than EIA reported amounts across all PADDs. Additionally, estimates of total use of natural gas and refinery gas based on back-calculating fuel use from carbon dioxide emissions is 5% higher than EIA reported fuel use nationally with the differences ranging between 2% and 16% at the PADD level. Together, these support the hypothesis that in aggregate, facilities are reporting a subset of emissions from natural gas combustion as refinery gas and supports the approach for combining emissions factors for natural gas and refinery gas.

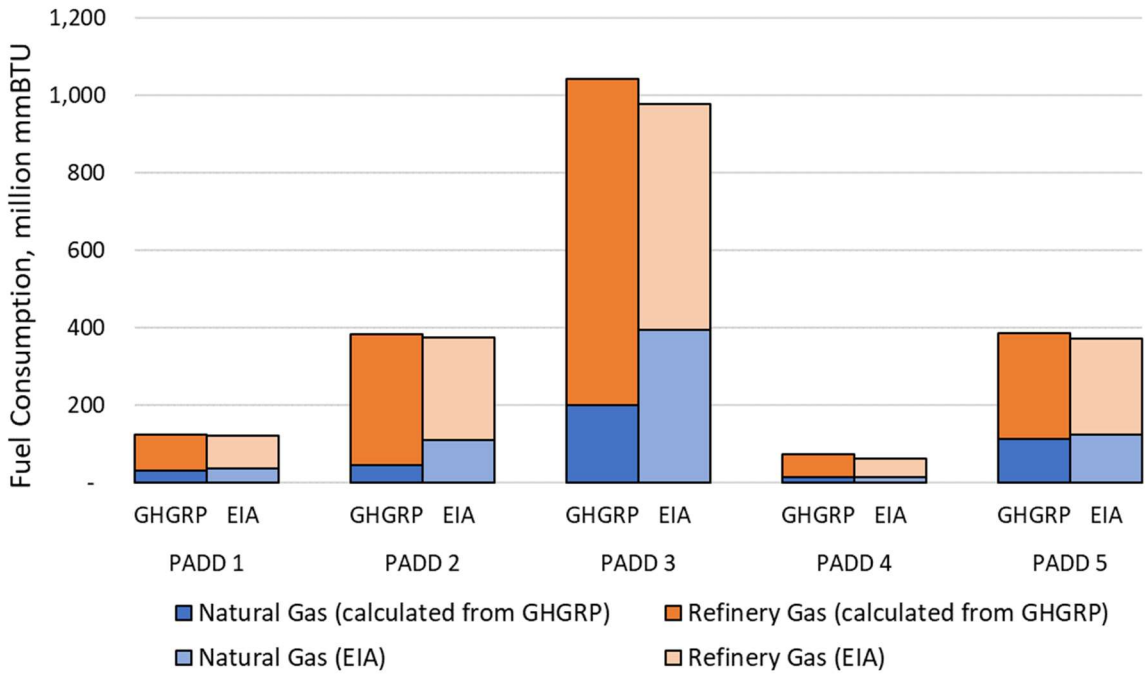


Figure 5-2. Comparing EIA fuel consumption at refineries to estimated fuel consumption calculated from GHGRP reported CO2 emissions.

5.2. Emission factors by fuel type

Emission factors by fuel type are calculated by dividing total emissions by total fuel consumption as calculated in section 3.4. Emission factors are calculated for the fuels which are included in both datasets at the national and PADD levels (Table 5-1). Total emissions, fuel use, and emission factors by PADD for each fuel type and pollutant are shown in Table 5-2 to Table 5-5. Individual emission factor tables for natural gas and refinery gas are provided in the Appendix for transparency, but are not recommended for use (Table 7-7, Table 7-8). Emission factors for coal and LPG are also shown in the appendix for transparency but are not recommended for use, for reasons discussed in section 5.3. The emissions tracked include greenhouse gases and criteria air pollutants as well as the organic carbon (OC) and elemental carbon (EC) contributions to PM2.5.

Table 5-2. Results for catalyst coke combustion emission factors.

Coke	Emissions (MT)						Emission Factor (g/mmBTU fuel)					
Pollutant	National	PADD 1	PADD 2	PADD 3	PADD 4	PADD 5	National	PADD 1	PADD 2	PADD 3	PADD 4	PADD 5
CO2	45,000,000	4,500,000	9,600,000	22,000,000	1,600,000	7,400,000	100,000	100,000	110,000	96,000	100,000	110,000
SO2	6,500	1,100	1,500	2,900	500	520	14	25	17	12	32	8.0
NOx	6,000	930	1,700	2,600	230	520	13	21	19	11	15	8.0
PM <2.5um	5,100	480	1,600	2,300	490	230	11	11	18	9.6	31	3.5
EC	3.6	0.34	1.2	1.6	0.34	0.16	7.9E-3	7.7E-3	0.013	6.7E-3	0.022	2.5E-3
OC	0.70	0.065	0.23	0.31	0.067	0.031	1.5E-3	1.5E-3	2.5E-3	1.3E-3	4.3E-3	4.8E-4
PM <10um	5,700	520	1,800	2,500	600	280	13	12	20	11	38	4.3
CO	6,200	140	1,600	3,300	150	1,100	14	3.2	17	14	9.4	16
CH4	1,400	170	290	680	58	210	3.1	3.9	3.2	2.9	3.7	3.2
VOCs	1,100	18	250	560	80	170	2.4	0.41	2.8	2.3	5.1	2.6
N2O	280	31	60	130	10	43	0.62	0.71	0.66	0.58	0.64	0.64
Fuel Use (1000 mmBTU)	450,000	43,000	91,000	230,000	16,000	67,000						

Table 5-3. Results for distillate combustion emission factors.

Distillate	Emissions (MT)						Emission Factor (g/mmBTU fuel)					
Pollutant	National	PADD 1	PADD 2	PADD 3	PADD 4	PADD 5	National	PADD 1	PADD 2	PADD 3	PADD 4	PADD 5
CO2	210,000	81,000	29,000	26,000	6,800	65,000	130,000	-	160,000	29,000	-	120,000
SO2	160	2.0	9.6	41	70	33	94	-	54	43	-	61
NOx	1,200	86	340	500	150	130	730	-	1,900	530	-	240
PM <2.5um	100	7.3	38	38	11	7.0	61	-	210	40	-	13
EC	76	4.0	29	29	8.1	5.4	46	-	170	31	-	10
OC	18	1.5	6.7	6.6	1.9	1.2	11	-	38	7.0	-	2.3
PM <10um	120	7.8	40	38	26	8.3	73	-	220	40	-	16
CO	440	74	83	200	51	27	260	-	470	210	-	51
CH4	8.4	3.3	1.2	1.1	0.27	2.6	5.1	-	6.5	1.2	-	4.7
VOCs	190	28	33	110	11	8.8	120	-	190	120	-	17
N2O	1.7	0.66	0.23	0.22	0.055	0.52	1.0	-	1.3	0.24	-	0.94
Fuel Use (1000 mmBTU)	1,600	-	180	910	-	550						

Table 5-4. Results of combined emissions factors for natural gas and refinery gas representing average refinery fuel mix.

Natural Gas and Refinery Gas	Emissions (MT)						Emission Factor (g/mmBTU fuel)					
Pollutant	National	PADD 1	PADD 2	PADD 3	PADD 4	PADD 5	National	PADD 1	PADD 2	PADD 3	PADD 4	PADD 5
CO2	120,000,000	7,200,000	22,000,000	60,000,000	4,200,000	22,000,000	61,000	60,000	60,000	62,000	67,000	59,000
SO2	13,000	430	2,600	5,800	780	3,200	6.7	3.5	7.0	6.0	12	8.6
NOx	64,000	4,200	15,000	31,000	2,800	12,000	34	35	40	31	44	31
PM <2.5um	8,700	670	2,200	4,100	280	1,500	4.6	5.5	5.7	4.2	4.5	4.0
EC	2,000	180	470	970	61	360	1.1	1.5	1.2	0.99	0.97	0.97
OC	2,400	180	610	1,100	80	420	1.3	1.5	1.6	1.2	1.3	1.1
PM <10um	9,100	790	2,300	4,200	310	1,500	4.8	6.5	6.1	4.3	4.9	4.1
CO	35,000	2,600	10,000	13,000	2,600	6,000	18	21	27	14	42	16
CH4	6,500	370	1,200	3,600	250	990	3.4	3.1	3.3	3.7	4.0	2.7
VOCs	4,800	160	890	2,300	190	1,300	2.5	1.3	2.4	2.3	3.0	3.4
N2O	1,300	72	240	700	48	190	0.65	0.59	0.65	0.71	0.77	0.50
Fuel Use (1000 mmBTU)	1,900,000	120,000	370,000	980,000	62,000	370,000						

Table 5-5. Results for residual fuel oil combustion emission factors.

Residual Oil	Emissions (MT)						Emission Factor (g/mmBTU fuel)					
Pollutant	National	PADD 1	PADD 2	PADD 3	PADD 4	PADD 5	National	PADD 1	PADD 2	PADD 3	PADD 4	PADD 5
CO2	180,000	390	4,300	-	12,000	160,000	72,000	22,000	32,000	-	150,000	78,000
SO2	990	22	65	9.8	0.24	890	420	1,200	480	60	3.2	450
NOx	1,100	1.7	35	160	1.9	890	460	93	260	990	25	450
PM <2.5um	280	110	4.1	17	0.069	140	120	6,400	30	110	0.90	72
EC	2.8	1.1	0.041	0.17	6.9E-4	1.4	1.2	64	0.30	1.1	9.0E-3	0.72
OC	2.8	1.1	0.041	0.17	6.9E-4	1.4	1.2	64	0.30	1.1	9.0E-3	0.72
PM <10um	350	170	4.7	18	0.37	160	150	9,500	35	110	4.9	82
CO	200	0.15	3.2	61	0.18	130	83	8.5	24	370	2.3	66
CH4	7.0	0.020	0.17	-	0.46	6.4	2.9	1.1	1.3	-	6.0	3.1
VOCs	38	5.6E-3	0.36	14	9.8E-3	24	16	0.32	2.7	82	0.13	12
N2O	1.4	2.0E-3	0.034	-	0.093	1.3	0.58	0.11	0.25	-	1.2	0.63
Fuel Use (1000 mmBTU)	2,400	18	140	160	77	2,000						

5.3. Validating combustion emission factors

Comparison to existing emission factors

Emission factors for criteria air pollutants for each fuel type are compared to existing emission factors developed for AP-42 (U.S. EPA, 1995), GREET 2016 (Argonne National Laboratory, 2017), and GHGRP (U.S. EPA, 2016b). Emission factors for all pollutants are not available from all sources. For instance, the GHGRP only provides emission factors for greenhouse gases, and AP-42 does not provide emission factors for coke combustion. In many instances, the specific combustion technology, control technology, or fuel characteristics impact emission factors; where possible a range in estimates is provided to reflect this variability. Given this variability, reported emissions by fuel type provides a useful reflection of control technologies (Table 5-6; Figure 5-3).

Emissions from coal combustion at refineries are almost entirely from a single facility in PADD 1. Coal is not a common fuel source at refineries. Using a single facility to generate emission factors for coal combustion is not likely to be representative. Emission factors from less common fuel types, such as LPG, are more susceptible to reporting errors such as mislabeled fuel categorization at the facility. However, because fuel consumption data is only available at the PADD level, comparison of combustion emission factors across refineries is not possible. As a result, emission factors for both coal and LPG are not recommended for use, but are included in the Appendix.

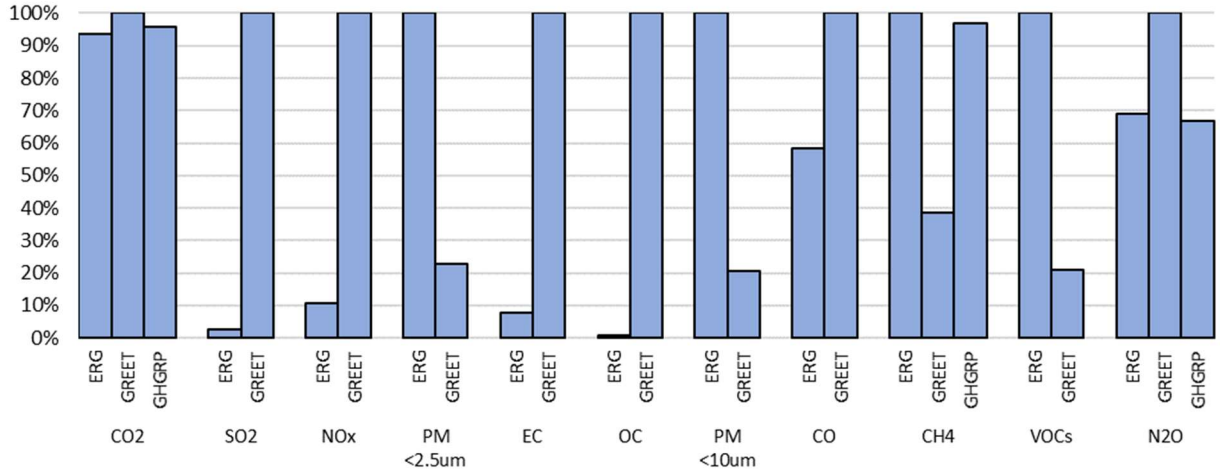
Across all fuels, estimates of sulfur dioxide release in both GREET and AP-42 are dependent upon the calculated sulfur content of fuels. As a result, it may be difficult to compare emission factors developed from NEI data with those reported for comparison.

Table 5-6. Comparison of combustion emission factors by fuel.

Pollutant	Updated Estimates	AP42[a]	GHGRP	GREET	Updated Estimates	AP42[b]	GHGRP	GREET	Updated Estimates	AP42[c]	GHGRP	GREET[d]
		Coal				**Coke**				**Distillate**		
CO2	150,000	96,000-130,000	93,000	100,000	100,000		100,000	110,000	130,000	74,000	74,000	77,000-78,000
SO2	1,600	620-760		540	14			540	94	130		0.54
NOx	370	140-620		120	13			120	730	2,000		54-2,100
PM <2.5um	29	0.64-110		2.5	11			2.5	61			5.5-54
EC	1.2			0.11	7.9E-3			0.10	46			0.55-44
OC	0.90			0.20	1.5E-3			0.20	11			1.4-9.8
PM <10um	30	1.4-260		2.7	13			2.7	73	140		8.1-55
CO	150	10-220		24	14			24	260	430		21-660
CH4	18	0.20-16	11	1.2	3.1		3.0	1.2	5.1		3.0	0.20-4.2
VOCs	12			0.47	2.4			0.50	120			0.80-2.0
N2O	2.6	0.60-1.6	1.6	0.86	0.62		0.60	0.90	1.0		0.60	0.60-0.92
	Updated Estimates	AP42[e]	GHGRP	GREET	Updated Estimates	AP42[g]	GHGRP	GREET[h]	Updated Estimates	AP42[i]	GHGRP	GREET
		LPG				**Refinery Gas Fuel Mix**[f]				**Residual Oil**		
CO2	4,600	67,000-76,000	62,000	68,000	61,000	55,000	53,000	59,000	72,000		74,000	85,000
SO2	0.066				6.7	0.28		0.27	420	460-510		680
NOx	3.7	69-80		69	34	15-88		36-41	460	32-180		140
PM <2.5um	0.17			3.7	4.6			3.5	120			16
EC	0.067			0.62	1.1			0.58	1.2			1.0
OC	0.043			1.6	1.3			1.5	1.2			0.71
PM <10um	0.17	3.7-4.3		3.7	4.8	3.5		3.5	150	6.5-32		35
CO	0.96	40-45		3.5	18	39		22-25	83	16		36
CH4	0.21	1.1	3.0	1.1	3.4	1.1	1.0	1.1	2.9		3.0	3.2
VOCs	0.51			4.3	2.5	2.5		2.5	16			0.91
N2O	0.042	4.8	0.60	4.8	0.65	0.30	0.10	0.35	0.58		0.60	1.7

a. Range of coal combustion boiler configurations.
b. AP-42 does not provide coke combustion emission factors.
c. Uncontrolled diesel engines
d. Range of distillate fired boilers and diesel powered reciprocating engines
e. Range of industrial and commercial boilers.
f. Refinery gas fuel mix includes reported natural gas and refinery still gas combustion emissions. Comparisons are made to reported emission factors for natural gas combustion as few estimates of emissions from refinery gas combustion exist.
g. Range of natural gas fired boilers
h. Range of boilers for residual oil combustion

Refinery Catalyst Coke



Distillate

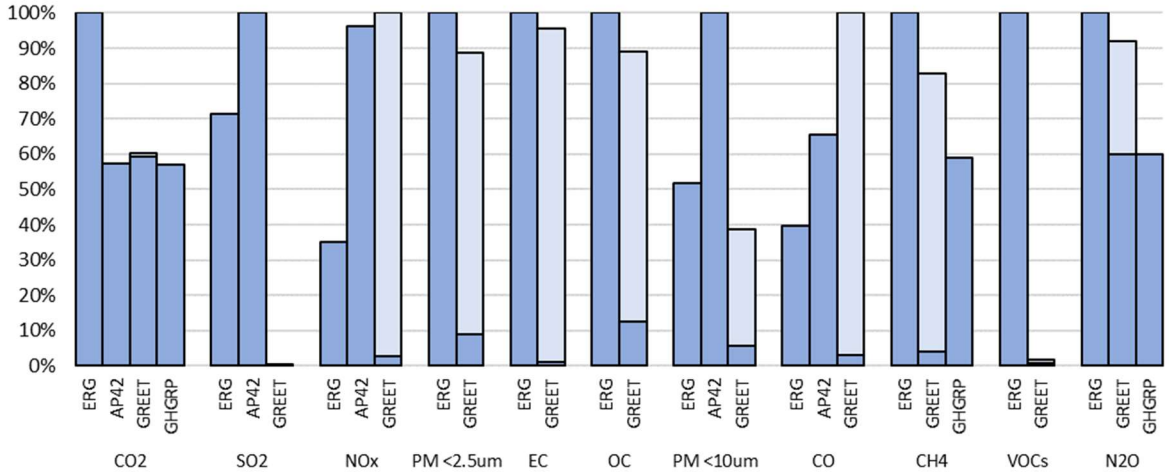
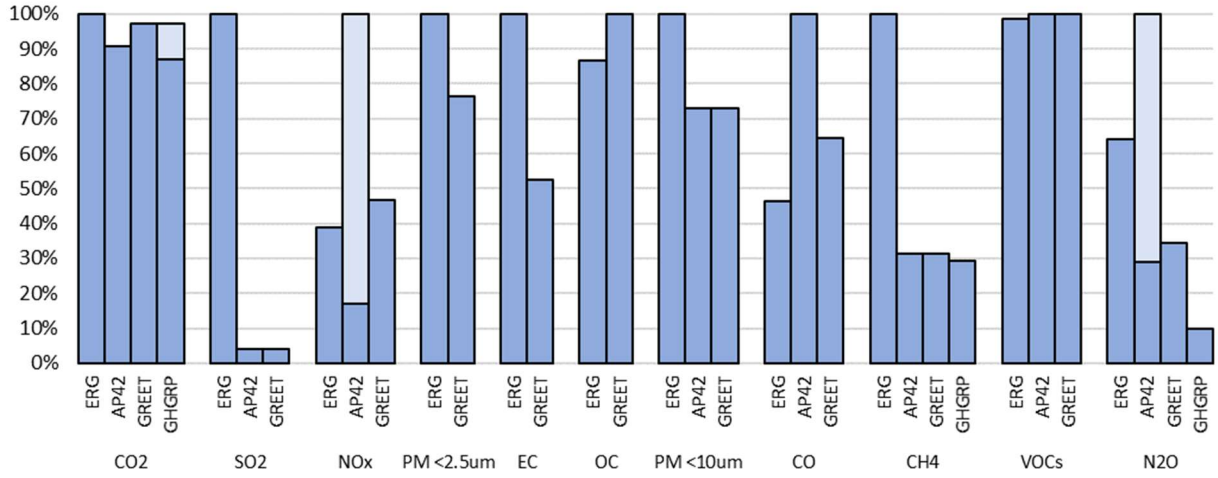


