Greenhouse Gas Reporting Program

Industrial Profile: Chemicals Sector (Non-Fluorinated)

September 2019

CONTENTS

CHEMICALS SECTOR (NON-FLUORINATED)

All emissions presented here are as of 8/19/2018 and exclude biogenic carbon dioxide (CO_2). All GHG emission data displayed in units of CO_2e reflect the global warming potential values from the Intergovernmental Panel on Climate Change's Fourth Assessment Report (IPCC AR4).

Highlights

- The Chemicals Sector has the fourth-largest greenhouse gas (GHG) emissions among sectors reporting to the Greenhouse Gas Reporting Program (GHGRP).
- The GHG emissions in this sector are emitted predominantly from facilities located in Texas and Louisiana.
- Emissions from the Chemicals Sector were 174.2 million metric tons of carbon dioxide equivalent (MMT CO_2e) in 2017.
- Emissions from this sector increased by 3% from 2016 to 2017, while the number of reporters did not increase.

About this Sector

The Non-fluorinated Chemical Manufacturing Sector, hereafter referred to as the Chemicals Sector, consists of facilities that emit GHGs from the manufacturing of organic or inorganic chemicals. For this summary, the Chemicals Sector comprises facilities that produce adipic acid, ammonia, hydrogen (both merchant and captive plants), nitric acid, petrochemicals, phosphoric acid, silicon carbide, and titanium dioxide. In addition to emissions from these chemical production processes, this sector includes combustion emissions from facilities that produce pesticides, fertilizer, pharmaceuticals, and other organic and inorganic chemicals.

Who Reports?

In 2017, 441 facilities in the Chemicals Sector submitted GHG reports. Total reported emissions were 174.2 MMT CO_2e. In 2017, the Chemicals Sector represents about 6% of the facilities reporting direct emissions to the GHGRP. In 2017, the Chemicals Sector represented 2.7% of total U.S. GHG emissions.[1] Emissions reported to the GHGRP represent all facilities and account for all U.S. emissions in each chemicals industry subsector. Table 1 shows the reporting schedule and GHGRP coverage by subpart. Table 2 shows the number of reporters from 2011 to 2017 for each subsector, and Table 3 shows the GHG emissions from 2011 to 2017 for each subsector. Figure 1 shows the percentage of emissions by subsector for 2017.

1. The total U.S. GHG emissions are 6,456.72 MMT CO_2e as reported in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2017*. EPA 430-R-19-001. U.S. Environmental Protection Agency. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2017.

Table 1: Chemicals Sector – Reporting Schedule and GHGRP Coverage by Subpart

Subpart	Source Category	Applicability	First Reporting Year	Estimated Percent of Industry Facilities Covered by GHGRP[a]	Estimated Percent of Industry Emissions Covered by GHGRP[a]
E	Adipic acid production	All facilities	2010	100%	100%
G	Ammonia manufacturing	All facilities	2010	100%	100%
P	Hydrogen production	Facilities emitting ≥ 25,000 metric tons CO_2e/year	2010	78%[b]	90%[c]
V	Nitric acid production	All facilities	2010	100%	100%
X	Petrochemical production	All facilities	2010	100%	100%
Z	Phosphoric acid production	All facilities	2010	100%	100%
BB	Silicon carbide production	All facilities	2010	100%	100%
EE	Titanium dioxide production	All facilities	2010	100%	100%
C	Other chemicals	The subset of facilities that reported only under Subpart C (stationary fuel combustion) and that reported North American Industry Classification System (NAICS) codes starting with 325 (except for 325193, 3252XX, 325510, and 325920)	2010	N/A[d]	N/A[d]

a. Unless otherwise noted, coverage is provided as of Reporting Year 2012. The reporting universe has evolved since 2012 (see Table 2), but these changes have not significantly impacted the percentage of emissions covered by the GHGRP in this sector.

b. Estimate of size of industry is based on the following source: Hydrogen Analysis Resource Center, Pacific National Laboratory. "Merchant Hydrogen Plant Capacities in North America" and "Captive, On-Purpose, Refinery Hydrogen Production Capacities at Individual U.S. Refineries" available at: https://h2tools.org/hyarc/hydrogen-production. Facilities with no hydrogen production capacity were not counted.

c. Estimate of size of industry emissions is based on the above sources, considering the cumulative capacity as indicator of GHG emissions.

d. Due to the diversity of facilities and products within the other chemicals subsector, the U.S. population of all facilities in this subsector of GHGRP reporters is not available.

Table 2: Chemicals Sector – Number of Reporters (2011–2017)[a]

Source Category	Number of Reporters						
	2011	2012	2013	2014	2015	2016	2017
Total Chemicals Sector	**442**	**452**	**457**	**449**	**450**	**441**	**441**
Adipic acid production	3	3	3	3	3	3	3
Ammonia manufacturing	22	22	23	23	23	26	29
Hydrogen production	105	109	109	109	110	113	114
Nitric acid production	36	36	35	34	34	34	32
Petrochemical production	64	65	65	65	68	68	67
Phosphoric acid production	13	13	12	12	12	12	11
Silicon carbide production	1	1	1	1	1	1	1
Titanium dioxide production	7	7	7	7	7	6	6
Other chemicals	215	220	226	219	215	204	206

a. The total number of reporters is less than the sum of the number of reporters in each individual source category because some facilities fall in more than one source category.

Reported Emissions

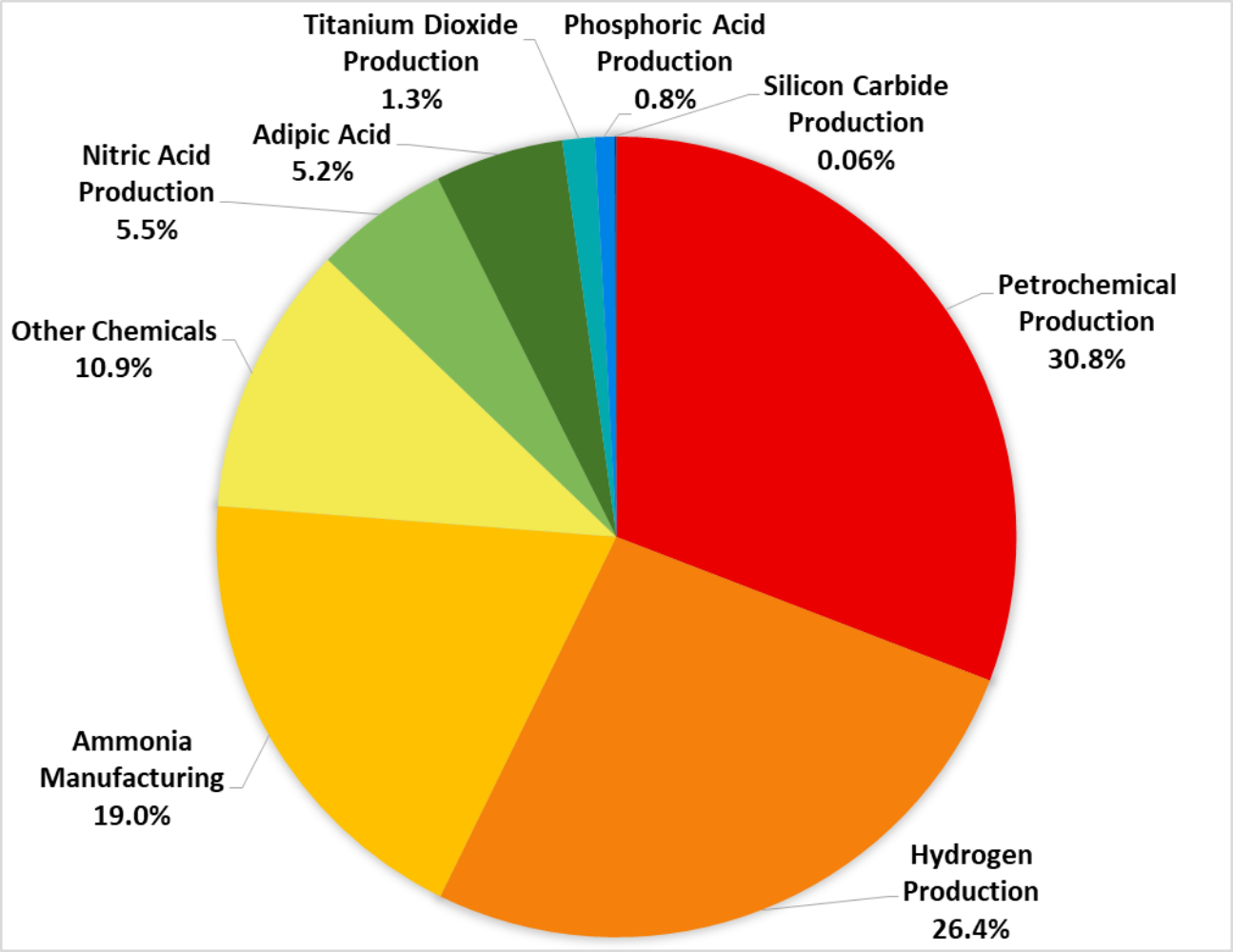
Table 3: Chemicals Sector – Emissions by Subsector (2011–2017)