Figure 5-3. Comparison of combustion emission factors. *Emissions factors for each pollutant are normalized to the maximum emissions factor for that pollutant. Ranges of emission factor based on combustion technology configuration, where applicable, are shown in light blue.*

Refinery Gas Fuel Mix (compared to Natural Gas)



Residual Fuel Oil

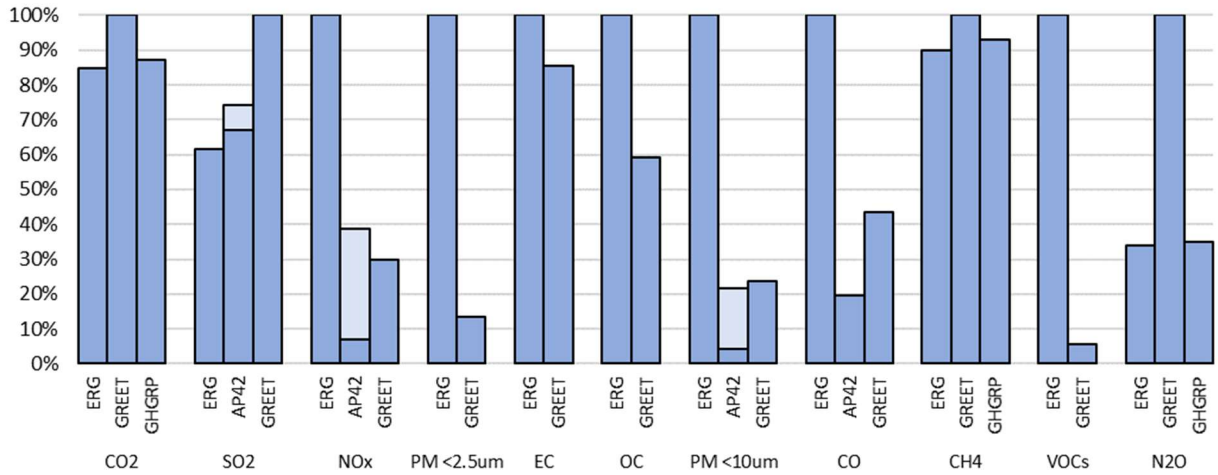


Figure 5-3. Comparison of combustion emission factors. *Emissions factors for each pollutant are normalized to the maximum emissions factor for that pollutant. Ranges of emission factor based on combustion technology configuration, where applicable, are shown in light blue.*

Validation of CO2 emissions from coke combustion

Under GHGRP Subpart Y, carbon dioxide emissions from the Fluid Catalytic Cracker (FCC) are reported based on continuous emissions monitoring (CEMS) or flue gas flow rates. FCC emissions correspond closely to EIA unit throughput estimates (Figure 5-4). Additionally, there is no clear distinction between facilities reporting via CEMS or via calculations. This provides additional confidence for carbon dioxide emissions as reported from the FCC.

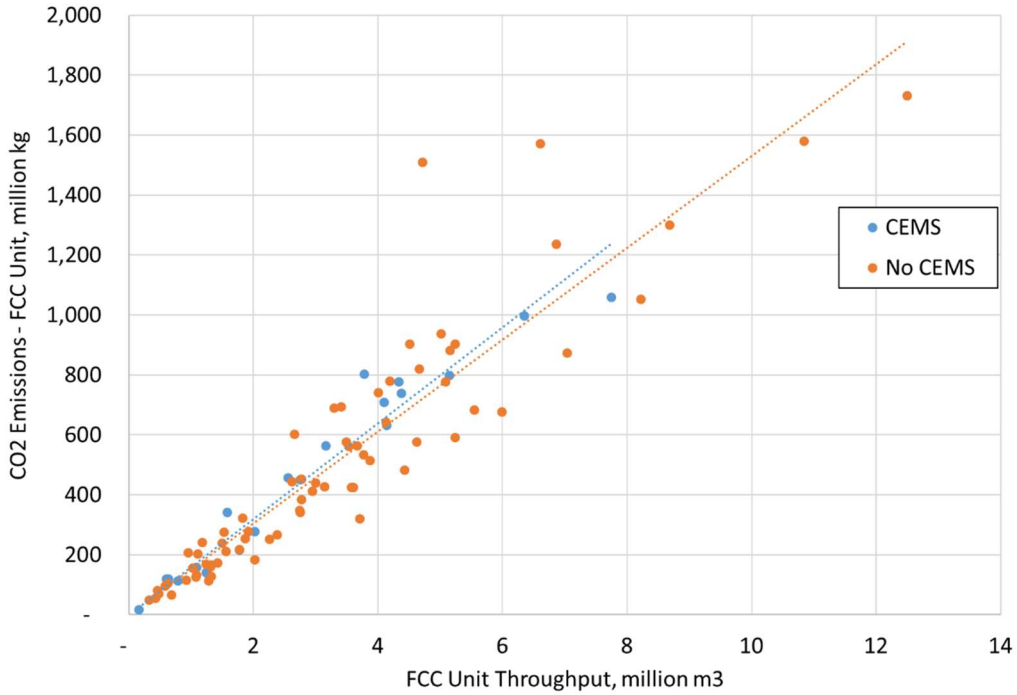


Figure 5-4. Distribution of Fluid Catalytic Cracker CO2 emissions compared to unit throughput.

EIA estimates of catalyst coke consumption at refineries for fuel at the PADD also correlate strongly with PADD level aggregate throughput (Figure 5-5). This provides additional confidence in both datasets.

The EIA dataset of catalyst coke combustion is not available at individual refineries. However, facility level emission factors based on unit throughput are shown below (Figure 5-6). Facility level carbon dioxide emissions from coke combustion at the FCC are relatively consistent across PADDs. Together with Figure 5-4 and Figure 5-5, this provides further confidence in the carbon dioxide emission factor from coke combustion presented in Table 5-2.

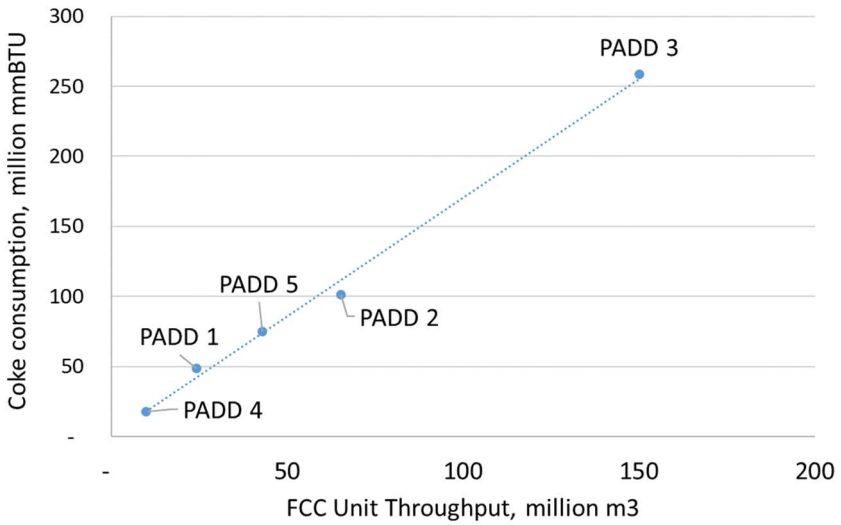


Figure 5-5. Comparing catalyst coke consumption with Fluid Catalytic Cracker unit throughput at each PADD

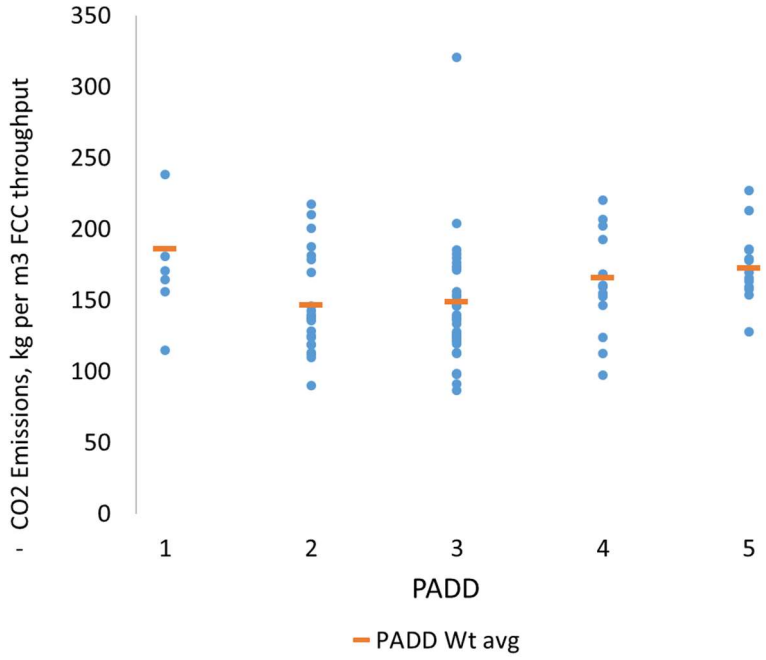


Figure 5-6. Distribution of CO2 emission factors at the Fluid Catalytic Cracker by PADD

In this chapter, emission factors from fuel combustion at refineries by fuel type for each PADD is provided. Coke, natural gas, and refinery still gas provide over 98% of the combustion energy generated on site (i.e. excluding electricity and purchased steam).

The emission factors provided here represent a PADD or national aggregation of combustion and control technologies and fuel specifications. Emission factors at individual refineries are likely to vary widely.

6. Emission Factors for Hydrogen Production at SMR Facilities

Emission factors for hydrogen production at SMR facilities are calculated by dividing total facility emissions by estimated production. Emission factors are calculated separately for each production dataset. Only facilities that have been matched across the relevant emissions and production dataset are included in the emission factor calculation. Production data from the CDR is only available for 2011, so emission factors for 2014 do not include CDR data. Emission factors calculated using CDR data and emissions from 2011 are included in the appendix.

National production weighted average emission factors based on production estimates from each dataset in 2014 are shown in Table 6-1. Because the PNNL dataset provides actual production related data, it is preferred to the calculated estimates from the GHGRP. The weighted average emission factors for facilities in both datasets are shown to the right. Where production is available from both datasets, the PNNL production estimate is used. Additional breakdown of weighted average emissions factors from PNNL production data into combustion and non-combustion sources is shown. Emission factors for carbon dioxide process emissions from the hydrogen plant are not calculated using GHGRP estimates of production.

Table 6-1. National SMR emission factors in 2014, g/mmBTU.

	PNNL	GHGRP	Both	PNNL			PNNL Avg	
	Avg	Avg	Avg	25th %	Median	75th %	Combustion	Non-Combustion
SO_2	0.33	8.3	7.3	0.018	0.038	0.15	0.17	0.16
NOx	5.8	13	11	1.9	5.5	8.6	3.8	2.0
PM < 2.5	1.8	3.0	2.6	1.1	1.8	2.1	0.82	1.0
EC	0.31	0.51	0.45	0.017	0.059	0.61	0.31	0.0
OC	0.23	0.40	0.35	0.060	0.13	0.42	0.20	0.026
PM < 10	1.9	3.1	2.7	1.2	2.0	2.3	0.83	1.04
CO	4.0	8.2	7.2	1.3	2.5	5.3	2.8	1.2
VOC	1.4	2.6	2.3	0.96	1.6	2.0	0.65	0.71
Facility Count	*29*	*42*	*42*					
Hydrogen Process Emissions								
CO_2	59,000	n.a.	n.a.	49,000	65,000	80,000		
Facility Count	*36*							

The median emission factor from the PNNL dataset is compared to those emission factors for hydrogen production from GREET 2016. Error bars on the updated estimates reflect the emission factor from the middle 50% of facilities for each pollutant (Figure 6-1). Across all pollutants, the median value is lower in this updated estimate than that provided in GREET. The weighted average sulfur dioxide emission factor is higher than the 75th percentile facility and higher than the emission factor reported in GREET, suggesting a possible outlier facility.

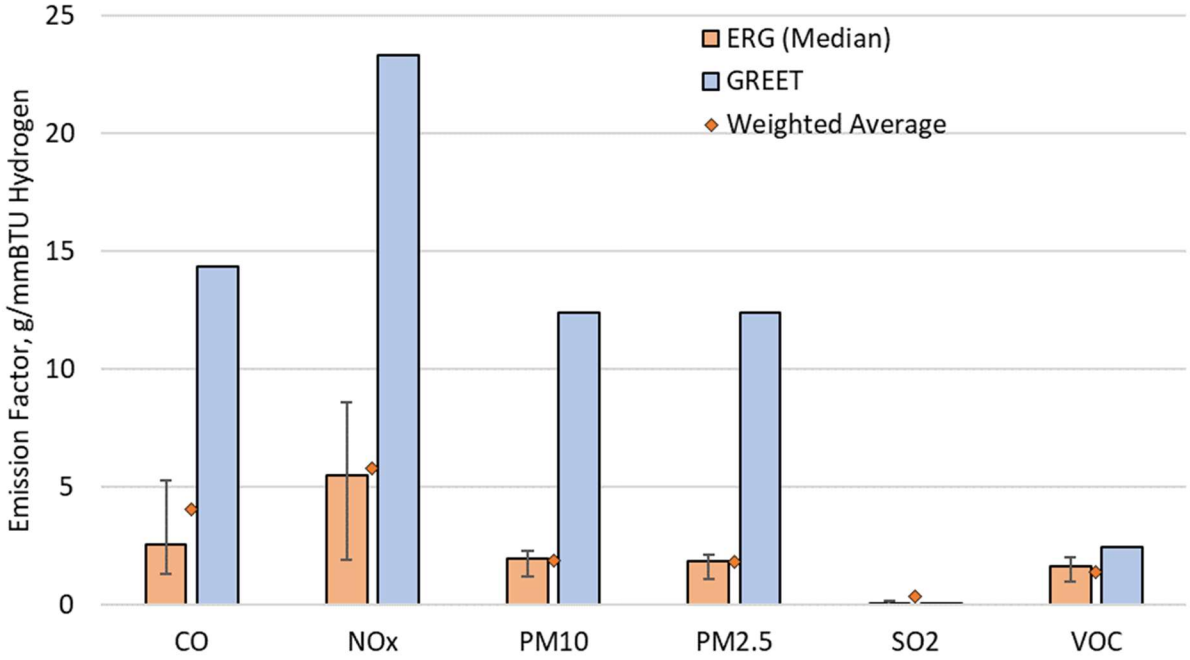


Figure 6-1. Comparison of emission factors for hydrogen production in 2014.

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APPENDIX A. SUPPORTING INFORMATION

Table 7-1. Complete list of refineries and presence within each dataset in 2014.

ID	Facility Name	State	PADD	EIA	NEI	GHGRP	PRELIM Config.
0	Nustar Asphalt Refining, Savannah	GA	1	x		x	n.a.
1	Alon Refinery, Bakersfield	CA	5	x	x	x	n.a.
2	Alon Refinery, Krotz Springs	LA	3	x	x	x	0
3	Alon USA Energy, Big Springs	TX	3	x	x	x	0
4	American Refining Group, Bradford	PA	1	x	x	x	0
5	Antelope Refining LLC, Douglas	WY	4	x		x	1
6	Axeon Specialty Products LLC, Paulsboro	NJ	1	x	x	x	4
7	Big West Oil Co., Salt Lake	UT	4	x	x	x	1
8	BP Exploration Alaska Inc., Prudhoe Bay	AK	5	x	x	x	6
9	BP Products North America Inc., Whiting	IN	2	x	x	x	1
10	BP West Coast Products LLC, Ferndale	WA	5	x	x	x	1
11	BP Husky Refining LLC, Toledo	OH	2	x	x	x	0
12	Calcasieu Refining Co., Lake Charles	LA	3	x	x	x	1
13	Calumet Lubricants Co, San Antonio	TX	3	x	x	x	1
14	Calumet Lubricants Co, Cotton Valley	LA	3	x	x	x	0
15	Calumet Lubricants Co, Princeton	LA	3	x	x	x	3
16	Calumet Lubricants Co, Superior	WI	2	x	x	x	1
17	Calumet Montana Refining LLC, Great Falls	MT	4	x	x	x	1
18	Calumet Lubricants Co., Shreveport	LA	3	x	x	x	6
19	Cenex Harvest States (CHS) Coop, Laurel	MT	4	x	x	x	4
20	Chalmette Refining LLC, Chalmette	LA	3	x	x	x	1
21	Chevron USA Inc., El Segundo	CA	5	x	x	x	1
22	Chevron USA Inc., Richmond	CA	5	x	x	x	4
23	Chevron USA Inc., Honolulu	HI	5	x	x	x	4
24	Chevron USA Inc., Pascagoula	MS	3	x	x	x	4
25	Chevron USA Inc., Salt Lake City	UT	4	x	x	x	6
26	Citgo Petroleum Corp., Lake Charles	LA	3	x	x	x	6
27	Citgo Petroleum Corp., Corpus Christi	TX	3	x	x	x	0
28	Coffeyville Resources and Refining LLC, Coffeyville	KS	2	x	x	x	0
29	ConocoPhillips Alaska, Prudhoe Bay	AK	5	x		x	4
30	Continental Refining Company LLC, Somerset	KY	2	x		x	4
31	Countrymark Cooperative Inc., Mount Vernon	IN	2	x	x	x	6
32	Cross Oil and Refining Co., Smackover	AR	3	x		x	4
33	Dakota Prairie Refining LLC, Dickinson	ND	2			x	n.a.
34	Deer Park Refining Ltd. Partnership, Deer Park	TX	3	x	x	x	1