	Emissions (MMT CO2e)[a, b]						
	2011	2012	2013	2014	2015	2016	2017
Total Chemicals Sector	**163.1**	**158.6**	**161.1**	**165.4**	**167.3**	**169.8**	**174.2**
Adipic acid production	11.9	7.0	5.7	7.2	6.1	8.7	9.1
Ammonia manufacturing	24.9	25.0	24.9	24.2	25.6	28.3	33.1
Hydrogen production	37.5	40.1	42.0	44.3	44.2	44.9	46.0
Nitric acid production	11.5	11.0	11.2	11.2	11.8	10.4	9.5
Petrochemical production	52.7	51.5	52.3	53.4	54.6	53.8	53.7
Phosphoric acid production	1.7	1.8	1.8	1.7	1.6	1.5	1.4
Silicon carbide production	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Titanium dioxide production	2.4	2.1	2.4	2.5	2.3	2.4	2.3
Other chemicals	20.4	19.9	20.7	20.7	20.8	19.8	19.1

a. These values represent total emissions reported to the GHGRP in these industry subsectors. Additional emissions may occur at facilities that have not reported (e.g., those below the 25,000 MT CO_2e reporting threshold).

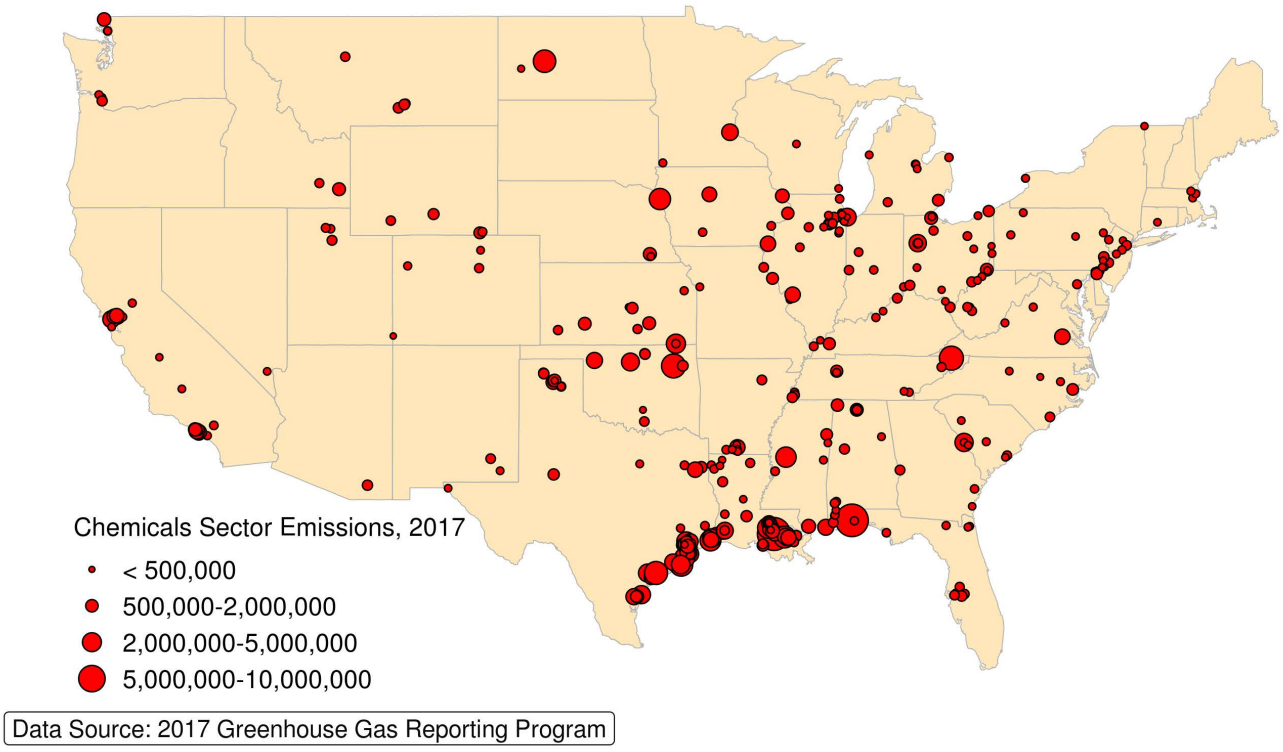
b. Totals might not sum due to independent rounding.

FIGURE 1: 2017 TOTAL REPORTED EMISSIONS FROM CHEMICALS SECTOR, BY SUBSECTOR



Click here to view the most current information using the Facility Level Information on Greenhouse Gases Tool (FLIGHT).