ID	Facility Name	State	PADD	EIA	NEI	GHGRP	PRELIM Config.
35	PBF Energy, Delaware City Refining Co. LLC, Delaware City	DE	1	x	x	x	6
36	Delek Refining Ltd., Tyler	TX	3	x	x	x	4
37	Lyondell, Equistar Chemicals LP, Channelview	TX	3	x	x		n.a.
38	Ergon Refining Inc., Vicksburg	MS	3	x	x	x	4
39	Ergon Refining Inc., Newell	WV	1	x	x	x	0
40	ConocoPhillips, Excel Paralubes, Lake Charles Refinery, Westlake	LA	3	x			n.a.
41	ExxonMobil Refining and Supply Co., Torrance	CA	5	x	x	x	0
42	ExxonMobil Refining and Supply Co., Joliet	IL	2	x	x	x	0
43	ExxonMobil Refining and Supply Co., Baton Rouge	LA	3	x	x	x	0
44	ExxonMobil Refining and Supply Co., Billings	MT	4	x	x	x	0
45	ExxonMobil Refining and Supply Co., Baytown	TX	3	x	x	x	0
46	ExxonMobil Refining and Supply Co., Beaumont	TX	3	x	x	x	0
47	Flint Hills Resources LP, Koch Industries, Saint Paul	MN	2	x	x	x	0
48	Flint Hills Resources LP, Koch Industries, Corpus Christi	TX	3	x	x	x	0
49	Foreland Refining Corp, Eagle Springs Refinery, Ely	NV	5	x	x	x	0
50	Holly Frontier Corp., El Dorado Refining, El Dorado	KS	2	x	x	x	0
51	Holly Frontier Corp., Cheyenne	WY	4	x	x	x	5
52	Goodway Refining LLC, Atmore	AL	3	x		x	0
53	Holly Frontier Corp. (East/West), Tulsa	OK	2	x	x	x	0
54	Valero Energy Corporation, Port Arthur	TX	3				n.a.
55	Holly Frontier Corp., Woods Cross	UT	4	x	x	x	1
56	Lyondell, Houston Refining LP, Houston	TX	3	x	x	x	1
57	Hunt Refining Co., Tuscaloosa	AL	3	x	x	x	1
58	Hunt Southland Refining Co., Sandersville	MS	3	x	x	x	0
59	Kern Oil and Refining Co., Bakersfield	CA	5	x	x	x	1
60	Kinder Morgan Crude and Condensate, Galena Park	TX	3				n.a.
61	Lazarus Energy LLC, Nixon	TX	3	x	x	x	0
62	Lima Refining Co., Husky Energy Lima	OH	2	x	x	x	0
63	Delek US Holdings Inc., Lion Oil Co., El Dorado	AR	3	x	x	x	3
64	Sinclair, Little America Refining Co., Evansville	WY	4	x	x	x	1
65	Lunday Thagard Co., Southgate	CA	5	x	x	x	1
66	Marathon Petroleum Co. LP, Robinson	IL	2	x	x	x	1
67	Marathon Petroleum Co. LP, Catlettsburg	KY	2	x	x	x	2
68	Marathon Petroleum Co. LP, Garyville	LA	3	x	x	x	1
69	Marathon Petroleum Co. LP, Detroit	MI	2	x	x	x	4
70	Marathon Petroleum Co. LP, Canton	OH	2	x	x	x	4
71	Marathon Petroleum Co. LP, Galveston Bay	TX	3	x	x	x	3
72	Marathon Petroleum Co. LP, Texas City	TX	3	x	x	x	4
73	Delta, Monroe Energy LLC, Trainer	PA	1	x	x	x	6

ID	Facility Name	State	PADD	EIA	NEI	GHGRP	PRELIM Config.
74	Motiva Enterprises LLC, Convent	LA	3	x	x	x	6
75	Motiva Enterprises LLC, Norco	LA	3	x	x		4
76	Motiva Enterprises LLC, Port Arthur	TX	3	x	x	x	4
77	Holly Frontier Corp., Navajo Refining Co. LLC, Artesia	NM	3	x	x	x	6
78	National Coop. Refinery Assc. (NCRA), CHS McPherson Refinery, McPherson	KS	2	x	x	x	7
79	Par Petroleum Corp., Ewa	HI	5	x	x	x	4
80	Alon USA, Paramount Petroleum Corp., Paramount	CA	5	x	x	x	4
81	PetroBras America, Pasadena Refining Systems Inc., Pasadena	TX	3	x	x	x	4
82	PBF Energy, Paulsboro Refining Co. LLC, Paulsboro	NJ	1	x	x	x	4
83	Citgo, PDV Midwest Refining LLC, Lemont	IL	2	x	x	x	4
84	Pelican Refining Co. LLC, Lake Charles	LA	3	x			6
85	Petro Star Inc., North Pole	AK	5	x	x	x	4
86	Petro Star Inc., Valdez	AK	5	x	x	x	6
87	Sunoco, Philadelphia Energy Solutions, Philadelphia	PA	1	x	x	x	6
88	Phillips 66 Co., Rodeo	CA	5	x	x	x	6
89	Phillips 66 Co., Wilmington/Carson	CA	5	x	x	x	4
90	Phillips 66 Co., Belle Chasse	LA	3	x	x	x	4
91	Phillips 66 Co., WestLake	LA	3	x	x	x	6
92	Phillips 66 Co., Billings	MT	4	x	x	x	4
93	Phillips 66 Co., Linden	NJ	1	x	x	x	6
94	Phillips 66 Co., Ponca City	OK	2	x	x	x	0
95	Phillips 66 Co., Sweeny	TX	3	x	x	x	0
96	Phillips 66 Co., Ferndale	WA	5	x	x	x	1
97	Placid Refining Co. LLC, Port Allen	LA	3	x	x	x	0
98	Valero, Premcor Refining Group Inc., Memphis	TN	2	x	x	x	0
99	Valero, Premcor Refining Group Inc., Port Arthur	TX	3	x	x	x	0
100	San Joaquin Refining Co., Bakersfield	CA	5	x	x	x	0
101	Greka, Santa Maria Refining Co., Santa Maria	CA	5	x	x	x	0
102	Shell Chemicals LP, Saraland	AL	3	x	x	x	1
103	Shell Oil Products US, Equilon Enterprise LLC, Martinez	CA	5	x	x	x	4
104	Shell Oil Products US, Equilon Enterprise LLC, Saint Rose	LA	3	x	x	x	4
105	Shell Oil Products US, Equilon Enterprise LLC, Anacortes	WA	5	x	x	x	0
106	International Group Inc., Silver Eagle Refining, Woods Cross	UT	4	x	x	x	4
107	International Group Inc., Silver Eagle Refining, Evanston	WY	4	x		x	4
108	Sinclair Wyoming Refinery Co., Sinclair	WY	4	x	x	x	4

ID	Facility Name	State	PADD	EIA	NEI	GHGRP	PRELIM Config.
109	Texas Oil and Chemical Co., South Hampton Resources Inc., Silsbee	TX	3	x	x		1
110	Northern Tier Energy LLC, St. Paul Park Refining Co. LLC, Saint Paul	MN	2	x	x	x	4
111	Suncor Energy (USA) Inc. (East/West), Commerce City	CO	4	x	x	x	0
112	Flint Hills, North Pole	AK	5	x		x	n.a.
113	Tesoro Refining Co., Kenai	AK	5	x	x	x	0
114	Tesoro Refining Co., Carson/LA/Wilmington	CA	5	x	x	x	0
115	Tesoro Refining Co., Martinez	CA	5	x	x	x	0
116	Phillips 66 Santa Maria	CA	5		x	x	n.a.
117	Tesoro West Coast Co., Mandan	ND	2	x	x	x	0
118	Tesoro West Coast Co., Salt Lake City	UT	4	x	x	x	0
119	Tesoro West Coast Co., Anacortes	WA	5	x	x	x	0
120	PBF, Toledo Refining Co. LLC, Toledo	OH	2	x	x	x	0
121	Total Petrochemicals and Refining USA, Port Arthur	TX	3	x	x	x	0
122	United Refining Co., Warren	PA	1	x	x	x	1
123	US Oil and Refining Co., Tacoma	WA	5	x	x	x	0
124	Valero Energy Corporation, Meraux	LA	3	x	x	x	2
125	Valero Energy Corporation, Sunray	TX	3	x	x	x	4
126	Valero Energy Corporation, Three Rivers	TX	3	x	x	x	2
127	Valero Energy Corporation, Benicia	CA	5	x	x	x	6
128	Valero Energy Corporation, Wilmington Asphalt Plant, Wilmington	CA	5	x	x	x	1
129	Valero Energy Corporation, Wilmington Refinery, Wilmington	CA	5	x	x	x	1
130	Valero Energy Corporation, Ardmore	OK	2	x	x	x	5
131	Valero Energy Corporation, Corpus Christi	TX	3	x	x	x	4
132	Valero Energy Corporation, Houston	TX	3	x	x	x	4
133	Valero Energy Corporation, Texas City	TX	3	x	x	x	4
134	Valero Energy Corporation, Norco	LA	3	x	x	x	4
135	Western Refining Co. LP, El Paso	TX	3	x	x	x	4
136	Western Refining Southwest Inc., Gallup	NM	3	x	x	x	6
137	WRB Refining LP, Wood River	IL	2	x	x	x	5
138	WRB Refining LP, Borger	TX	3	x	x	x	3
139	Wynnewood Refining Co., Wynnewood	OK	2	x	x	x	4
140	Wyoming Refining CO.	WY	4	x	x	x	6
145	Ventura Refining and Transmission, Thomas	OK	2	x			n.a.
151	Tricor Refining, Bakersfield	CA	5			x	n.a.
152	Navajo Refining Company, Lovington	NM	3			x	n.a.
153	BTB Trigeant, Corpus Christi	TX	3	x		x	n.a.

Table 7-2. Complete list of SMR facilities and presence within each dataset.

ID	Facility Name	State	CDR 2011	PNNL	NEI 2011	NEI 2014	GHGRP Subpart P 2011	GHGRP Subpart P 2014
201	Air Liquide, El Segundo	CA		x	x	x	x	x
202	Air Liquide, Corpus Christi	TX		x	x	x	x	x
203	Air Liquide, Freeport	TX		x	x	x	x	x
204	Air Liquide, Longview	TX			x	x	x	x
205	Air Liquide, Anacortes	WA		x		x	x	x
206	Air Liquide, Pasadena	TX		x	x	x	x	x
207	Air Liquide, Rodeo	CA		x	x	x	x	x
208	Air Products, Geismar	LA			x	x		
209	Air Products, Westlake	LA		x		x	x	x
210	Air Products, Catlettsburg	KY		x	x	x	x	x
211	Air Products, Convent	LA		x		x	x	x
212	Air Products, Geismar	LA			x	x	x	x
213	Air Products, New Orleans	LA		x	x	x	x	x
214	Air Products, Martinez	CA		x			x	x
215	Air Products Tesoro, Martinez	CA			x	x	x	x
216	Air Products, Norco	LA		x		x		x
217	Air Products, Garyville	LA		x		x	x	x
218	Air Products, Luling	LA		x		x		x
219	Air Products, Detroit	MI		x				x
220	Air Products, Sacramento	CA			x	x	x	x
221	Air Products, Cincinnati	OH		x			x	x
222	Air Products, Baton Rouge	LA		x	x	x	x	x
223	Air Products, Baytown	TX		x	x	x	x	x
224	Air Products, Carson	CA		x	x	x	x	x
225	Air Products, Corpus Christi	TX					x	x
226	Air Products, Pasadena	TX		x			x	x
227	Air Products, Port Arthor	TX		x	x	x	x	x
228	Air Products, Wilmington	CA			x	x	x	x
229	Ascend, Decatur	AL			x	x	x	x
230	Ascend, Cantonment	FL			x	x	x	x
234	Evonik Corporation, Mapleton	IL			x	x	x	x
235	Air Liquide, La Porte	TX		x		x		x
236	Linde Gas, Decatur	AL	x	x		x	x	x
237	Linde Gas, Anacortes	WA		x		x		x
238	Linde Gas, Pasadena	TX	x		x	x	x	x
239	Linde Gas, La Porte	TX	x		x	x	x	x
240	Linde Gas, Romeoville	IL	x	x	x	x	x	x
241	Linde Gas, Lima	OH	x	x		x	x	x

ID	Facility Name	State	CDR 2011	PNNL	NEI 2011	NEI 2014	GHGRP Subpart P 2011	GHGRP Subpart P 2014
243	Linde Gas, Salt Lake City	UT	x	x			x	x
244	Linde Gas, Saraland	AL	x	x			x	x
245	Linde Gas, Toldeo	OH	x	x			x	x
246	Motiva, Norco	LA			x	x	x	
247	Praxair Whiting, East Chicago	IN		x	x	x	x	x
249	Praxair Shell, Carneys Point	NJ			x	x	x	x
251	Praxair, Geismar	LA		x	x	x	x	x
252	Praxair, Hemlock	MI			x	x	x	x
253	Praxair, Ontario	CA		x	x	x	x	x
254	Praxair, Port Arthur	TX		x	x	x	x	x
256	Praxair, Texas City	TX		x	x	x	x	x
257	Praxair Hydrogen, Texas City	TX			x	x	x	x
258	Praxair, Sulphur	LA		x	x	x	x	x
259	Praxair, Norco	LA		x		x		x
260	Solvay Chemicals, Longview	WA					x	x

Table 7-3. SubPADD petroleum refinery capacity utilization in 2014.

RDIST	PADD Number	Utilization
Appalachian No. 1	1	93%
East Coast	1	67%
Indiana-Illinois-Kentucky	2	90%
Minnesota-Wisconsin-North and South Dakota	2	103%
Oklahoma-Kansas-Missouri	2	88%
Louisiana Gulf Coast	3	91%
New Mexico	3	74%
North Louisiana-Arkansas	3	85%
Texas Gulf Coast	3	87%
Texas Inland	3	91%
Rocky Mountain	4	88%
West Coast	5	82%

Source: U.S. EIA, 2017b

Table 7-4. Lower Heating Values of common fuel types at refineries.

Fuel	LHV		Source
Coal	0.025	mmBTU / kg	GREET 2016
Marketable petcoke	0.030	mmBTU/ kg	GREET 2016
Catalyst petcoke	0.030	mmBTU/ kg	GREET 2016
Distillate fuel oil	33.9	mmBTU / m3	GREET 2016
Liquefied petroleum gases	22.4	mmBTU / m3	GREET 2016
Natural Gas, fuel	0.035	mmBTU / m3	GREET 2016
Other[a]	31.5	mmBTU / m3	GREET 2016
Electricity, purchased	0.003	mmBTU / kwh	
Steam, purchased	0.003	mmBTU/ kg	PRELIM
Still gas[b]	34.0	mmBTU / m3 fuel oil equivalent	GREET 2016
Residual fuel oil	37.1	mmBTU / m3	GREET 2016

a. Heating value of other fuels estimated as an average of gasoline, kerosene, and petroleum naphtha as reported by GREET.
b. Heat content (LHV) of liquid still gas as reported by GREET is used to reflect that the original unit volume for refinery still gas in the EIA dataset is in fuel oil equivalents.

Table 7-5. Energy content, density, and value of common refinery products.

Product	Unit	Energy Content (mmBTUs)	Density (kg)	Value (USD)
Asphalt and Road Oil	m3	37.57	1,037	409
Finished Motor Gasoline	m3	29.64	749	614
Motor Gasoline Blending Components	m3	30.67	745	614
Petroleum Coke	kg	0.030	1	0.058
Finished Aviation Gasoline	m3	32.84	802	567
Kerosene	m3	32.84	802	567
Special Naphthas	m3	30.89	725	458
Lubricants	m3	34.33	991	337
Miscellaneous Petroleum Products	m3	30.89	725	337
Residual Fuel Oil	m3	37.08	991	337
Waxes	m3	31.34	991	337
Liquefied Refinery Gases	m3	22.44	508	560
Petrochemical Feedstocks	m3	30.89	725	337
Still Gas	m3	33.97	702	214
Distillate Fuel Oil	m3	33.93	837	562

Energy content represents the LHV of products
Source: GREET 2016 (energy and density); PRELIM (value)

Table 7-6. Classification of Source Classification Codes (SCC) by combustion source and fuel type.