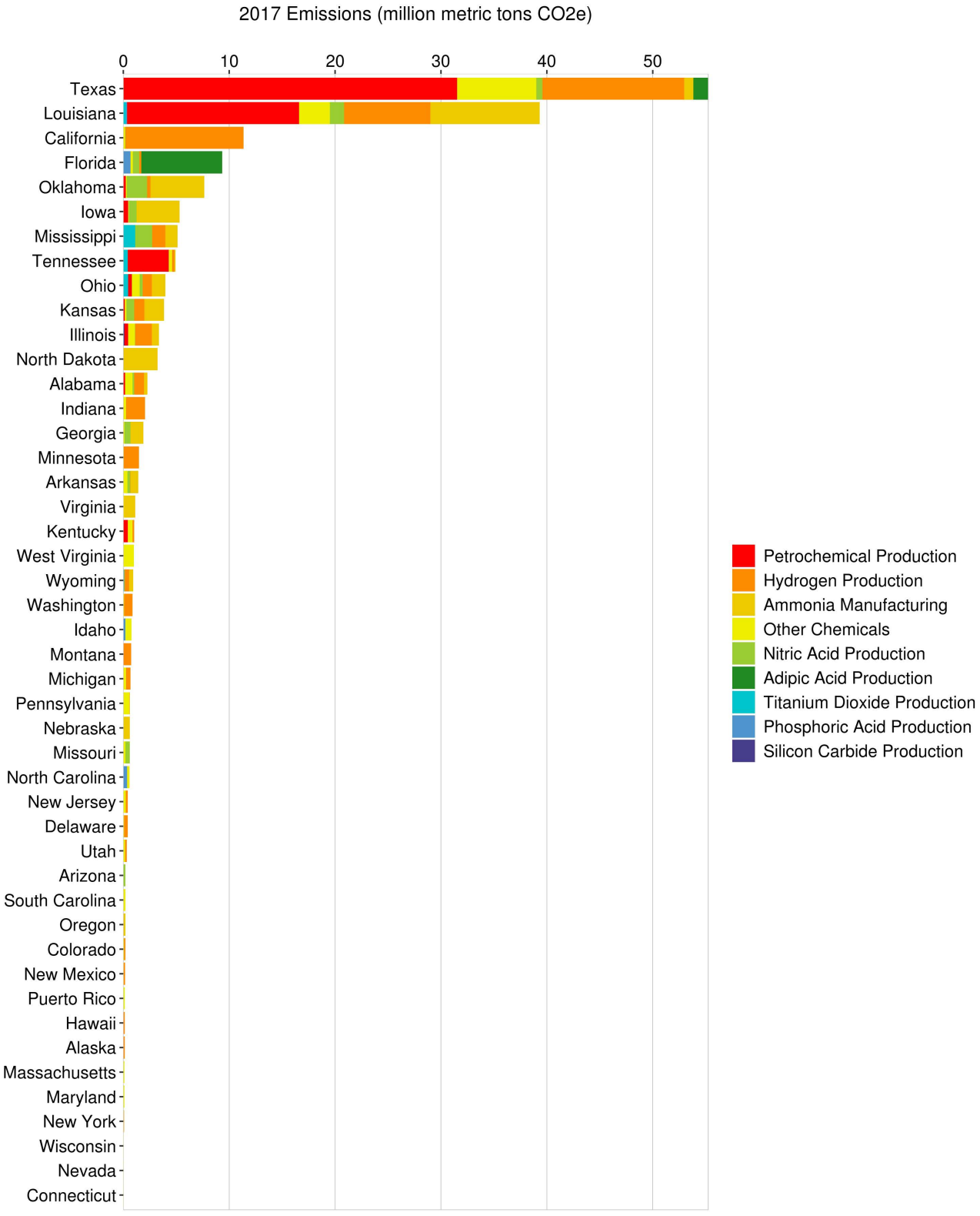
FIGURE 2: CHEMICALS SECTOR-EMISSIONS BY RANGE AND LOCATION (2017)



Readers can identify the largest emitting facilities by visiting the FLIGHT website (http://ghgdata.epa.gov/ghgp/main.do).

As shown in Figure 3, a large percentage of emissions from the Chemicals Sector originate in Texas and Louisiana. In 2017, the emissions from these two states totaled 95.2 MMT CO_2e, which is 55% of the total emissions from the Chemicals Sector. Eight of the nine subsectors are represented in these two states. Only silicon carbide production, which has one reporter, is not represented in Texas or Louisiana. The petrochemical production subsector is especially concentrated there, with about 87% of facilities and 89% of GHG emissions from the subsector located in these two states.