SCC	Description	Assigned Category	Assigned Fuel Type
10100101	External Combustion Boilers Electric Generation Anthracite Coal, Pulverized Boiler	Boiler	Coal
10100401	External Combustion Boilers Electric Generation Residual Oil - Grade 6 Boiler, Normal Firing	Boiler	Residual Oil
10100601	External Combustion Boilers Electric Generation Natural Gas Boiler, >= 100 Million BTU/hr	Boiler	Natural Gas
10100604	External Combustion Boilers Electric Generation Natural Gas Boiler, Tangential-fired	Boiler	Natural Gas
10100701	External Combustion Boilers Electric Generation Process Gas Boiler, >= 100 Million BTU/hr	Boiler	Refinery Gas
10100702	External Combustion Boilers Electric Generation Process Gas Boiler < 100 Million Btu/hr	Boiler	Refinery Gas
10100703	External Combustion Boilers Electric Generation Petroleum Refinery Gas Boiler	Boiler	Refinery Gas
10200101	External Combustion Boilers Industrial Anthracite Coal Pulverized Coal	Boiler	Coal
10200204	External Combustion Boilers Industrial Bituminous Coal Spreader Stoker	Boiler	Coal
10200401	External Combustion Boilers Industrial Residual Oil Grade 6 oil	Boiler	Residual Oil
10200402	External Combustion Boilers Industrial Residual Oil 10-100 Million BTU/hr	Boiler	Residual Oil
10200403	External Combustion Boilers Industrial Residual Oil < 10 Million BTU/hr	Boiler	Residual Oil
10200404	External Combustion Boilers Industrial Residual Oil Grade 5 Oil	Boiler	Residual Oil
10200405	External Combustion Boilers Industrial Residual Oil Cogeneration	Boiler	Residual Oil
10200501	External Combustion Boilers Industrial Distillate Oil - Grades 1 and 2 Boiler	Boiler	Distillate
10200502	External Combustion Boilers Industrial Distillate Oil 10-100 Million BTU/hr **	Boiler	Distillate
10200503	External Combustion Boilers Industrial Distillate Oil < 10 Million BTU/hr **	Boiler	Distillate
10200601	External Combustion Boilers Industrial Natural Gas > 100 Million BTU/hr	Boiler	Natural Gas
10200602	External Combustion Boilers Industrial Natural Gas 10-100 Million BTU/hr	Boiler	Natural Gas
10200603	External Combustion Boilers Industrial Natural Gas < 10 Million BTU/hr	Boiler	Natural Gas
10200604	External Combustion Boilers Industrial Natural Gas Cogeneration	Boiler	Natural Gas
10200701	External Combustion Boilers Industrial Process Gas Petroleum Refinery Gas	Boiler	Refinery Gas
10200707	External Combustion Boilers Industrial Process Gas Coke Oven Gas	Boiler	Refinery Gas
10200710	External Combustion Boilers Industrial Process Gas Cogeneration	Boiler	Refinery Gas
10200799	External Combustion Boilers Industrial Process Gas Other: Specify in Comments	Boiler	Refinery Gas
10201002	External Combustion Boilers Industrial Liquified Petroleum Gas (LPG) Propane	Boiler	LPG
10201301	External Combustion Boilers Industrial Liquid Waste Specify Waste Material in Comments	Boiler	Other
10201302	External Combustion Boilers Industrial Liquid Waste Waste Oil	Boiler	Other
10201701	External Combustion Boilers Industrial Gasoline Industrial Boiler	Boiler	Other
10300404	External Combustion Boilers Commercial/Institutional Residual Oil Grade 5 Oil	Boiler	Residual Oil
10300602	External Combustion Boilers Commercial/Institutional Natural Gas 10-100 Million BTU/hr	Boiler	Natural Gas
10300603	External Combustion Boilers Commercial/Institutional Natural Gas < 10 Million BTU/hr	Boiler	Natural Gas
10300701	External Combustion Boilers Commercial/Institutional Process Gas POTW Digester Gas-fired Boiler	Boiler	Refinery Gas
10300799	External Combustion Boilers Commercial/Institutional Process Gas Other Not Classified	Boiler	Refinery Gas

SCC	Description	Assigned Category	Assigned Fuel Type
39000701	Industrial Processes In-process Fuel Use Process Gas Coke Oven or Blast Furnace	Coker	Refinery Gas
39000702	Industrial Processes In-process Fuel Use Process Gas Coke Oven Gas	Coker	Refinery Gas
20100101	Internal Combustion Engines Electric Generation Distillate Oil (Diesel) Turbine	Engine	Distillate
20100102	Internal Combustion Engines Electric Generation Distillate Oil (Diesel) Reciprocating	Engine	Distillate
20100107	Internal Combustion Engines Electric Generation Distillate Oil (Diesel) Reciprocating: Exhaust	Engine	Distillate
20100201	Internal Combustion Engines Electric Generation Natural Gas Turbine	Engine	Natural Gas
20100202	Internal Combustion Engines Electric Generation Natural Gas Reciprocating	Engine	Natural Gas
20100207	Internal Combustion Engines Electric Generation Natural Gas Reciprocating: Exhaust	Engine	Natural Gas
20100707	Internal Combustion Engines Electric Generation Process Gas Reciprocating: Exhaust	Engine	Refinery Gas
20100901	Internal Combustion Engines Electric Generation Kerosene/Naphtha (Jet Fuel) Turbine	Engine	Other
20200101	Internal Combustion Engines Industrial Distillate Oil (Diesel) Turbine	Engine	Distillate
20200102	Internal Combustion Engines Industrial Distillate Oil (Diesel) Reciprocating	Engine	Distillate
20200103	Internal Combustion Engines Industrial Distillate Oil (Diesel) Turbine: Cogeneration	Engine	Distillate
20200104	Internal Combustion Engines Industrial Distillate Oil (Diesel) Reciprocating: Cogeneration	Engine	Distillate
20200107	Internal Combustion Engines Industrial Distillate Oil (Diesel) Reciprocating: Exhaust	Engine	Distillate
20200201	Internal Combustion Engines Industrial Natural Gas Turbine	Engine	Natural Gas
20200202	Internal Combustion Engines Industrial Natural Gas Reciprocating	Engine	Natural Gas
20200203	Internal Combustion Engines Industrial Natural Gas Turbine: Cogeneration	Engine	Natural Gas
20200204	Internal Combustion Engines Industrial Natural Gas Reciprocating: Cogeneration	Engine	Natural Gas
20200251	Internal Combustion Engines Industrial Natural Gas 2-cycle Rich Burn	Engine	Natural Gas
20200252	Internal Combustion Engines Industrial Natural Gas 2-cycle Lean Burn	Engine	Natural Gas
20200253	Internal Combustion Engines Industrial Natural Gas 4-cycle Rich Burn	Engine	Natural Gas
20200254	Internal Combustion Engines Industrial Natural Gas 4-cycle Lean Burn	Engine	Natural Gas
20200401	Internal Combustion Engines Industrial Large Bore Engine Diesel	Engine	Distillate
20200402	Internal Combustion Engines Industrial Large Bore Engine Dual Fuel (Oil/Gas)	Engine	Residual Oil
20200501	Internal Combustion Engines Industrial Residual/Crude Oil Reciprocating	Engine	Residual Oil
20200701	Internal Combustion Engines Industrial Process Gas Turbine	Engine	Refinery Gas
20200702	Internal Combustion Engines Industrial Process Gas Reciprocating Engine	Engine	Refinery Gas
20200705	Internal Combustion Engines Industrial Process Gas Refinery Gas: Turbine	Engine	Refinery Gas
20200706	Internal Combustion Engines Industrial Process Gas Refinery Gas: Reciprocating Engine	Engine	Refinery Gas
20200712	Internal Combustion Engines Industrial Process Gas Reciprocating: Exhaust	Engine	Refinery Gas
20200714	Internal Combustion Engines Industrial Process Gas Turbine: Exhaust	Engine	Refinery Gas
20201001	Internal Combustion Engines Industrial Liquified Petroleum Gas (LPG) Propane: Reciprocating	Engine	LPG
20201002	Internal Combustion Engines Industrial Liquified Petroleum Gas (LPG) Butane: Reciprocating	Engine	LPG
20201013	Internal Combustion Engines Industrial Liquified Petroleum Gas (LPG) Turbine: Cogeneration	Engine	LPG
20201701	Internal Combustion Engines Industrial Gasoline Turbine	Engine	Other

SCC	Description	Assigned Category	Assigned Fuel Type
20201702	Internal Combustion Engines Industrial Gasoline Reciprocating Engine	Engine	Other
20280001	Internal Combustion Engines Industrial Equipment Leaks Equipment Leaks	Engine	Other
20282001	Internal Combustion Engines Industrial Wastewater, Aggregate Process Area Drains	Engine	Other
20300101	Internal Combustion Engines Commercial/Institutional Distillate Oil (Diesel) Reciprocating	Engine	Distillate
20300102	Internal Combustion Engines Commercial/Institutional Distillate Oil (Diesel) Turbine	Engine	Distillate
20300107	Internal Combustion Engines Commercial/Institutional Distillate Oil (Diesel) Reciprocating: Exhaust	Engine	Distillate
20300201	Internal Combustion Engines Commercial/Institutional Natural Gas Reciprocating	Engine	Natural Gas
20300203	Internal Combustion Engines Commercial/Institutional Natural Gas Turbine: Cogeneration	Engine	Natural Gas
20300301	Internal Combustion Engines Commercial/Institutional Gasoline Reciprocating	Engine	Other
20301001	Internal Combustion Engines Commercial/Institutional Liquified Petroleum Gas (LPG) Propane: Reciprocating	Engine	LPG
20400302	Internal Combustion Engines Engine Testing Turbine Diesel/Kerosene	Engine	Distillate
20400401	Internal Combustion Engines Engine Testing Reciprocating Engine Gasoline	Engine	Other
27000320	Internal Combustion Engines Off-highway Diesel Engines Industrial Equipment Industrial Fork Lift: Diesel	Engine	Distillate
28888801	Internal Combustion Engines Fugitive Emissions Other Not Classified Specify in Comments	Engine	Other
10201401	External Combustion Boilers Industrial CO Boiler Natural Gas	FCC	Natural Gas
10201402	External Combustion Boilers Industrial CO Boiler Process Gas	FCC	Refinery Gas
10201404	External Combustion Boilers Industrial CO Boiler Residual Oil	FCC	Residual Oil
30600201	Industrial Processes Petroleum Industry Catalytic Cracking Units Fluid Catalytic Cracking Unit	FCC	Coke
30600202	Industrial Processes Petroleum Industry Catalytic Cracking Units Catalyst Handling System	FCC	Coke
10500206	External Combustion Space Heaters Commercial/Institutional Natural Gas	Heater	Natural Gas
30190003	Industrial Processes Chemical Manufacturing Fuel Fired Equipment Process Heater: Natural Gas	Heater	Natural Gas
30190004	Industrial Processes Chemical Manufacturing Fuel Fired Equipment Process Heater: Process Gas	Heater	Refinery Gas
30190099	Industrial Processes Chemical Manufacturing Fuel Fired Equipment Other Not Classified	Heater	Other
30500206	Industrial Processes Mineral Products Asphalt Concrete Asphalt Heater: Natural Gas	Heater	Natural Gas
30590002	Industrial Processes Mineral Products Fuel Fired Equipment Residual Oil: Process Heaters	Heater	Residual Oil
30600101	Industrial Processes Petroleum Industry Process Heaters Oil-fired **	Heater	Residual Oil
30600102	Industrial Processes Petroleum Industry Process Heaters Gas-fired **	Heater	Refinery Gas
30600103	Industrial Processes Petroleum Industry Process Heaters Oil-fired	Heater	Residual Oil
30600104	Industrial Processes Petroleum Industry Process Heaters Gas-fired	Heater	Refinery Gas
30600105	Industrial Processes Petroleum Industry Process Heaters Natural Gas-fired	Heater	Natural Gas
30600106	Industrial Processes Petroleum Industry Process Heaters Process Gas-fired	Heater	Refinery Gas
30600107	Industrial Processes Petroleum Industry Process Heaters LPG-fired	Heater	LPG
30600111	Industrial Processes Petroleum Industry Process Heaters Oil-fired (No. 6 Oil) : 100 Million Btu Capacity	Heater	Residual Oil
30600199	Industrial Processes Petroleum Industry Process Heaters Other Not Classified	Heater	Other

SCC	Description	Assigned Category	Assigned Fuel Type
30890003	Industrial Processes Rubber and Miscellaneous Plastics Products Fuel Fired Equipment Natural Gas: Process Heaters	Heater	Natural Gas
31000404	Industrial Processes Oil and Gas Production Process Heaters Natural Gas	Heater	Natural Gas
31000405	Industrial Processes Oil and Gas Production Process Heaters Process Gas	Heater	Refinery Gas
31000414	Industrial Processes Oil and Gas Production Process Heaters Natural Gas: Steam Generators	Heater	Natural Gas
31000415	Industrial Processes Oil and Gas Production Process Heaters Process Gas: Steam Generators	Heater	Refinery Gas
39000699	Industrial Processes In-process Fuel Use Natural Gas General	Heater	Natural Gas
39001099	Industrial Processes In-process Fuel Use Liquified Petroleum Gas General	Heater	LPG
39900701	Industrial Processes Miscellaneous Manufacturing Industries Process Heater/Furnace Process Gas	Heater	Refinery Gas
39900711	Industrial Processes Miscellaneous Manufacturing Industries Process Heater/Furnace Refinery Gas	Heater	Refinery Gas
39990003	Industrial Processes Miscellaneous Manufacturing Industries Miscellaneous Manufacturing Industries Natural Gas: Process Heaters	Heater	Natural Gas
39990004	Industrial Processes Miscellaneous Manufacturing Industries Miscellaneous Manufacturing Industries Process Gas: Process Heaters	Heater	Refinery Gas
30390024	Industrial Processes Primary Metal Production Fuel Fired Equipment Process Gas: Flares	Flare	Refinery Gas
30600401	Industrial Processes Petroleum Industry Blowdown Systems Blowdown System with Vapor Recovery System with Flaring	Flare	Other
30600901	Industrial Processes Petroleum Industry Flares Distillate Oil	Flare	Distillate
30600903	Industrial Processes Petroleum Industry Flares Natural Gas	Flare	Natural Gas
30600904	Industrial Processes Petroleum Industry Flares Process Gas	Flare	Refinery Gas
30600905	Industrial Processes Petroleum Industry Flares Liquified Petroleum Gas	Flare	LPG
30600906	Industrial Processes Petroleum Industry Flares Hydrogen Sulfide	Flare	Other
30600999	Industrial Processes Petroleum Industry Flares Not Classified **	Flare	Other
31000160	Industrial Processes Oil and Gas Production Crude Oil Production Flares	Flare	Other
31000205	Industrial Processes Oil and Gas Production Natural Gas Production Flares	Flare	Natural Gas
39990023	Industrial Processes Miscellaneous Manufacturing Industries Miscellaneous Manufacturing Industries Natural Gas: Flares	Flare	Natural Gas
39990024	Industrial Processes Miscellaneous Manufacturing Industries Miscellaneous Manufacturing Industries Process Gas: Flares	Flare	Refinery Gas
30190013	Industrial Processes Chemical Manufacturing Fuel Fired Equipment Incinerator: Natural Gas	Incinerator	Natural Gas
30190014	Industrial Processes Chemical Manufacturing Fuel Fired Equipment Incinerator: Process Gas	Incinerator	Refinery Gas
30590013	Industrial Processes Mineral Products Fuel Fired Equipment Natural Gas: Incinerators	Incinerator	Natural Gas
30609902	Industrial Processes Petroleum Industry Incinerators Residual Oil	Incinerator	Residual Oil
30609903	Industrial Processes Petroleum Industry Incinerators Natural Gas	Incinerator	Natural Gas
30609904	Industrial Processes Petroleum Industry Incinerators Process Gas	Incinerator	Refinery Gas
30609905	Industrial Processes Petroleum Industry Incinerators Liquified Petroleum Gas	Incinerator	LPG
39990013	Industrial Processes Miscellaneous Manufacturing Industries Miscellaneous Manufacturing Industries Natural Gas: Incinerators	Incinerator	Natural Gas
39990014	Industrial Processes Miscellaneous Manufacturing Industries Miscellaneous Manufacturing Industries Process Gas: Incinerators	Incinerator	Refinery Gas
40290013	Chemical Evaporation Surface Coating Operations Fuel Fired Equipment Natural Gas: Incinerator/Afterburner	Incinerator	Natural Gas

SCC	Description	Assigned Category	Assigned Fuel Type
30601602	Industrial Processes Petroleum Industry Catalytic Reforming Unit Alkylation Feed Treater	Alkylation	n.a.
30601603	Industrial Processes Petroleum Industry Catalytic Reforming Unit Alkylation Unit: Hydrofluoric Acid	Alkylation	n.a.
30601604	Industrial Processes Petroleum Industry Catalytic Reforming Unit Alkylation Unit: Sulfuric Acid	Alkylation	n.a.
31000201	Industrial Processes Oil and Gas Production Natural Gas Production Amine Process	Amine Treating	n.a.
30125801	Industrial Processes Chemical Manufacturing Benzene/Toluene/Aromatics/Xylenes Benzene: General	Aromatics	n.a.
30125807	Industrial Processes Chemical Manufacturing Benzene/Toluene/Aromatics/Xylenes Toluene: Distillation Unit	Aromatics	n.a.
30125810	Industrial Processes Chemical Manufacturing Benzene/Toluene/Aromatics/Xylenes p-Xylene: General	Aromatics	n.a.
30125815	Industrial Processes Chemical Manufacturing Benzene/Toluene/Aromatics/Xylenes Xylenes: General	Aromatics	n.a.
30505001	Industrial Processes Mineral Products Asphalt Processing (Blowing) Asphalt Processing (Blowing)	Asphalt Unit	n.a.
30505005	Industrial Processes Mineral Products Asphalt Processing (Blowing) Asphalt Storage (Prior to Blowing)	Asphalt Unit	n.a.
30602001	Industrial Processes Petroleum Industry Crude Unit Atmospheric Distillation General	Atmospheric Distillation Tower	n.a.
30601601	Industrial Processes Petroleum Industry Catalytic Reforming Unit General	Catalytic Reformer	n.a.
30100101	Industrial Processes Chemical Manufacturing Adipic Acid General	Chemical Production	n.a.
30100104	Industrial Processes Chemical Manufacturing Adipic Acid Nitric Acid Reaction	Chemical Production	n.a.
30100180	Industrial Processes Chemical Manufacturing Adipic Acid Fugitive Emissions: General	Chemical Production	n.a.
30100599	Industrial Processes Chemical Manufacturing Carbon Black Production Other Not Classified	Chemical Production	n.a.
30101030	Industrial Processes Chemical Manufacturing Explosives (Trinitrotoluene) Open Burning: Waste	Chemical Production	n.a.
30101499	Industrial Processes Chemical Manufacturing Paint Manufacture Other Not Classified	Chemical Production	n.a.
30101802	Industrial Processes Chemical Manufacturing Plastics Production Polypropylene and Copolymers	Chemical Production	n.a.
30101816	Industrial Processes Chemical Manufacturing Plastics Production Transferring/Handling/Loading/Packing	Chemical Production	n.a.
30101820	Industrial Processes Chemical Manufacturing Plastics Production Polymer Drying	Chemical Production	n.a.
30101847	Industrial Processes Chemical Manufacturing Plastics Production Epoxy Resins	Chemical Production	n.a.
30101864	Industrial Processes Chemical Manufacturing Plastics Production Pellet Silo/Storage	Chemical Production	n.a.
30101899	Industrial Processes Chemical Manufacturing Plastics Production Others Not Specified	Chemical Production	n.a.
30102201	Industrial Processes Chemical Manufacturing Sulfuric Acid (Chamber Process) General	Chemical Production	n.a.
30102301	Industrial Processes Chemical Manufacturing Sulfuric Acid Absorber (99.9% Conversion)	Chemical Production	n.a.
30102306	Industrial Processes Chemical Manufacturing Sulfuric Acid Absorber (99.0% Conversion)	Chemical Production	n.a.
30102310	Industrial Processes Chemical Manufacturing Sulfuric Acid Absorber (97.0% Conversion)	Chemical Production	n.a.
30103499	Industrial Processes Chemical Manufacturing Aniline/Ethanolamines Other Not Classified	Chemical Production	n.a.
30103801	Industrial Processes Chemical Manufacturing Sodium Bicarbonate General	Chemical Production	n.a.
30104002	Industrial Processes Chemical Manufacturing Urea Production Solution Concentration (Controlled)	Chemical Production	n.a.

SCC	Description	Assigned Category	Assigned Fuel Type
30107002	Industrial Processes Chemical Manufacturing Inorganic Chemical Manufacturing (General) Storage/Transfer	Chemical Production	n.a.
30109180	Industrial Processes Chemical Manufacturing Acetone/Ketone Production Acetone: Fugitive Emissions	Chemical Production	n.a.
30109199	Industrial Processes Chemical Manufacturing Acetone/Ketone Production Ketone: Other Not Classified	Chemical Production	n.a.
30110099	Industrial Processes Chemical Manufacturing Maleic Anhydride Other Not Classified	Chemical Production	n.a.
30113003	Industrial Processes Chemical Manufacturing Ammonium Sulfate (Use 3-01-210 for Caprolactum Production) Process Vents	Chemical Production	n.a.
30115201	Industrial Processes Chemical Manufacturing Bisphenol A General	Chemical Production	n.a.
30115704	Industrial Processes Chemical Manufacturing Cyclohexane Catalyst Replacement	Chemical Production	n.a.
30119701	Industrial Processes Chemical Manufacturing Butylene, Ethylene, Propylene, Olefin Production Ethylene: General	Chemical Production	n.a.
30119799	Industrial Processes Chemical Manufacturing Butylene, Ethylene, Propylene, Olefin Production Other Not Classified	Chemical Production	n.a.
30120201	Industrial Processes Chemical Manufacturing Phenol General	Chemical Production	n.a.
30120501	Industrial Processes Chemical Manufacturing Propylene Oxide General	Chemical Production	n.a.
30125001	Industrial Processes Chemical Manufacturing Methanol/Alcohol Production Methanol: General	Chemical Production	n.a.
30125004	Industrial Processes Chemical Manufacturing Methanol/Alcohol Production Methanol: Fugitive Emissions	Chemical Production	n.a.
30125015	Industrial Processes Chemical Manufacturing Methanol/Alcohol Production Isopropanol	Chemical Production	n.a.
30125099	Industrial Processes Chemical Manufacturing Methanol/Alcohol Production Other Not Classified	Chemical Production	n.a.
30125101	Industrial Processes Chemical Manufacturing Ethylene Glycol General	Chemical Production	n.a.
30130115	Industrial Processes Chemical Manufacturing Chlorobenzene Atmospheric Distillation Vents	Chemical Production	n.a.
30130501	Industrial Processes Chemical Manufacturing Epichlorohydrin General	Chemical Production	n.a.
30180002	Industrial Processes Chemical Manufacturing General Processes Pipeline Valves: Gas Stream	Chemical Production	n.a.
30180004	Industrial Processes Chemical Manufacturing Equipment Leaks Pipeline Valves: Heavy Liquid Stream	Chemical Production	n.a.
30180007	Industrial Processes Chemical Manufacturing Equipment Leaks Flanges: All Streams	Chemical Production	n.a.
30182001	Industrial Processes Chemical Manufacturing Wastewater Treatment Stripper	Chemical Production	n.a.
30182002	Industrial Processes Chemical Manufacturing Wastewater Treatment General	Chemical Production	n.a.
30182005	Industrial Processes Chemical Manufacturing Wastewater Treatment Lift Station	Chemical Production	n.a.
30182007	Industrial Processes Chemical Manufacturing Wastewater Treatment Non-aerated Impoundment	Chemical Production	n.a.
30184001	Industrial Processes Chemical Manufacturing General Processes Distillation Units	Chemical Production	n.a.
30187598	Industrial Processes Chemical Manufacturing Inorganic Chemical Storage Floating Roof Tank: Other Liquids: Working Loss	Chemical Production	n.a.
30199998	Industrial Processes Chemical Manufacturing Other Not Classified Other Not Classified	Chemical Production	n.a.
30300312	Industrial Processes Primary Metal Production Metallurgical Coke Manufacturing Coke Crushing/Screening/Handling	Coker	n.a.
30300331	Industrial Processes Primary Metal Production Metallurgical Coke Manufacturing By-product Process: General	Coker	n.a.
30510104	Industrial Processes Mineral Products Bulk Materials Conveyors Coke	Coker	n.a.
30601201	Industrial Processes Petroleum Industry Fluid Coking Units General	Coker	n.a.

SCC	Description	Assigned Category	Assigned Fuel Type
30601301	Industrial Processes Petroleum Industry Coke Handling System Storage and Transfer	Coker	n.a.
30601401	Industrial Processes Petroleum Industry Petroleum Coke Calcining Coke Calciner	Coker	n.a.
30601402	Industrial Processes Petroleum Industry Petroleum Coke Calcining Delayed Coking	Coker	n.a.
39000889	Industrial Processes In-process Fuel Use Coke General	Coker	n.a.
30600701	Industrial Processes Petroleum Industry Cooling Towers Cooling Towers	Cooling Tower	n.a.
38500101	Industrial Processes Cooling Tower Process Cooling Mechanical Draft	Cooling Tower	n.a.
38500102	Industrial Processes Cooling Tower Process Cooling Natural Draft	Cooling Tower	n.a.
38500110	Industrial Processes Cooling Tower Process Cooling Other Not Classified	Cooling Tower	n.a.
30107001	Industrial Processes Chemical Manufacturing Inorganic Chemical Manufacturing (General) Fugitive Leaks	Fugitive Emissions	n.a.
30180001	Industrial Processes Chemical Manufacturing Equipment Leaks General	Fugitive Emissions	n.a.
30188801	Industrial Processes Chemical Manufacturing Fugitive Emissions General	Fugitive Emissions	n.a.
30588801	Industrial Processes Mineral Products Fugitive Emissions Specify in Comments Field	Fugitive Emissions	n.a.
30600402	Industrial Processes Petroleum Industry Blowdown Systems Blowdown System w/o Controls	Fugitive Emissions	n.a.
30600801	Industrial Processes Petroleum Industry Fugitive Emissions Pipeline Valves and Flanges	Fugitive Emissions	n.a.
30600802	Industrial Processes Petroleum Industry Fugitive Emissions Vessel Relief Valves	Fugitive Emissions	n.a.
30600803	Industrial Processes Petroleum Industry Fugitive Emissions Pump Seals w/o Controls	Fugitive Emissions	n.a.
30600804	Industrial Processes Petroleum Industry Fugitive Emissions Compressor Seals	Fugitive Emissions	n.a.
30600805	Industrial Processes Petroleum Industry Fugitive Emissions Miscellaneous: Sampling/Non-Asphalt Blowing/Purging/etc.	Fugitive Emissions	n.a.
30600806	Industrial Processes Petroleum Industry Fugitive Emissions Pump Seals with Controls	Fugitive Emissions	n.a.
30600807	Industrial Processes Petroleum Industry Fugitive Emissions Blind Changing	Fugitive Emissions	n.a.
30600811	Industrial Processes Petroleum Industry Fugitive Emissions Pipeline Valves: Gas Streams	Fugitive Emissions	n.a.
30600812	Industrial Processes Petroleum Industry Fugitive Emissions Pipeline Valves: Light Liquid/Gas Streams	Fugitive Emissions	n.a.
30600813	Industrial Processes Petroleum Industry Fugitive Emissions Pipeline Valves: Heavy Liquid Streams	Fugitive Emissions	n.a.
30600815	Industrial Processes Petroleum Industry Fugitive Emissions Open-ended Valves: All Streams	Fugitive Emissions	n.a.
30600816	Industrial Processes Petroleum Industry Fugitive Emissions Flanges: All Streams	Fugitive Emissions	n.a.
30600817	Industrial Processes Petroleum Industry Fugitive Emissions Pump Seals: Light Liquid/Gas Streams	Fugitive Emissions	n.a.
30600818	Industrial Processes Petroleum Industry Fugitive Emissions Pump Seals: Heavy Liquid Streams	Fugitive Emissions	n.a.
30600819	Industrial Processes Petroleum Industry Fugitive Emissions Compressor Seals: Gas Streams	Fugitive Emissions	n.a.
30600820	Industrial Processes Petroleum Industry Fugitive Emissions Compressor Seals: Heavy Liquid Streams	Fugitive Emissions	n.a.
30600821	Industrial Processes Petroleum Industry Fugitive Emissions Drains: All Streams	Fugitive Emissions	n.a.
30600822	Industrial Processes Petroleum Industry Fugitive Emissions Vessel Relief Valves: All Streams	Fugitive Emissions	n.a.
30688801	Industrial Processes Petroleum Industry Fugitive Emissions Specify in Comments Field	Fugitive Emissions	n.a.
31088801	Industrial Processes Oil and Gas Production Fugitive Emissions Specify in Comments Field	Fugitive Emissions	n.a.

SCC	Description	Assigned Category	Assigned Fuel Type
31088804	Industrial Processes Oil and Gas Production Fugitive Emissions Specify in Comments Field	Fugitive Emissions	n.a.
31088805	Industrial Processes Oil and Gas Production Fugitive Emissions Specify in Comments Field	Fugitive Emissions	n.a.
31088811	Industrial Processes Oil and Gas Production Fugitive Emissions Fugitive Emissions	Fugitive Emissions	n.a.
40188898	Chemical Evaporation Organic Solvent Evaporation Fugitive Emissions General	Fugitive Emissions	n.a.
40288822	Chemical Evaporation Surface Coating Operations Fugitive Emissions Coating	Fugitive Emissions	n.a.
40388801	Chemical Evaporation Petroleum Product Storage at Refineries Fugitive Emissions General	Fugitive Emissions	n.a.
30602201	Industrial Processes Petroleum Industry Gasoline Blending Unit General	Gasoline Blending	n.a.
30602301	Industrial Processes Petroleum Industry Hydrocracking Unit General	Hydrocracker	n.a.
30107101	Industrial Processes Chemical Manufacturing Hydrogen Reformers	Hydrogen Plant	n.a.
30601801	Industrial Processes Petroleum Industry Hydrogen Generation Unit General	Hydrogen Plant	n.a.
30601701	Industrial Processes Petroleum Industry Catalytic Hydrotreating Unit General	Hydrotreater	n.a.
30610001	Industrial Processes Petroleum Industry Lube Oil Refining General	Lubricant Production	n.a.
40100251	Chemical Evaporation Organic Solvent Evaporation Degreasing Stoddard (Petroleum Solvent): General Degreasing Units	Lubricant Production	n.a.
40100296	Chemical Evaporation Organic Solvent Evaporation Degreasing Other Not Classified: General Degreasing Units	Lubricant Production	n.a.
40100305	Chemical Evaporation Organic Solvent Evaporation Cold Solvent Cleaning/Stripping 1,1,1-Trichloroethane (Methyl Chloroform)	Lubricant Production	n.a.
40100399	Chemical Evaporation Organic Solvent Evaporation Cold Solvent Cleaning/Stripping Other Not Classified	Lubricant Production	n.a.
30300831	Industrial Processes Primary Metal Production Iron Production (See 3-03-015 for Integrated Iron & Steel MACT) Unpaved Roads: Light Duty Vehicles	Other	n.a.
30300834	Industrial Processes Primary Metal Production Iron Production (See 3-03-015 for Integrated Iron & Steel MACT) Paved Roads: All Vehicle Types	Other	n.a.
30400113	Industrial Processes Secondary Metal Production Aluminum Slab Furnace	Other	n.a.
30400199	Industrial Processes Secondary Metal Production Aluminum Other Not Classified	Other	n.a.
30402001	Industrial Processes Secondary Metal Production Furnace Electrode Manufacture Calcination	Other	n.a.
30500298	Industrial Processes Mineral Products Asphalt Concrete Other Not Classified	Other	n.a.
30500503	Industrial Processes Mineral Products Castable Refractory Electric Arc Melt Furnace	Other	n.a.
30501011	Industrial Processes Mineral Products Coal Mining, Cleaning, and Material Handling Coal Transfer	Other	n.a.
30501039	Industrial Processes Mineral Products Coal Mining, Cleaning, and Material Handling Hauling: Haul Trucks	Other	n.a.
30501050	Industrial Processes Mineral Products Coal Mining, Cleaning, and Material Handling Vehicle Traffic: Light/Medium Vehicles	Other	n.a.
30501613	Industrial Processes Mineral Products Lime Manufacture Lime Silos	Other	n.a.
30502011	Industrial Processes Mineral Products Stone Quarrying - Processing (See also 305320) Hauling	Other	n.a.
30502504	Industrial Processes Mineral Products Construction Sand and Gravel Hauling	Other	n.a.
30502511	Industrial Processes Mineral Products Construction Sand and Gravel Screening	Other	n.a.
30504030	Industrial Processes Mineral Products Mining and Quarrying of Nonmetallic Minerals Primary Crusher	Other	n.a.
30510304	Industrial Processes Mineral Products Bulk Materials Open Stockpiles Coke	Other	n.a.
30510499	Industrial Processes Mineral Products Bulk Materials Unloading Operation Other Not Classified	Other	n.a.

SCC	Description	Assigned Category	Assigned Fuel Type
30510598	Industrial Processes Mineral Products Bulk Materials Loading Operation Mineral: Specify in Comments	Other	n.a.
30599999	Industrial Processes Mineral Products Other Not Defined Specify in Comments Field	Other	n.a.
30601001	Industrial Processes Petroleum Industry Sludge Converter General	Other	n.a.
30601011	Industrial Processes Petroleum Industry Sludge Converter Oil/Sludge Dewatering Unit: General	Other	n.a.
30601901	Industrial Processes Petroleum Industry Merox Treating Unit General	Other	n.a.
30602101	Industrial Processes Petroleum Industry Light Ends Fractionation Unit General	Other	n.a.
30603201	Industrial Processes Petroleum Industry Sour Gas Treating Unit General	Other	n.a.
30622001	Industrial Processes Petroleum Industry Underground Storage Remediation & Other Remediation Soil	Other	n.a.
30622201	Industrial Processes Petroleum Industry Underground Storage Remediation & Other Remediation Vapor Extract	Other	n.a.
30622401	Industrial Processes Petroleum Industry Underground Storage Remediation & Other Remediation Air Stripping	Other	n.a.
30699999	Industrial Processes Petroleum Industry Petroleum Products - Not Classified Not Classified **	Other	n.a.
30700106	Industrial Processes Pulp and Paper and Wood Products Sulfate (Kraft) Pulping Lime Kiln	Other	n.a.
30700401	Industrial Processes Pulp and Paper and Wood Products Paper and Paperboard Manufacture Paper Machine / Pulp Dryer	Other	n.a.
30900201	Industrial Processes Fabricated Metal Products Abrasive Blasting of Metal Parts General	Other	n.a.
30900203	Industrial Processes Fabricated Metal Products Abrasive Blasting of Metal Parts Slag Abrasive	Other	n.a.
30900204	Industrial Processes Fabricated Metal Products Abrasive Blasting of Metal Parts Garnet Abrasive	Other	n.a.
30900205	Industrial Processes Fabricated Metal Products Abrasive Blasting of Metal Parts Steel Grit Abrasive	Other	n.a.
30901098	Industrial Processes Fabricated Metal Products Electroplating Operations Other Not Classified	Other	n.a.
30901199	Industrial Processes Fabricated Metal Products Conversion Coating of Metal Products Other Not Classified	Other	n.a.
30901601	Industrial Processes Fabricated Metal Products Metal Pipe Coating of Metal Parts Asphalt Dipping	Other	n.a.
30903005	Industrial Processes Fabricated Metal Products Machining Operations Sawing: Specify Material in Comments	Other	n.a.
30903099	Industrial Processes Fabricated Metal Products Machining Operations See Comment	Other	n.a.
30905100	Industrial Processes Fabricated Metal Products Shielded Metal Arc Welding (SMAW) General	Other	n.a.
31000102	Industrial Processes Oil and Gas Production Crude Oil Production Miscellaneous Well: General	Other	n.a.
31000104	Industrial Processes Oil and Gas Production Crude Oil Production Crude Oil Sumps	Other	n.a.
31000199	Industrial Processes Oil and Gas Production Crude Oil Production Processing Operations: Not Classified	Other	n.a.
31000202	Industrial Processes Oil and Gas Production Natural Gas Production Gas Stripping Operations	Other	n.a.
31000207	Industrial Processes Oil and Gas Production Natural Gas Production Valves: Fugitive Emissions	Other	n.a.
31000220	Industrial Processes Oil and Gas Production Natural Gas Production All Equipt Leak Fugitives (Valves, Flanges, Connections, Seals, Drains	Other	n.a.
31000299	Industrial Processes Oil and Gas Production Natural Gas Production Other Not Classified	Other	n.a.

SCC	Description	Assigned Category	Assigned Fuel Type
31000304	Industrial Processes Oil and Gas Production Natural Gas Processing Glycol Dehydrator (See also 31000301-31000303)	Other	n.a.
31299999	Industrial Processes Machinery, Miscellaneous Miscellaneous Machinery Other Not Classified	Other	n.a.
31503002	Industrial Processes Photo Equip/Health Care/Labs/Air Condit/SwimPools Laboratories Bench Scale Reagents: Testing	Other	n.a.
39000499	Industrial Processes In-process Fuel Use Residual Oil General	Other	n.a.
39000797	Industrial Processes In-process Fuel Use Process Gas General	Other	n.a.
39000999	Industrial Processes In-process Fuel Use Wood General: Wood	Other	n.a.
39999989	Industrial Processes Miscellaneous Manufacturing Industries Miscellaneous Industrial Processes Other Not Classified	Other	n.a.
39999992	Industrial Processes Miscellaneous Manufacturing Industries Miscellaneous Industrial Processes Other Not Classified	Other	n.a.
39999993	Industrial Processes Miscellaneous Manufacturing Industries Miscellaneous Industrial Processes Other Not Classified	Other	n.a.
39999994	Industrial Processes Miscellaneous Manufacturing Industries Miscellaneous Industrial Processes Other Not Classified	Other	n.a.
39999995	Industrial Processes Miscellaneous Manufacturing Industries Miscellaneous Industrial Processes Other Not Classified	Other	n.a.
39999996	Industrial Processes Miscellaneous Manufacturing Industries Miscellaneous Industrial Processes Other Not Classified	Other	n.a.
39999997	Industrial Processes Miscellaneous Manufacturing Industries Miscellaneous Industrial Processes Other Not Classified	Other	n.a.
39999998	Industrial Processes Miscellaneous Manufacturing Industries Miscellaneous Industrial Processes Other Not Classified	Other	n.a.
39999999	Industrial Processes Miscellaneous Manufacturing Industries Miscellaneous Industrial Processes Other Not Classified	Other	n.a.
40200101	Chemical Evaporation Surface Coating Operations Surface Coating Application - General Paint: Solvent-base	Other	n.a.
40200201	Chemical Evaporation Surface Coating Operations Surface Coating Application - General Paint: Water-base	Other	n.a.
40200301	Chemical Evaporation Surface Coating Operations Surface Coating Application - General Varnish/Shellac	Other	n.a.
40200401	Chemical Evaporation Surface Coating Operations Surface Coating Application - General Lacquer	Other	n.a.
40200501	Chemical Evaporation Surface Coating Operations Surface Coating Application - General Enamel	Other	n.a.
40200601	Chemical Evaporation Surface Coating Operations Surface Coating Application - General Primer	Other	n.a.
40200710	Chemical Evaporation Surface Coating Operations Surface Coating Application - General Adhesive: General	Other	n.a.
40200801	Chemical Evaporation Surface Coating Operations Coating Oven - General General	Other	n.a.
40200922	Chemical Evaporation Surface Coating Operations Thinning Solvents - General Toluene	Other	n.a.
40201901	Chemical Evaporation Surface Coating Operations Wood Furniture Surface Coating Coating Operation	Other	n.a.
40201999	Chemical Evaporation Surface Coating Operations Wood Furniture Surface Coating Other Not Classified	Other	n.a.
40202501	Chemical Evaporation Surface Coating Operations Miscellaneous Metal Parts Coating Operation	Other	n.a.
40202502	Chemical Evaporation Surface Coating Operations Miscellaneous Metal Parts Cleaning/Pretreatment	Other	n.a.
40202546	Chemical Evaporation Surface Coating Operations Miscellaneous Metal Parts Single Coat Application: Flashoff	Other	n.a.
40202599	Chemical Evaporation Surface Coating Operations Miscellaneous Metal Parts Other Not Classified	Other	n.a.