FIGURE 3: DIRECT EMISSIONS BY STATE FROM THE CHEMICALS SECTOR (2017)[a]



a. Represents total emissions reported to the GHGRP from this industry. Additional emissions may occur at facilities that have not reported, such as those below the reporting threshold.

Click here to view the most current information using FLIGHT.

Chemicals Sector: Emissions Trends 2016 to 2017

Emissions from the Chemicals Sector increased by 4.4 MMT CO_2e from 2016 to 2017 (a 2.6% increase). Most subsectors had relatively small emission changes – generally less than 5 MMT CO_2e. The cause of these changes is discussed in the longer-term emission trends section below.

Chemicals Sector: Longer-Term Emission Trends

As shown in Figure 4, the three sectors with the largest percentage change in emissions from 2011 to 2017 are ammonia production, adipic acid production, and hydrogen production, respectively. These trends are explained further below.

Ammonia Production. Emissions from the ammonia production subsector increased by 33% from 2011 to 2017. During this same period, the number of reporting facilities increased from 22 to 29 (GHGRP), and production increased from 9,350,000 metric tons in 2011 to 10,500,000 metric tons in 2017 (USGS – National Minerals Information Center – Nitrogen Statistics and Information). A long period of stable and low natural gas prices in the United States has made it economical for companies to upgrade existing plants and plan for the construction of new nitrogen projects.[1]

Adipic Acid Production. Emissions from the adipic acid source category have been variable from 2011 to 2017. Because this source category has only three facilities, changes at a single facility can have a large impact on the total source category trends. Between 2010 (not shown in this document) and 2011, there was a large spike in emissions from one of the facilities that reported under this subsector. The spike in emissions in 2011 was due to the nitrous oxide (N_2O) abatement device at the facility undergoing maintenance for much of the year. This abatement equipment downtime caused higher N_2O emissions in 2011. In 2012, the control device was brought back online for part of the year and the emissions from that reporter dropped to a level more consistent with 2010. Emissions continued to decrease from 2012 to 2013 because the device was operating for all of 2013. Emissions increased in 2014, decreased slightly in 2015, and then increased in 2016 and 2017. Production in this industry has been variable during this time period. In 2011, US production was 840,000 metric tons. In the following years production increased, and reached 1,055,000 mt in 2015. Since then, production decreased to 830,000 mt in 2017.[2]

Hydrogen Production. GHG emissions from hydrogen production have increased fairly steadily from 2011 to 2017, with an overall increase of 23% during that time period. The increased emissions reflect an increase in the quantity of hydrogen produced. Hydrogen demand is increasing, in part due to an expansion of the scope of engines required to use low sulfur and ultra-low sulfur diesel fuels.[3]

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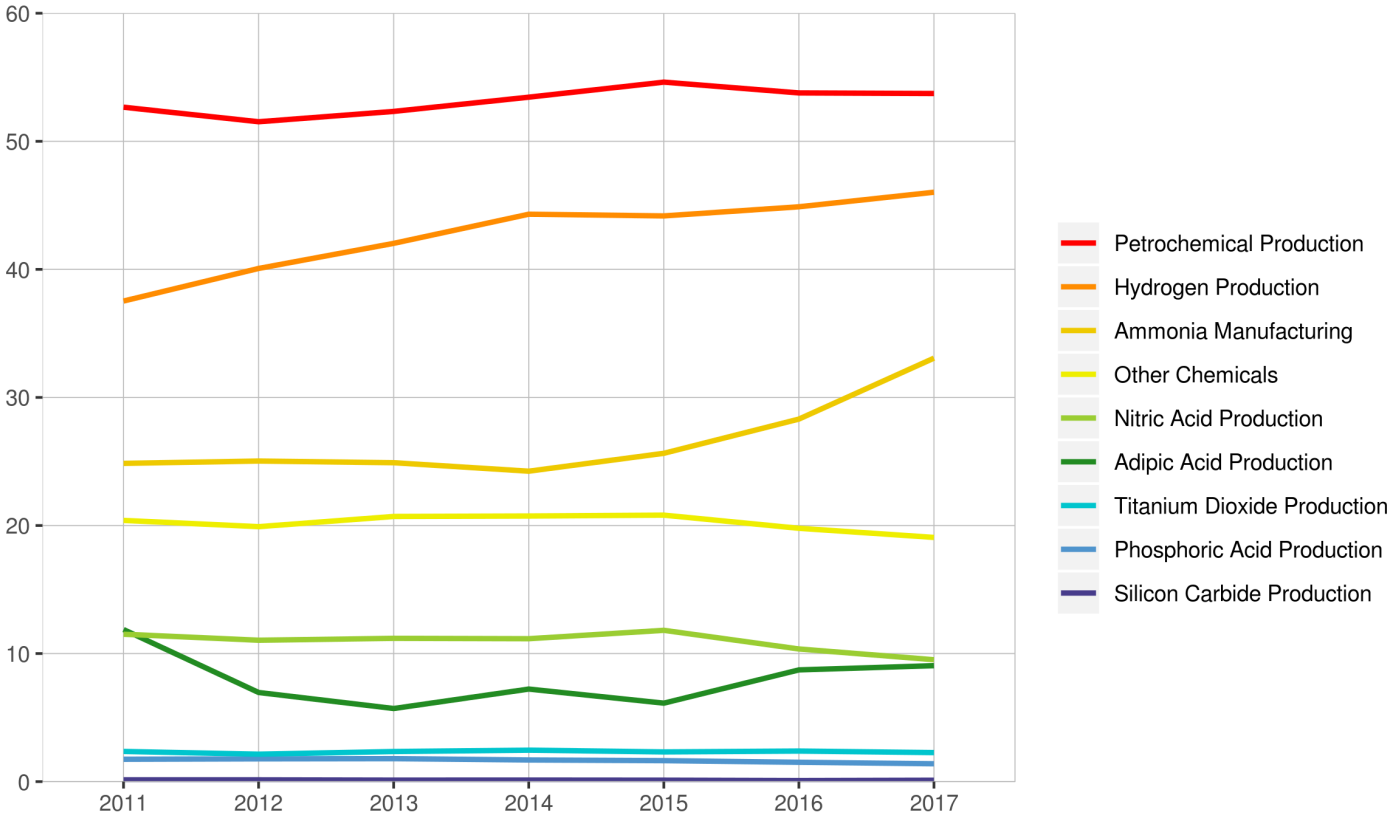
[1] https://www.usgs.gov/centers/nmic/nitrogen-statistics-and-information.