SCC	Description	Assigned Category	Assigned Fuel Type
40202601	Chemical Evaporation Surface Coating Operations Steel Drums Coating Operation	Other	n.a.
40299998	Chemical Evaporation Surface Coating Operations Miscellaneous Miscellaneous	Other	n.a.
40500215	Chemical Evaporation Printing/Publishing Letterpress Cleaning Solution	Other	n.a.
49000502	Chemical Evaporation Organic Solvent Evaporation Air Stripping Tower Perchloroethylene	Other	n.a.
49099998	Chemical Evaporation Organic Solvent Evaporation Miscellaneous Volatile Organic Compound Evaporation Miscellaneous	Other	n.a.
50410420	Waste Disposal Site Remediation Air Stripping of Groundwater Air Stripping Tower	Other	n.a.
64633020	MACT Source Categories Vinyl-based Resins Polyvinyl Chloride and Copolymers Production - Bulk Process Process Vents, Polymerization Reactor: Safety Valve Vents	Other	n.a.
68445012	MACT Source Categories Miscellaneous Processes (Chemicals) Hydrazine Production, Olin Raschig Process Process Vents: Chloramine Reactor	Other	n.a.
2275050011	Mobile Sources Aircraft General Aviation Piston	Other	n.a.
2275050012	Mobile Sources Aircraft General Aviation Turbine	Other	n.a.
30103201	Industrial Processes Chemical Manufacturing Elemental Sulfur Production Mod. Claus: 2 Stage w/o Control (92-95% Removal)	Sulfur Plant	n.a.
30103202	Industrial Processes Chemical Manufacturing Elemental Sulfur Production Mod. Claus: 3 Stage w/o Control (95-96% Removal)	Sulfur Plant	n.a.
30103203	Industrial Processes Chemical Manufacturing Elemental Sulfur Production Mod. Claus: 4 Stage w/o Control (96-97% Removal)	Sulfur Plant	n.a.
30103204	Industrial Processes Chemical Manufacturing Elemental Sulfur Production Sulfur Removal Process (99.9% Removal)	Sulfur Plant	n.a.
30103205	Industrial Processes Chemical Manufacturing Elemental Sulfur Production Sulfur Storage	Sulfur Plant	n.a.
30103299	Industrial Processes Chemical Manufacturing Elemental Sulfur Production Other Not Classified	Sulfur Plant	n.a.
30510208	Industrial Processes Mineral Products Bulk Materials Storage Bins Sulfur	Sulfur Plant	n.a.
30603301	Industrial Processes Petroleum Industry Desulfurization Sulfur Recovery Unit	Sulfur Plant	n.a.
31000208	Industrial Processes Oil and Gas Production Natural Gas Production Sulfur Recovery Unit	Sulfur Plant	n.a.
30183001	Industrial Processes Chemical Manufacturing General Processes Storage/Transfer	Tank	n.a.
30187009	Industrial Processes Chemical Manufacturing Inorganic Chemical Storage Fixed Roof Tank: Sulfuric Acid: Breathing Loss	Tank	n.a.
30187010	Industrial Processes Chemical Manufacturing Inorganic Chemical Storage Fixed Roof Tank: Sulfuric Acid: Working Loss	Tank	n.a.
30187018	Industrial Processes Chemical Manufacturing Inorganic Chemical Storage Fixed Roof Tank: Aqueous Ammonia: Working Loss	Tank	n.a.
30187097	Industrial Processes Chemical Manufacturing Inorganic Chemical Storage Fixed Roof Tank: Other Liquids: Breathing Loss	Tank	n.a.
30187098	Industrial Processes Chemical Manufacturing Inorganic Chemical Storage Fixed Roof Tank: Other Liquids: Working Loss	Tank	n.a.
30187597	Industrial Processes Chemical Manufacturing Inorganic Chemical Storage Floating Roof Tank: Other Liquids: Breathing Loss	Tank	n.a.
30188599	Industrial Processes Chemical Manufacturing Inorganic Chemical Storage Pressure Tank: Other Gases: Working Loss	Tank	n.a.
30630006	Industrial Processes Petroleum Industry Re-refining of Lube Oils and Greases Waste Oil Storage Tank	Tank	n.a.
39090001	Industrial Processes In-process Fuel Use Fuel Storage - Fixed Roof Tanks Residual Oil: Breathing Loss	Tank	n.a.
39090007	Industrial Processes In-process Fuel Use Fuel Storage - Fixed Roof Tanks Methanol: Breathing Loss	Tank	n.a.
39090010	Industrial Processes In-process Fuel Use Fuel Storage - Fixed Roof Tanks Residual Oil/Crude Oil: Working Loss	Tank	n.a.

SCC	Description	Assigned Category	Assigned Fuel Type
39091009	Industrial Processes In-process Fuel Use Fuel Storage - Floating Roof Tanks Residual Oil/Crude Oil: Standing Loss	Tank	n.a.
39091010	Industrial Processes In-process Fuel Use Fuel Storage - Floating Roof Tanks Residual Oil/Crude Oil: Withdrawal Loss	Tank	n.a.
40301010	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Crude Oil RVP 5: Breathing Loss (67000 Bbl. Tank Size)	Tank	n.a.
40301011	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Crude Oil RVP 5: Breathing Loss (250000 Bbl. Tank Size)	Tank	n.a.
40301012	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Crude Oil RVP 5: Working Loss (Tank Diameter Independent)	Tank	n.a.
40301097	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Other Liquids: Breathing Loss (67000 Bbl. Tank Size)	Tank	n.a.
40301098	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Other Liquids: Breathing Loss (250000 Bbl. Tank Size)	Tank	n.a.
40301099	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Other Liquids: Working Loss (Tank Diameter Independent)	Tank	n.a.
40301109	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Crude Oil RVP 5: Breathing Loss (67000 Bbl. Tank Size)	Tank	n.a.
40301110	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Crude Oil RVP 5: Breathing Loss (250000 Bbl. Tank Size)	Tank	n.a.
40301117	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Crude Oil RVP 5: Working Loss	Tank	n.a.
40301130	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Other Liquids: Breathing Loss - External - Primary Seal	Tank	n.a.
40301132	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Crude Oil: Breathing Loss - External - Primary Seal	Tank	n.a.
40301140	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Other Liquids: Breathing Loss - External - Secondary Seal	Tank	n.a.
40301142	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Crude Oil: Breathing Loss - External - Secondary Seal	Tank	n.a.
40301150	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Other Liquids: Breathing Loss - Internal	Tank	n.a.
40301152	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Crude Oil: Breathing Loss - Internal	Tank	n.a.
40301197	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Other Liquids: Working Loss	Tank	n.a.
40301198	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Other Liquids: Breathing Loss (67000 Bbl. Tank Size)	Tank	n.a.
40301199	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Other Liquids: Breathing Loss (250000 Bbl. Tank Size)	Tank	n.a.
40301207	Chemical Evaporation Petroleum Product Storage at Refineries Variable Vapor Space Benzene: Filling Loss	Tank	n.a.
40301299	Chemical Evaporation Petroleum Product Storage at Refineries Variable Vapor Space Other Liquids: Filling Loss	Tank	n.a.
40399999	Chemical Evaporation Petroleum Product Storage at Refineries Other Not Classified Other Not Classified	Tank	n.a.
40400250	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Bulk Plants Loading Racks	Tank	n.a.
40400251	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Bulk Plants Valves, Flanges, and Pumps	Tank	n.a.
40400252	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Bulk Plants Miscellaneous Losses/Leaks: Vapor Collection Losses	Tank	n.a.
40400253	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Bulk Plants Miscellaneous Losses/Leaks: Vapor Control Unit Losses	Tank	n.a.
40400254	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Bulk Plants Tank Truck Vapor Losses	Tank	n.a.
40400260	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Bulk Plants Other Liquids: Breathing Loss - Internal Floating Roof w/ Primary Seal	Tank	n.a.

SCC	Description	Assigned Category	Assigned Fuel Type
40400301	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Oil and Gas Field Storage and Working Tanks Fixed Roof Tank: Breathing Loss	Tank	n.a.
40400302	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Oil and Gas Field Storage and Working Tanks Fixed Roof Tank: Working Loss	Tank	n.a.
40400305	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Oil and Gas Field Storage and Working Tanks Internal Floating Roof Tank: Breathing Loss	Tank	n.a.
40400311	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Oil and Gas Field Storage and Working Tanks Fixed Roof Tank, Condensate, working+breathing+flashing losses	Tank	n.a.
40400312	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Oil and Gas Field Storage and Working Tanks Fixed Roof Tank, Crude Oil, working+breathing+flashing losses	Tank	n.a.
40400313	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Oil and Gas Field Storage and Working Tanks Fixed Roof Tank, Lube Oil, working+breathing+flashing losses	Tank	n.a.
40400314	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Oil and Gas Field Storage and Working Tanks Fixed Roof Tank, Specialty Chem-working+breathing+flashing	Tank	n.a.
40400315	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Oil and Gas Field Storage and Working Tanks Fixed Roof Tank, Produced Water, working+breathing+flashing	Tank	n.a.
40400321	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Oil and Gas Field Storage and Working Tanks External Floating Roof Tank, Condensate, working+breathing+flashing	Tank	n.a.
40400324	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Oil and Gas Field Storage and Working Tanks External Floating Roof Tank, Specialty Chem-working+breathing+flashing	Tank	n.a.
40400326	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Oil and Gas Field Storage and Working Tanks External Floating Roof Tank, Diesel, working+breathing+flashing	Tank	n.a.
40400332	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Oil and Gas Field Storage and Working Tanks Internal Floating Roof Tank, Crude Oil, working+breathing+flashing	Tank	n.a.
40400497	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Petroleum Products - Underground Tanks Other Liquids: Breathing Loss	Tank	n.a.
40400498	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Petroleum Products - Underground Tanks Other Liquids: Working Loss	Tank	n.a.
40700497	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Acid Anhydrides Other Anhydrides: Breathing Loss	Tank	n.a.
40700807	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Alcohols Cyclohexanol: Breathing Loss	Tank	n.a.
40700809	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Alcohols Ethyl Alcohol: Breathing Loss	Tank	n.a.
40700810	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Alcohols Ethyl Alcohol: Working Loss	Tank	n.a.
40700813	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Alcohols Isopropyl Alcohol: Breathing Loss	Tank	n.a.
40700815	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Alcohols Methyl Alcohol: Breathing Loss	Tank	n.a.
40700816	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Alcohols Methyl Alcohol: Working Loss	Tank	n.a.
40700817	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Alcohols N-Propyl Alcohol: Breathing Loss	Tank	n.a.
40700897	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Alcohols Other Alcohols: Breathing Loss	Tank	n.a.
40701606	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Alkanes (Paraffins) N-Heptane: Working Loss	Tank	n.a.
40701611	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Alkanes (Paraffins) Naphtha: Breathing Loss	Tank	n.a.

SCC	Description	Assigned Category	Assigned Fuel Type
40701612	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Alkanes (Paraffins) Naphtha: Working Loss	Tank	n.a.
40701613	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Alkanes (Paraffins) Petroleum Distillate: Breathing Loss	Tank	n.a.
40701614	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Alkanes (Paraffins) Petroleum Distillate: Working Loss	Tank	n.a.
40701697	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Alkanes (Paraffins) Other Alkanes: Breathing Loss	Tank	n.a.
40701698	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Alkanes (Paraffins) Other Alkanes: Working Loss	Tank	n.a.
40702097	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Alkenes (Olefins) Other Olefins: Breathing Loss	Tank	n.a.
40703203	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Amines Ethanolamines: Breathing Loss	Tank	n.a.
40703204	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Amines Ethanolamines: Working Loss	Tank	n.a.
40703297	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Amines Other Amines: Breathing Loss	Tank	n.a.
40703298	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Amines Other Amines: Working Loss	Tank	n.a.
40703601	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Aromatics Benzene: Breathing Loss	Tank	n.a.
40703602	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Aromatics Benzene: Working Loss	Tank	n.a.
40703605	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Aromatics Cumene: Breathing Loss	Tank	n.a.
40703606	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Aromatics Cumene: Working Loss	Tank	n.a.
40703607	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Aromatics Diisopropyl Benzene: Breathing Loss	Tank	n.a.
40703613	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Aromatics Styrene: Breathing Loss	Tank	n.a.
40703615	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Aromatics Toluene: Breathing Loss	Tank	n.a.
40703616	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Aromatics Toluene: Working Loss	Tank	n.a.
40703620	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Aromatics o-Xylene: Working Loss	Tank	n.a.
40703623	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Aromatics Xylenes, Mixed: Breathing Loss	Tank	n.a.
40703697	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Aromatics Other Aromatics: Breathing Loss	Tank	n.a.
40703698	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Aromatics Other Aromatics: Working Loss	Tank	n.a.
40704801	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Ethers Methyl-tert-Butyl Ether: Breathing Loss	Tank	n.a.
40704802	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Ethers Methyl-tert-Butyl Ether: Working Loss	Tank	n.a.
40704897	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Ethers Other Ethers: Breathing Loss	Tank	n.a.
40705203	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Glycol Ethers Butyl Cellosolve: Breathing Loss	Tank	n.a.
40705609	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Glycols Propylene Glycol: Breathing Loss	Tank	n.a.
40705610	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Glycols Propylene Glycol: Working Loss	Tank	n.a.
40705697	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Glycols Other Glycols: Breathing Loss	Tank	n.a.

SCC	Description	Assigned Category	Assigned Fuel Type
40706003	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Halogenated Organics Caprolactum (Soln): Breathing Loss	Tank	n.a.
40706013	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Halogenated Organics Epichlorohydrin: Breathing Loss	Tank	n.a.
40706020	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Halogenated Organics Methylene Chloride (Dichloromethane): Working Loss	Tank	n.a.
40706021	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Halogenated Organics Perchloroethylene: Breathing Loss	Tank	n.a.
40706022	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Halogenated Organics Perchloroethylene: Working Loss	Tank	n.a.
40706807	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Ketones Methyl Isobutyl Ketone: Breathing Loss	Tank	n.a.
40706897	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Ketones Other Ketones: Breathing Loss	Tank	n.a.
40707697	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Nitriles Other Nitriles: Breathing Loss	Tank	n.a.
40708403	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Phenols Phenol: Breathing Loss	Tank	n.a.
40714697	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Miscellaneous Other: Breathing Loss	Tank	n.a.
40714698	Chemical Evaporation Organic Chemical Storage Fixed Roof Tanks - Miscellaneous Other: Working Loss	Tank	n.a.
40715801	Chemical Evaporation Organic Chemical Storage Floating Roof Tanks - Alcohols Methanol: Breathing Loss	Tank	n.a.
40715809	Chemical Evaporation Organic Chemical Storage Floating Roof Tanks - Alcohols Ethyl Alcohol: Breathing Loss	Tank	n.a.
40715810	Chemical Evaporation Organic Chemical Storage Floating Roof Tanks - Alcohols Ethyl Alcohol: Working Loss	Tank	n.a.
40717604	Chemical Evaporation Organic Chemical Storage Floating Roof Tanks - Alkanes (Paraffins) n-Hexane: Working Loss	Tank	n.a.
40717611	Chemical Evaporation Organic Chemical Storage Floating Roof Tanks - Alkanes (Paraffins) Naphtha: Breathing Loss	Tank	n.a.
40717612	Chemical Evaporation Organic Chemical Storage Floating Roof Tanks - Alkanes (Paraffins) Naphtha: Working Loss	Tank	n.a.
40717614	Chemical Evaporation Organic Chemical Storage Floating Roof Tanks - Alkanes (Paraffins) Petroleum Distillates: Working Loss	Tank	n.a.
40717697	Chemical Evaporation Organic Chemical Storage Floating Roof Tanks - Alkanes (Paraffins) Other Alkanes: Breathing Loss	Tank	n.a.
40717698	Chemical Evaporation Organic Chemical Storage Floating Roof Tanks - Alkanes (Paraffins) Other Alkanes: Working Loss	Tank	n.a.
40719601	Chemical Evaporation Organic Chemical Storage Floating Roof Tanks - Aromatics Benzene: Breathing Loss	Tank	n.a.
40719602	Chemical Evaporation Organic Chemical Storage Floating Roof Tanks - Aromatics Benzene: Working Loss	Tank	n.a.
40719615	Chemical Evaporation Organic Chemical Storage Floating Roof Tanks - Aromatics Toluene: Breathing Loss	Tank	n.a.
40719616	Chemical Evaporation Organic Chemical Storage Floating Roof Tanks - Aromatics Toluene: Working Loss	Tank	n.a.
40719698	Chemical Evaporation Organic Chemical Storage Floating Roof Tanks - Aromatics Other Aromatics: Working Loss	Tank	n.a.
40720897	Chemical Evaporation Organic Chemical Storage Floating Roof Tanks - Ethers Other Ethers: Breathing Loss	Tank	n.a.
40720898	Chemical Evaporation Organic Chemical Storage Floating Roof Tanks - Ethers Other Ethers: Working Loss	Tank	n.a.
40722022	Chemical Evaporation Organic Chemical Storage Floating Roof Tanks - Halogenated Organics Perchloroethylene: Working Loss	Tank	n.a.
40722801	Chemical Evaporation Organic Chemical Storage Floating Roof Tanks - Ketones Acetone: Breathing Loss	Tank	n.a.