[2] https://www.statista.com/statistics/974666/us-adipic-acid-production-volume/

3. Lowering the sulfur content of diesel fuel is achieved by increasing the hydro-treating capacity of fluid catalytic crackers, and requires additional inputs of hydrogen at refineries. See *Emissions Modeling Technical Support Document: Tier 3 Motor Vehicle Emission and Fuel Standards.* EPA-454/R-14-003. U.S. Environmental Protection Agency. February 2014. Available: https://nepis.epa.gov/Exe/ZyNET.exe/P100HX5N.txt?ZyActionD=ZyDocument&Client=EPA&Index=2011%20Thru%202015&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&UseQField=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5CZYFILES%5CINDEX%20DATA%5C11THRU15%5CTXT%5C00000009%5CP100HX5N.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=hpfr&Def

FIGURE 4: ANNUAL REPORTED DIRECT EMISSIONS FROM THE CHEMICALS SECTOR, BY SUBSECTOR (2011–2017)



Click here to view the most current information using FLIGHT.

SeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=2.

As shown in Table 4, CO_2 is the primary GHG emitted from all chemical production subsectors, with the exception of the nitric acid and adipic acid subsectors. N_2O is produced as a by-product of nitric acid and adipic acid processes, and is the primary GHG emitted from these two subsectors. Small amounts of methane (CH_4) are emitted from facilities in all subsectors, primarily from the combustion of fossil fuels or process off-gases for energy recovery or to control emissions of volatile organic compounds or organic hazardous air pollutants.

Table 4: Chemicals Sector – Emissions by GHG (MMT CO_2e)[a]

Chemicals Sector	Reporting Year						
	2011	2012	2013	2014	2015	2016	2017
Number of facilities	**442**	**452**	**457**	**449**	**450**	**441**	**441**
Total emissions	**163.1**	**158.6**	**161.1**	**165.4**	**167.3**	**169.8**	**174.2**
Emissions by GHG							
CO2							
Adipic acid production	1.6	1.6	1.8	1.8	1.9	1.7	1.7
Ammonia manufacturing	24.8	25.0	24.9	24.2	25.6	28.3	33.1
Hydrogen production	37.5	40.1	42.0	44.3	44.2	44.9	46.0
Nitric acid production	0.6	0.6	0.5	0.2	0.2	0.2	0.2
Petrochemical production	52.4	51.2	52.0	53.0	54.3	53.4	53.3
Phosphoric acid production	1.7	1.8	1.8	1.7	1.6	1.5	1.4
Silicon carbide production	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Titanium dioxide production	2.4	2.1	2.3	2.5	2.3	2.4	2.3
Other chemicals	20.4	19.9	20.7	20.7	20.8	19.7	19.0
CH4							
Adipic acid production	**	**	**	**	**	**	**
Ammonia manufacturing	**	**	**	**	**	**	**
Hydrogen production	**	**	**	**	**	**	**
Nitric acid production	**	**	**	**	**	**	**
Petrochemical production	0.1	0.2	0.2	0.3	0.2	0.2	0.3
Phosphoric acid production	**	**	**	**	**	**	**
Silicon carbide production	**	**	**	**	**	**	**
Titanium dioxide production	**	**	**	**	**	**	**
Other chemicals	**	**	**	**	**	**	**
N2O							
Adipic acid production	10.2	5.3	3.9	5.4	4.3	7.0	7.4
Ammonia manufacturing	**	**	**	**	**	**	**
Hydrogen production	**	**	**	**	**	**	**
Nitric acid production	10.9	10.5	10.7	10.9	11.6	10.1	9.3
Petrochemical production	0.1	0.1	0.1	0.1	0.1	0.2	0.1
Phosphoric acid production	**	**	**	**	**	**	**
Silicon carbide production	**	**	**	**	**	**	**
Titanium dioxide production	**	**	**	**	**	**	**
Other chemicals	**	**	**	**	**	**	**

a. Totals might not sum due to independent rounding.

** Total reported emissions are less than 0.05 MMT CO_2e.

Table 5 shows subsector emissions by fuel combustion and other processes, and Table 6 breaks down subsector emissions by fuel type.

Table 5: Chemicals Sector – Emissions from Industrial Process and Fuel Combustion

Chemicals Sector	Emissions (MMT CO2e)[a, b, c]						
	2011	2012	2013	2014	2015	2016	2017
Total Chemicals Sector	**163.1**	**158.6**	**161.1**	**165.4**	**167.3**	**169.8**	**174.2**
Adipic acid production	**11.9**	**7.0**	**5.7**	7.2	6.1	8.7	9.1
Fuel combustion	1.6	1.6	1.8	1.8	1.9	1.7	1.7
Other processes	10.2	5.3	3.9	5.4	4.3	7.0	7.4
Ammonia manufacturing	**24.9**	**25.0**	**24.9**	**24.2**	**25.6**	**28.3**	**33.1**
Fuel combustion	10.8	10.8	10.5	9.6	11.2	12.7	13.9
Other processes	14.0	14.2	14.4	14.6	14.4	15.6	19.1
Hydrogen production	**37.5**	**40.1**	**42.0**	**44.3**	**44.2**	**44.9**	**46.0**
Fuel combustion	1.3	1.4	1.6	1.6	1.6	1.3	1.5
Other processes	36.2	38.7	40.4	42.7	42.6	43.5	44.5
Nitric acid production	**11.5**	**11.0**	**11.2**	**11.2**	**11.8**	**10.4**	**9.5**
Fuel combustion	0.6	0.5	0.5	0.2	0.2	0.3	0.2
Other processes	10.9	10.5	10.7	10.9	11.6	10.1	9.3
Miscellaneous use of carbonate[d]	**	**	**	**	**	**	**
Petrochemical production	**52.7**	**51.5**	**52.3**	**53.4**	**54.6**	**53.8**	**53.7**
Fuel combustion	43.2	42.0	44.0	43.8	45.2	44.0	43.2
Other processes	9.4	9.5	8.3	9.6	9.4	9.7	10.5
Miscellaneous use of carbonate[d]	**	**	[e]	[e]	[e]	[e]	[e]
Phosphoric acid production	**1.7**	**1.8**	**1.8**	**1.7**	**1.6**	**1.5**	**1.4**
Fuel combustion	0.6	0.6	0.6	0.6	0.5	0.5	0.4
Other processes	1.2	1.1	1.1	1.1	1.1	1.0	0.9
Miscellaneous use of carbonate[d]	**	**	**	**	**	**	**
Sorbent[f]			**	**	**	**	**
Silicon carbide production	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**
Fuel combustion	**	**	**	**	**	**	**
Other processes	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Titanium dioxide production	**2.4**	**2.1**	**2.4**	**2.5**	**2.3**	**2.4**	**2.3**
Fuel combustion	1.0	1.0	1.0	1.0	1.0	1.0	0.9
Other processes	1.3	1.2	1.3	1.4	1.3	1.3	1.3
Other chemicals	**20.4**	**19.9**	**20.7**	**20.7**	**20.8**	**19.8**	**19.1**
Fuel combustion	20.3	19.9	20.6	20.7	20.7	19.7	19.0
Miscellaneous use of carbonate[d]	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sorbent[f]	**	**	**	**	**	**	**

a. These values represent total emissions reported to the GHGRP in these industry sectors. Additional emissions may occur at facilities that have not reported (e.g., those below the 25,000 MT CO_2e reporting threshold).

b. Emission values presented may differ slightly from other publicly available GHGRP data due to minor differences in the calculation methodology. Totals might not sum due to independent rounding.

c. Emissions from fuel combustion are defined here as emissions reported under Subpart C.

d. Emissions from the miscellaneous use of carbonates are defined here as emissions reported under Subpart U.

e. No petrochemical production facilities reported under Subpart U in 2013 through 2017.

f. Does not include sorbent emissions monitored by a continuous emissions monitoring system (CEMS); no reported emissions in 2011 and 2012.