SCC	Description	Assigned Category	Assigned Fuel Type
40729697	Chemical Evaporation Organic Chemical Storage Floating Roof Tanks - Miscellaneous Other: Breathing Loss	Tank	n.a.
40729698	Chemical Evaporation Organic Chemical Storage Floating Roof Tanks - Miscellaneous Other: Working Loss	Tank	n.a.
40781602	Chemical Evaporation Organic Chemical Storage Pressure Tanks - Alkanes (Paraffins) Butane: Working Loss	Tank	n.a.
40781605	Chemical Evaporation Organic Chemical Storage Pressure Tanks - Alkanes (Paraffins) Propane: Working Loss	Tank	n.a.
40781699	Chemical Evaporation Organic Chemical Storage Pressure Tanks - Alkanes (Paraffins) Other Alkanes: Working Loss	Tank	n.a.
40782006	Chemical Evaporation Organic Chemical Storage Pressure Tanks - Alkenes (Olefins) Propylene: Working Loss	Tank	n.a.
40799997	Petroleum and Solvent Evaporation Organic Chemical Storage Miscellaneous Specify in Comments	Tank	n.a.
40799999	Chemical Evaporation Organic Chemical Storage Miscellaneous Other Not Classified	Tank	n.a.
42500202	Chemical Evaporation unknown unknown Fixed Roof Tanks (500 Bbl Size) Working Loss	Tank	n.a.
42500301	Chemical Evaporation unknown unknown Fixed Roof Tanks (1,000 Bbl Size) Breathing Loss	Tank	n.a.
42500302	Chemical Evaporation unknown unknown Fixed Roof Tanks (1,000 Bbl Size) Working Loss	Tank	n.a.
42505002	Chemical Evaporation unknown unknown Floating Roof Tanks (1,000 Bbl Size) Working Loss	Tank	n.a.
40301022	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Asphalt Oil: Breathing Loss (67000 Bbl. Tank Size)	Tank - Asphalt	n.a.
40301023	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Asphalt Oil: Working Loss	Tank - Asphalt	n.a.
40301024	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Asphalt Oil: Breathing Loss (250000 Bbl. Tank Size)	Tank - Asphalt	n.a.
40301019	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Distillate Fuel #2: Breathing Loss (67000 Bbl. Tank Size)	Tank - Distillate	n.a.
40301020	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Distillate Fuel #2: Breathing Loss (250000 Bbl. Tank Size)	Tank - Distillate	n.a.
40301021	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Distillate Fuel #2: Working Loss (Tank Diameter Independent)	Tank - Distillate	n.a.
40301115	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Distillate Fuel #2: Breathing Loss (67000 Bbl. Tank Size)	Tank - Distillate	n.a.
40301116	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Distillate Fuel #2: Breathing Loss (250000 Bbl. Tank Size)	Tank - Distillate	n.a.
40301120	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Distillate Fuel #2: Working Loss	Tank - Distillate	n.a.
40301135	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Distillate Fuel #2: Breathing Loss - External - Primary Seal	Tank - Distillate	n.a.
40301145	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Distillate Fuel #2: Breathing Loss - External - Secondary Seal	Tank - Distillate	n.a.
40301155	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Distillate Fuel #2: Breathing Loss - Internal	Tank - Distillate	n.a.
40301206	Chemical Evaporation Petroleum Product Storage at Refineries Variable Vapor Space Distillate Fuel #2: Filling Loss	Tank - Distillate	n.a.
40400413	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Petroleum Products - Underground Tanks Distillate Fuel #2: Breathing Loss	Tank - Distillate	n.a.
40400414	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Petroleum Products - Underground Tanks Distillate Fuel #2: Working Loss	Tank - Distillate	n.a.
40301025	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Grade 6 Fuel Oil: Breathing Loss (67000 Bbl. Tank Size)	Tank - Fuel Oil	n.a.
40301027	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Grade 4 Fuel Oil: Breathing Loss (67000 Bbl. Tank Size)	Tank - Fuel Oil	n.a.

SCC	Description	Assigned Category	Assigned Fuel Type
40301028	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Grade 2 Fuel Oil: Breathing Loss (67000 Bbl. Tank Size)	Tank - Fuel Oil	n.a.
40301029	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Grade 1 Fuel Oil: Breathing Loss (67000 Bbl. Tank Size)	Tank - Fuel Oil	n.a.
40301065	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Grade 6 Fuel Oil: Breathing Loss (250000 Bbl. Tank Size)	Tank - Fuel Oil	n.a.
40301067	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Grade 4 Fuel Oil: Breathing Loss (250000 Bbl. Tank Size)	Tank - Fuel Oil	n.a.
40301068	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Grade 2 Fuel Oil: Breathing Loss (250000 Bbl. Tank Size)	Tank - Fuel Oil	n.a.
40301075	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Grade 6 Fuel Oil: Working Loss (Independent Tank Diameter)	Tank - Fuel Oil	n.a.
40301076	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Grade 5 Fuel Oil: Working Loss (Independent Tank Diameter)	Tank - Fuel Oil	n.a.
40301077	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Grade 4 Fuel Oil: Working Loss (Independent Tank Diameter)	Tank - Fuel Oil	n.a.
40301078	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Grade 2 Fuel Oil: Working Loss (Independent Tank Diameter)	Tank - Fuel Oil	n.a.
40301079	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Grade 1 Fuel Oil: Working Loss (Independent Tank Diameter)	Tank - Fuel Oil	n.a.
40301125	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Grade 6 Fuel Oil: Breathing Loss (67000 Bbl. Tank Size)	Tank - Fuel Oil	n.a.
40301126	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Grade 5 Fuel Oil: Breathing Loss (67000 Bbl. Tank Size)	Tank - Fuel Oil	n.a.
40301129	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Grade 1 Fuel Oil: Breathing Loss (67000 Bbl. Tank Size)	Tank - Fuel Oil	n.a.
40301165	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Grade 6 Fuel Oil: Breathing Loss (250000 Bbl. Tank Size)	Tank - Fuel Oil	n.a.
40301166	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Grade 5 Fuel Oil: Breathing Loss (250000 Bbl. Tank Size)	Tank - Fuel Oil	n.a.
40301167	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Grade 4 Fuel Oil: Breathing Loss (250000 Bbl. Tank Size)	Tank - Fuel Oil	n.a.
40301175	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Grade 6 Fuel Oil: Working Loss (Independent Tank Diameter)	Tank - Fuel Oil	n.a.
40301177	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Grade 4 Fuel Oil: Working Loss (Independent Tank Diameter)	Tank - Fuel Oil	n.a.
40301178	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Grade 2 Fuel Oil: Working Loss (Independent Tank Diameter)	Tank - Fuel Oil	n.a.
40301179	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Grade 1 Fuel Oil: Working Loss (Independent Tank Diameter)	Tank - Fuel Oil	n.a.
40301001	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Gasoline RVP 13: Breathing Loss (67000 Bbl. Tank Size)	Tank - Gasoline	n.a.
40301002	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Gasoline RVP 10: Breathing Loss (67000 Bbl. Tank Size)	Tank - Gasoline	n.a.
40301003	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Gasoline RVP 7: Breathing Loss (67000 Bbl. Tank Size)	Tank - Gasoline	n.a.
40301004	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Gasoline RVP 13: Breathing Loss (250000 Bbl. Tank Size)	Tank - Gasoline	n.a.
40301005	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Gasoline RVP 10: Breathing Loss (250000 Bbl. Tank Size)	Tank - Gasoline	n.a.
40301006	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Gasoline RVP 7: Breathing Loss (250000 Bbl. Tank Size)	Tank - Gasoline	n.a.
40301007	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Gasoline RVP 13: Working Loss (Tank Diameter Independent)	Tank - Gasoline	n.a.

SCC	Description	Assigned Category	Assigned Fuel Type
40301008	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Gasoline RVP 10: Working Loss (Tank Diameter Independent)	Tank - Gasoline	n.a.
40301009	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Gasoline RVP 7: Working Loss (Tank Diameter Independent)	Tank - Gasoline	n.a.
40301101	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Gasoline RVP 13: Breathing Loss (67000 Bbl. Tank Size)	Tank - Gasoline	n.a.
40301102	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Gasoline RVP 10: Breathing Loss (67000 Bbl. Tank Size)	Tank - Gasoline	n.a.
40301103	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Gasoline RVP 7: Breathing Loss (67000 Bbl. Tank Size)	Tank - Gasoline	n.a.
40301104	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Gasoline RVP 13: Breathing Loss (250000 Bbl. Tank Size)	Tank - Gasoline	n.a.
40301105	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Gasoline RVP 10: Breathing Loss (250000 Bbl. Tank Size)	Tank - Gasoline	n.a.
40301106	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Gasoline RVP 7: Breathing Loss (250000 Bbl. Tank Size)	Tank - Gasoline	n.a.
40301107	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Gasoline RVP 13/10/7: Working Loss (67000 Bbl. Tank Size)	Tank - Gasoline	n.a.
40301108	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Gasoline RVP 13/10/7: Working Loss (250000 Bbl.Tank Size)	Tank - Gasoline	n.a.
40301131	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Gasoline: Breathing Loss - External - Primary Seal	Tank - Gasoline	n.a.
40301141	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Gasoline: Breathing Loss - External - Secondary Seal	Tank - Gasoline	n.a.
40301151	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Gasoline: Breathing Loss - Internal	Tank - Gasoline	n.a.
40301180	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Gasoline RVP 13: Working Loss (Independent Tank Diameter)	Tank - Gasoline	n.a.
40301181	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Gasoline RVP 10: Working Loss (Independent Tank Diameter)	Tank - Gasoline	n.a.
40301182	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Gasoline RVP 7: Working Loss (Independent Tank Diameter)	Tank - Gasoline	n.a.
40301201	Chemical Evaporation Petroleum Product Storage at Refineries Variable Vapor Space Gasoline RVP 13: Filling Loss	Tank - Gasoline	n.a.
40301202	Chemical Evaporation Petroleum Product Storage at Refineries Variable Vapor Space Gasoline RVP 10: Filling Loss	Tank - Gasoline	n.a.
40400203	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Bulk Plants Gasoline RVP 7: Breathing Loss (67000 Bbl. Capacity) - Fixed Roof Tank	Tank - Gasoline	n.a.
40400206	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Bulk Plants Gasoline RVP 7: Working Loss (67000 Bbl. Capacity) - Fixed Roof Tank	Tank - Gasoline	n.a.
40400210	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Bulk Plants Gasoline RVP 13/10/7: Working Loss (67000 Bbl Cap.) - Float Rf Tnk	Tank - Gasoline	n.a.
40400241	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Bulk Plants Gasoline RVP 13: Breathing Loss - Ext. Floating Roof w/ Secondary Seal	Tank - Gasoline	n.a.
40400261	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Bulk Plants Gasoline RVP 13: Breathing Loss - Int. Floating Roof w/ Primary Seal	Tank - Gasoline	n.a.
40400402	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Petroleum Products - Underground Tanks Gasoline RVP 13: Working Loss	Tank - Gasoline	n.a.
40400403	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Petroleum Products - Underground Tanks Gasoline RVP 10: Breathing Loss	Tank - Gasoline	n.a.
40400404	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Petroleum Products - Underground Tanks Gasoline RVP 10: Working Loss	Tank - Gasoline	n.a.
40301013	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Jet Naphtha (JP-4): Breathing Loss (67000 Bbl. Tank Size)	Tank - Kerosene	n.a.

SCC	Description	Assigned Category	Assigned Fuel Type
40301014	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Jet Naphtha (JP-4): Breathing Loss (250000 Bbl. Tank Size)	Tank - Kerosene	n.a.
40301015	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Jet Naphtha (JP-4): Working Loss (Tank Diameter Independent)	Tank - Kerosene	n.a.
40301016	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Jet Kerosene: Breathing Loss (67000 Bbl. Tank Size)	Tank - Kerosene	n.a.
40301017	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Jet Kerosene: Breathing Loss (250000 Bbl. Tank Size)	Tank - Kerosene	n.a.
40301018	Chemical Evaporation Petroleum Product Storage at Refineries Fixed Roof Tanks (Varying Sizes) Jet Kerosene: Working Loss (Tank Diameter Independent)	Tank - Kerosene	n.a.
40301111	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Jet Naphtha (JP-4): Breathing Loss (67000 Bbl. Tank Size)	Tank - Kerosene	n.a.
40301112	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Jet Naphtha (JP-4): Breathing Loss (250000 Bbl. Tank Size)	Tank - Kerosene	n.a.
40301113	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Jet Kerosene: Breathing Loss (67000 Bbl. Tank Size)	Tank - Kerosene	n.a.
40301114	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Jet Kerosene: Breathing Loss (250000 Bbl. Tank Size)	Tank - Kerosene	n.a.
40301118	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Jet Naphtha (JP-4): Working Loss	Tank - Kerosene	n.a.
40301119	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Jet Kerosene: Working Loss	Tank - Kerosene	n.a.
40301133	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Jet Naphtha (JP-4): Breathing Loss - External - Primary Seal	Tank - Kerosene	n.a.
40301134	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Jet Kerosene: Breathing Loss - External - Primary Seal	Tank - Kerosene	n.a.
40301143	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Jet Naphtha (JP-4): Breathing Loss - External - Secondary Seal	Tank - Kerosene	n.a.
40301144	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Jet Kerosene: Breathing Loss - External - Secondary Seal	Tank - Kerosene	n.a.
40301153	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Jet Naphtha (JP-4): Breathing Loss - Internal	Tank - Kerosene	n.a.
40301154	Chemical Evaporation Petroleum Product Storage at Refineries Floating Roof Tanks (Varying Sizes) Jet Kerosene: Breathing Loss - Internal	Tank - Kerosene	n.a.
40301204	Chemical Evaporation Petroleum Product Storage at Refineries Variable Vapor Space Jet Naphtha (JP-4): Filling Loss	Tank - Kerosene	n.a.
40400409	Chemical Evaporation Petroleum Liquids Storage (non-Refinery) Petroleum Products - Underground Tanks Jet Naphtha (JP-4): Breathing Loss	Tank - Kerosene	n.a.
30600301	Industrial Processes Petroleum Industry Catalytic Cracking Units Thermal Catalytic Cracking Unit	Thermal Cracking	n.a.
30600602	Industrial Processes Petroleum Industry Vacuum Distillate Column Condensors Vacuum Distillation Column Condenser	Vacuum Distillation	n.a.
31000140	Industrial Processes Oil and Gas Production Crude Oil Production Waste Sumps: Primary Light Crude	Waste	n.a.
31000503	Industrial Processes Oil and Gas Production Liquid Waste Treatment Oil-Water Separator	Waste	n.a.
31000506	Industrial Processes Oil and Gas Production Liquid Waste Treatment Oil-Water Separation Wastewater Holding Tanks	Waste	n.a.
39001299	Industrial Processes In-process Fuel Use Solid Waste General	Waste	n.a.
49000201	Chemical Evaporation Organic Solvent Evaporation Waste Solvent Recovery Operations Storage Tank Vent	Waste	n.a.
50100402	Waste Disposal Solid Waste Disposal - Municipal Waste Landfill Dump Fugitive Emissions	Waste	n.a.
50100601	Waste Disposal Solid Waste Disposal - Government Fire Fighting Structure: Jet Fuel	Waste	n.a.
50300506	Waste Disposal Solid Waste Disposal - Industrial Incineration Sludge	Waste	n.a.

SCC	Description	Assigned Category	Assigned Fuel Type
50300710	Waste Disposal Solid Waste Disposal - Industrial Liquid Waste Open Sump	Waste	n.a.
50300713	Waste Disposal Solid Waste Disposal - Industrial Liquid Waste Oil/Water Separator	Waste	n.a.
50300781	Waste Disposal Solid Waste Disposal - Industrial Liquid Waste Sludge Digester	Waste	n.a.
50300820	Waste Disposal Solid Waste Disposal - Industrial Treatment, Storage, Disposal/TSDF Land Treatment: Fugitive Emissions	Waste	n.a.
50300901	Waste Disposal Solid Waste Disposal - Industrial Asbestos Removal General	Waste	n.a.
50390006	Waste Disposal Solid Waste Disposal - Industrial Auxillary Fuel/No Emissions Natural Gas	Waste	n.a.
50400151	Waste Disposal Site Remediation General Processes Liquid Waste: General: Transfer	Waste	n.a.
50410001	Waste Disposal Site Remediation Excavation/Soils Handling Excavation	Waste	n.a.
50410021	Waste Disposal Site Remediation Excavation/Soils Handling Dumping: Machinery into Truck	Waste	n.a.
50410310	Waste Disposal Site Remediation In Situ Venting/Venting of Soils Active Aeration	Waste	n.a.
50410405	Waste Disposal Site Remediation Air Stripping of Groundwater Oil/Water Separator	Waste	n.a.
50410408	Waste Disposal Site Remediation Air Stripping of Groundwater Treatment Tanks	Waste	n.a.
50410520	Waste Disposal Site Remediation Thermal Destruction Waste Feed System	Waste	n.a.
50410780	Waste Disposal Site Remediation Biological Treatment In Situ Bioremediation	Waste	n.a.
50482599	Waste Disposal Site Remediation Wastewater, Points of Generation Specify Point of Generation	Waste	n.a.
68482599	MACT Source Categories Miscellaneous Processes (Chemicals) Wastewater, Points of Generation Specify Point of Generation	Waste	n.a.
30600503	Industrial Processes Petroleum Industry Wastewater Treatment Process Drains and Wastewater Separators	Wastewater Treatment	n.a.
30600505	Industrial Processes Petroleum Industry Wastewater Treatment Wastewater Treatment w/o Separator	Wastewater Treatment	n.a.
30600508	Industrial Processes Petroleum Industry Wastewater Treatment Oil/Water Separator	Wastewater Treatment	n.a.
30600510	Industrial Processes Petroleum Industry Wastewater Treatment Liquid-Liquid Separator: Hydrocarbon/Amine	Wastewater Treatment	n.a.
30600511	Industrial Processes Petroleum Industry Wastewater Treatment Sour Water Treating	Wastewater Treatment	n.a.
30600514	Industrial Processes Petroleum Industry Wastewater Treatment Petroleum Refinery Wastewater System: Junction Box	Wastewater Treatment	n.a.
30600515	Industrial Processes Petroleum Industry Wastewater Treatment Petroleum Refinery Wastewater System: Lift Station	Wastewater Treatment	n.a.
30600516	Industrial Processes Petroleum Industry Wastewater Treatment Petroleum Refinery Wastewater System: Aerated Impoundment	Wastewater Treatment	n.a.
30600517	Industrial Processes Petroleum Industry Wastewater Treatment Petroleum Refinery Wastewater System: Non-aerated Impoundment	Wastewater Treatment	n.a.
30600518	Industrial Processes Petroleum Industry Wastewater Treatment Petroleum Refinery Wastewater System: Weir	Wastewater Treatment	n.a.
30600519	Industrial Processes Petroleum Industry Wastewater Treatment Petroleum Refinery Wastewater System: Activated Sludge Impoundment	Wastewater Treatment	n.a.
30600520	Industrial Processes Petroleum Industry Wastewater Treatment Petroleum Refinery Wastewater System: Clarifier	Wastewater Treatment	n.a.
30600521	Industrial Processes Petroleum Industry Wastewater Treatment Petroleum Refinery Wastewater System: Open Trench	Wastewater Treatment	n.a.
30600522	Industrial Processes Petroleum Industry Wastewater Treatment Petroleum Refinery Wastewater System: Auger Pumps	Wastewater Treatment	n.a.

Table 7-7. Results for natural gas combustion emission factors.

Natural Gas	Emissions (MT)						Emission Factor (g/mmBTU fuel)					
Pollutant	National	PADD 1	PADD 2	PADD 3	PADD 4	PADD 5	National	PADD 1	PADD 2	PADD 3	PADD 4	PADD 5
CO2	22,000,000	1,700,000	2,400,000	11,000,000	800,000	6,000,000	32,000	44,000	22,000	27,000	53,000	48,000
SO2	1,100	21	93	690	190	73	1.5	0.54	0.85	1.7	12	0.60
NOx	8,800	140	1,400	5,000	300	1,900	13	3.7	13	12	20	15
PM <2.5um	1,300	16	150	910	36	180	1.9	0.40	1.4	2.2	2.4	1.5
EC	490	6.0	59	350	14	68	0.72	0.15	0.53	0.86	0.91	0.56
OC	320	3.8	38	220	8.9	44	0.46	0.099	0.34	0.55	0.59	0.36
PM <10um	1,300	19	150	920	36	180	1.9	0.48	1.4	2.3	2.4	1.5
CO	5,600	68	1,100	2,700	790	990	8.2	1.8	10	6.5	52	8.2
CH4	410	32	46	200	15	120	0.60	0.84	0.42	0.51	0.99	0.92
VOCs	850	7.4	95	390	19	340	1.2	0.19	0.86	0.96	1.2	2.8
N2O	42	3.2	4.6	21	1.5	12	0.061	0.084	0.042	0.053	0.099	0.092
Fuel Use (1000 mmBTU)	680,000	39,000	110,000	400,000	15,000	120,000						

Table 7-8. Results for refinery gas combustion emission factors.

Refinery Gas	Emissions (MT)						Emission Factor (g/mmBTU fuel)					
Pollutant	National	PADD 1	PADD 2	PADD 3	PADD 4	PADD 5	National	PADD 1	PADD 2	PADD 3	PADD 4	PADD 5
CO2	95,000,000	5,500,000	20,000,000	50,000,000	3,400,000	16,000,000	77,000	67,000	75,000	85,000	72,000	65,000
SO2	12,000	410	2,500	5,100	590	3,100	9.6	5.0	9.6	8.6	13	13
NOx	55,000	4,100	13,000	26,000	2,500	9,700	45	50	51	43	52	40
PM <2.5um	7,400	650	2,000	3,200	240	1,300	6.0	8.0	7.6	5.3	5.2	5.6
EC	1,500	170	410	620	47	300	1.3	2.1	1.5	1.0	1.0	1.2
OC	2,100	180	580	930	71	380	1.7	2.2	2.2	1.5	1.5	1.6
PM <10um	7,800	770	2,100	3,300	270	1,400	6.3	9.4	8.1	5.4	5.8	5.7
CO	29,000	2,500	9,100	11,000	1,800	5,000	24	30	34	18	38	21
CH4	6,000	340	1,200	3,400	230	880	4.9	4.2	4.5	5.8	4.9	3.5
VOCs	4,000	150	800	1,900	170	940	3.2	1.8	3.0	3.2	3.6	3.9
N2O	1,200	68	240	680	46	180	0.99	0.84	0.91	1.2	0.98	0.71
Fuel Use (1000 mmBTU)	1,200,000	82,000	260,000	580,000	47,000	250,000						

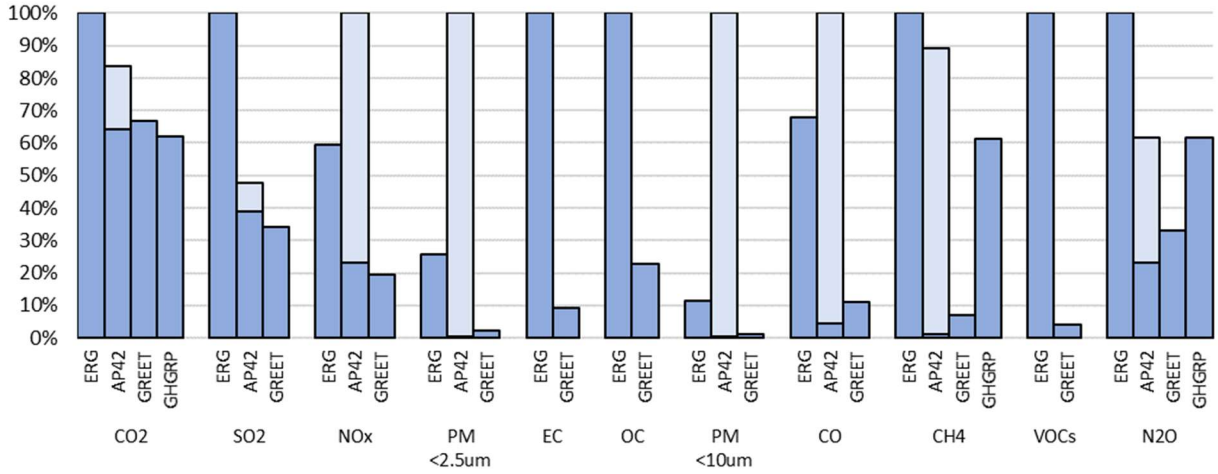
Table 7-9. Results for coal combustion emission factors.

Coal	Emissions (metric tonnes)						Emission Factor (g/mmBTU fuel)					
Pollutant	National	PADD 1	PADD 2	PADD 3	PADD 4	PADD 5	National	PADD 1	PADD 2	PADD 3	PADD 4	PADD 5
CO2	54,000	54,000	-	-	-	-	150,000	150,000	-	-	-	-
SO2	590	590	2.5	7.0E-3	-	-	1,600	1,600	-	-	-	-
NOx	140	130	0.63	0.039	-	-	370	370	-	-	-	-
PM <2.5um	10	10	0.093	3.6E-4	-	-	29	28	-	-	-	-
EC	0.44	0.44	4.0E-3	1.6E-5	-	-	1.2	1.2	-	-	-	-
OC	0.33	0.32	2.9E-3	1.1E-5	-	-	0.90	0.90	-	-	-	-
PM <10um	11	11	0.23	1.4E-3	-	-	30	29	-	-	-	-
CO	53	47	5.8	4.7E-3	-	-	150	130	-	-	-	-
CH4	6.4	6.4	-	-	-	-	18	18	-	-	-	-
VOCs	4.3	0.65	0.43	3.3	-	-	12	1.8	-	-	-	-
N2O	0.93	0.93	-	-	-	-	2.6	2.6	-	-	-	-
Fuel Use (1000 mmBTU)	360	360	-	-	-	-						

Table 7-10. Results for LPG combustion emission factors.

LPG	Emissions (MT)						Emission Factor (g/mmBTU fuel)					
Pollutant	National	PADD 1	PADD 2	PADD 3	PADD 4	PADD 5	National	PADD 1	PADD 2	PADD 3	PADD 4	PADD 5
CO2	38,000	-	-	-	17	38,000	4,600	-	-	-	200	20,000
SO2	0.54	-	7.5E-3	0.36	-	0.17	0.066	-	1.6E-3	0.24	-	0.097
NOx	30	-	0.26	1.5	-	28	3.7	-	0.055	0.99	-	16
PM <2.5um	1.4	-	9.3E-3	0.065	-	1.3	0.17	-	1.9E-3	0.043	-	0.76
EC	0.55	-	3.6E-3	0.025	-	0.52	0.067	-	7.4E-4	0.017	-	0.29
OC	0.35	-	2.3E-3	0.016	-	0.33	0.043	-	4.8E-4	0.011	-	0.19
PM <10um	1.4	-	9.3E-3	0.065	-	1.4	0.17	-	1.9E-3	0.043	-	0.76
CO	7.9	-	0.53	1.2	-	6.1	0.96	-	0.11	0.83	-	3.4
CH4	1.7	-	-	-	-	1.7	0.21	-	-	-	-	0.95
VOCs	4.2	-	1.9	0.76	-	1.6	0.51	-	0.39	0.50	-	0.89
N2O	0.35	-	-	-	-	0.35	0.042	-	-	-	-	0.19
Fuel Use (1000 mmBTU)	8,200	-	4,800	1,500	82	1,800						

Coal



LPG

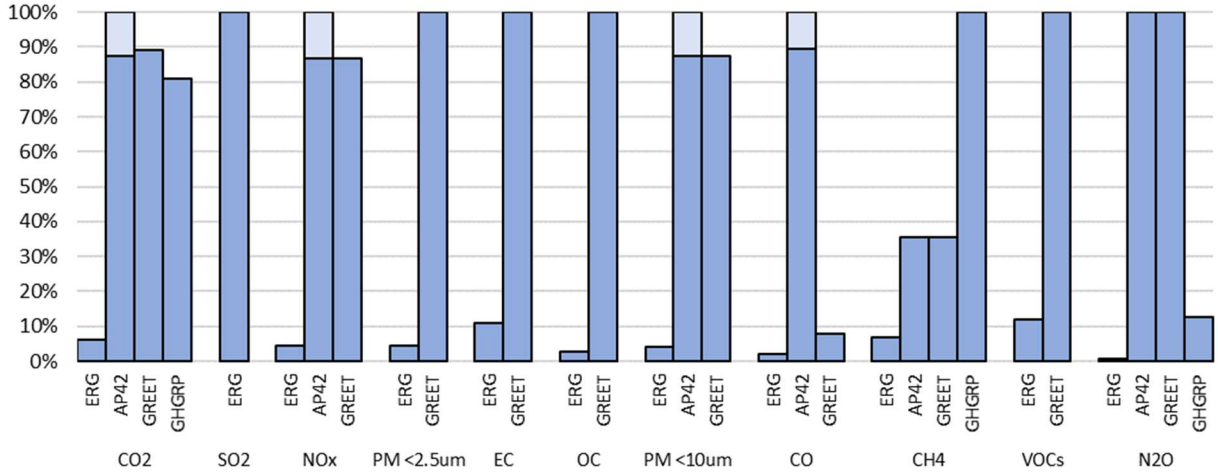


Figure 7-1. Comparison of combustion emission factors. Emission factors for coal and LPG not recommended for use. *Emission factors for each pollutant are normalized to the maximum emission factor for that pollutant. Ranges of emission factor based on combustion technology configuration where applicable, are shown in light blue.*

Allocation Factor Verification Supporting Information

The following list indicates deviations from PRELIM standard settings used to generate subprocess final product allocation factors:

- Crude selection: West texas sour_Stratiev
- PRELIM was set to allocate to all available products on an energy (LHV) basis.
- Asphalt production was set to 87% for PADDs 1, 2, and 4. Asphalt production was set to 13% for PADDs 3 and 5. These settings apply to both coking and hydro refineries.
    - Values were chosen to minimize percent difference between EIA and PRELIM estimated production in Table 7-11.
- Offgas product production was set to ON for both LPG and Petrochemical Feedstocks.
- Naptha-Kero Swing Blend setting on the both the coking and hydro refinery controls tab was set to 0% (preset is 50%) and the Kero Swing Cut value was changed from 0 to 70% by volume, which shifts PRELIM kerosene production to distillate fuel oil.
    - Values were chosen to minimize percent difference between EIA and PRELIM estimated production in Table 7-11.

Table 7-11. EIA vs PRELIM estimated production comparison

		Production (metric tonnes)		Percent
PADD	**Product Category (ERG)**	**EIA**	**PRELIM**	**Difference**
1	Asphalt and Road Oil	3,036,760	2,604,519	-14%
2	Asphalt and Road Oil	8,510,712	8,828,039	4%
3	Asphalt and Road Oil	4,437,948	3,032,146	-32%
4	Asphalt and Road Oil	2,008,837	1,380,174	-31%
5	Asphalt and Road Oil	1,248,286	882,388	-29%
1	Distillate Fuel Oil	16,221,456	17,329,932	7%
2	Distillate Fuel Oil	52,735,262	53,613,881	2%
3	Distillate Fuel Oil	131,941,242	126,241,528	-4%
4	Distillate Fuel Oil	9,421,249	8,828,740	-6%
5	Distillate Fuel Oil	27,891,174	38,935,674	40%
1	Finished Aviation Gasoline	-	-	0%
2	Finished Aviation Gasoline	87,598	155,663	78%
3	Finished Aviation Gasoline	391,321	454,782	16%
4	Finished Aviation Gasoline	10,456	24,215	132%
5	Finished Aviation Gasoline	83,135	56,975	-31%
1	Finished Motor Gasoline	2,600,206	2,341,631	-10%
2	Finished Motor Gasoline	16,916,317	15,303,175	-10%
3	Finished Motor Gasoline	35,861,171	37,290,160	4%
4	Finished Motor Gasoline	8,771,555	8,448,023	-4%
5	Finished Motor Gasoline	8,427,844	7,858,926	-7%
1	Kerosene	4,562,356	6,607,730	45%
2	Kerosene	10,775,938	19,149,070	78%
3	Kerosene	36,508,411	42,428,966	16%
4	Kerosene	1,383,842	3,204,927	132%
5	Kerosene	19,922,326	13,653,269	-31%
1	Liquefied Petroleum Gases	1,175,630	872,345	-26%
2	Liquefied Petroleum Gases	3,489,253	3,300,861	-5%
3	Liquefied Petroleum Gases	12,520,265	8,950,498	-29%
4	Liquefied Petroleum Gases	309,091	515,690	67%
5	Liquefied Petroleum Gases	1,767,241	2,436,734	38%

PADD	Product Category (ERG)	Production (metric tonnes) EIA	PRELIM	Percent Difference
1	Lubricants	742,693	626,284	-16%
2	Lubricants	458,097	378,753	-17%
3	Lubricants	7,210,256	6,025,642	-16%
4	Lubricants	-	-	0%
5	Lubricants	1,150,836	879,624	-24%
1	Miscellaneous Petroleum Products	129,471	149,229	15%
2	Miscellaneous Petroleum Products	604,581	683,240	13%
3	Miscellaneous Petroleum Products	2,252,536	2,573,030	14%
4	Miscellaneous Petroleum Products	143,536	166,160	16%
5	Miscellaneous Petroleum Products	548,435	572,966	4%
1	Motor Gasoline Blending Components	21,036,128	18,941,681	-10%
2	Motor Gasoline Blending Components	62,964,885	56,952,918	-10%
3	Motor Gasoline Blending Components	134,126,464	139,451,555	4%
4	Motor Gasoline Blending Components	3,215,808	3,096,783	-4%
5	Motor Gasoline Blending Components	45,410,369	42,339,320	-7%
1	Petrochemical Feedstocks	135,581	646,867	377%
2	Petrochemical Feedstocks	1,319,263	2,351,142	78%
3	Petrochemical Feedstocks	11,680,030	6,188,520	-47%
4	Petrochemical Feedstocks	-	370,254	0%
5	Petrochemical Feedstocks	8,301	1,701,559	20399%
1	Petroleum Coke	2,152,749	568,473	-74%
2	Petroleum Coke	11,572,774	4,557,063	-61%
3	Petroleum Coke	32,925,544	16,882,815	-49%
4	Petroleum Coke	1,548,746	592,152	-62%
5	Petroleum Coke	9,926,053	4,349,686	-56%
1	Residual Fuel Oil	3,210,932	2,403,545	-25%
2	Residual Fuel Oil	2,973,452	2,921,608	-2%
3	Residual Fuel Oil	10,770,866	9,054,097	-16%
4	Residual Fuel Oil	684,072	566,328	-17%
5	Residual Fuel Oil	7,359,330	6,647,578	-10%
1	Special Naphthas	26,517	42,474	60%
2	Special Naphthas	53,264	104,682	97%
3	Special Naphthas	1,643,228	2,112,090	29%
4	Special Naphthas	-	-	0%
5	Special Naphthas	47,499	36,002	-24%
1	Waxes	11,031	9,302	-16%
2	Waxes	63,506	52,507	-17%
3	Waxes	333,290	278,532	-16%
4	Waxes	-	-	0%
5	Waxes	-	-	0%

Table 7-12. National SMR emission factors in 2011, g/mmBTU.

	CDR	PNNL	GHGRP	Preferred Datasets			
	Avg	Avg	Avg	Avg	25th %	Median	75th %
SO_2	0.82	0.29	16	0.33	0.017	0.039	0.25
NOx	8.8	5.0	34	5.3	1.2	2.4	9.7
PM2.5	4.4	1.8	5.2	2.0	0.75	1.7	3.5
PM10	4.5	1.8	6.2	2.0	0.76	1.8	3.5
CO	36	4.4	16	7.0	1.2	2.6	5.4
VOC	14	1.2	7.8	2.1	0.70	1.3	2.4
Facility Count	*3*	*18*	*32*	*20*			
Hydrogen Process Emissions							
CO_2	140,000	52,000	n.a.	59,000	45,000	72,000	85,000
Facility Count	*8*	*29*		*31*			

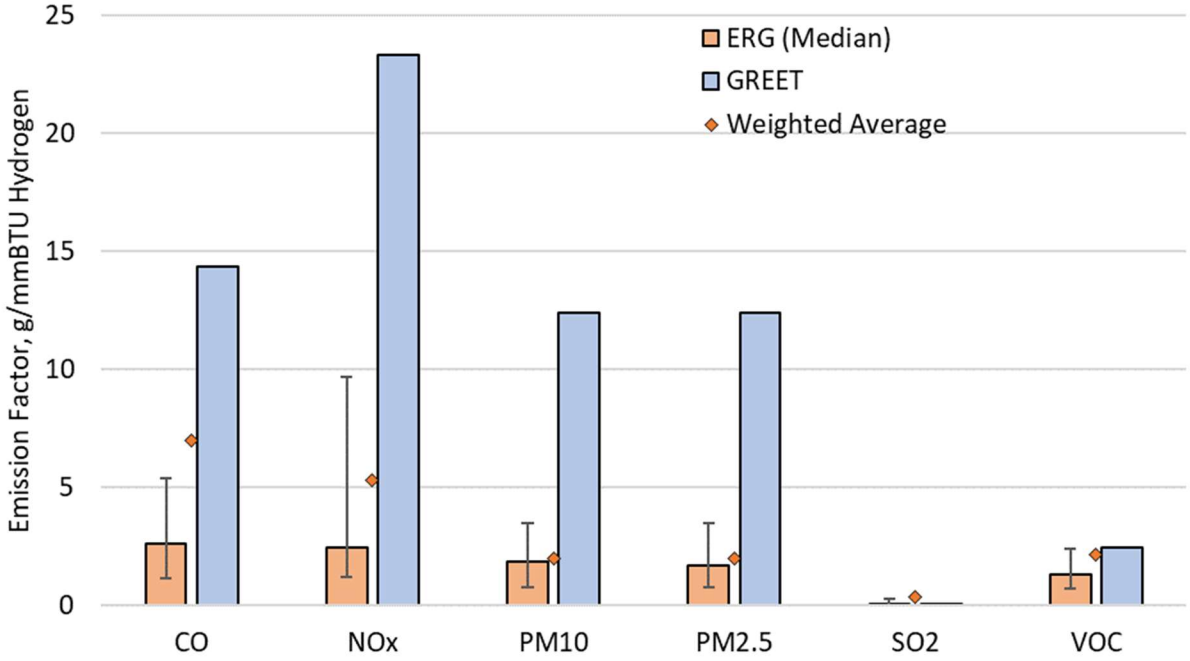


Figure 7-2. Comparison of emission factors for hydrogen production in 2011.