** Total reported emissions are less than 0.05 MMT CO_2e.

Table 6: Chemicals Sector – Combustion Emissions by Fuel Type

Chemicals Sector	Emissions (MMT CO_2e)[a, b, c]						
	2011	2012	2013	2014	2015	2016	2017
Adipic acid production	**1.6**	**1.6**	**1.8**	**1.8**	**1.9**	**1.7**	**1.7**
Natural gas	1.5	1.5	1.7	1.6	1.7	1.6	1.5
Petroleum products	**	**	**	**	**	**	0
Other fuels	0.1	0.1	0.1	0.2	0.1	0.1	0.1
Ammonia manufacturing	**10.8**	**10.8**	**10.5**	**9.6**	**11.2**	**12.7**	**13.9**
Natural gas	8.3	8.3	8.9	8.8	8.9	9.8	10.8
Petroleum products	0.4	0.5	0.3	0.3	0.2	0.3	0.2
Other fuels	2.1	2.0	1.3	0.5	2.1	2.6	2.8
Hydrogen production	**1.3**	**1.4**	**1.6**	**1.6**	**1.6**	**1.3**	**1.5**
Coal	0.5	0.5	0.6	0.6	0.6	0.3	0.3
Natural gas	0.7	0.8	0.9	0.9	0.9	0.9	1.1
Petroleum products	**	**	**	**	**	**	0
Other fuels	0.1	**	0.1	0.1	0.1	0.1	0.1
Nitric acid production	**0.6**	**0.5**	**0.5**	**0.2**	**0.2**	**0.3**	**0.2**
Coal	0.3	0.3	0.3	0	0	0	0
Natural gas	0.3	0.3	0.2	0.2	0.2	0.3	0.2
Petroleum products	**	**	**	**	**	**	**
Petrochemical production	**43.2**	**42.0**	**44.0**	**43.8**	**45.2**	**44.0**	**43.2**
Coal	4.1	4.1	4.2	3.9	3.7	3.2	2.6
Natural gas	20.0	19.4	19.7	20.4	21.5	21.4	22.0
Petroleum products	0.1	0.1	0.3	0.1	0.1	0.1	**
Other fuels[d]	19.0	18.4	19.9	19.4	20.0	19.4	18.7
Phosphoric acid production	**0.6**	**0.6**	**0.6**	**0.6**	**0.5**	**0.5**	**0.4**
Coal	0.1	0.2	0.2	0.2	0.2	0.2	0.2
Natural gas	0.4	0.4	0.3	0.3	0.2	0.2	0.2
Petroleum products	0.1	0.1	**	**	**	**	**
Silicon carbide production	**	**	**	**	**	**	**
Natural gas	**	**	**	**	**	**	**
Titanium dioxide production	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**0.9**
Coal	0.3	0.3	0.3	0.2	0.2	0.2	0
Natural gas	0.8	0.7	0.8	0.8	0.8	0.8	0.9
Petroleum products	**	**	**	**	**	**	**
Other fuels	**	**	**	**	**	**	**
Other chemicals	**20.3**	**19.9**	**20.6**	**20.7**	**20.7**	**19.7**	**19.0**
Coal	3.5	2.5	2.3	2.7	2.3	1.2	0.7
Natural gas	13.4	13.8	14.3	14.1	14.6	14.5	14.3
Petroleum products	0.5	0.3	0.4	0.4	0.4	0.3	0.4
Other fuels	3.0	3.3	3.6	3.6	3.5	3.7	3.7

a. These values represent total emissions reported to the GHGRP in these industry sectors. Additional emissions may occur at facilities that have not reported (e.g., those below the 25,000 MT CO_2e reporting threshold).

b. Totals might not sum due to independent rounding.

c. In cases where CO_2 emissions were reported at the unit level (i.e., CEMS-monitored sources), fuel-level CO_2 emissions were calculated by the U.S. Environmental Protection Agency (EPA) based on other data directly reported by facilities.

d. The primary fuel contributing to emissions from the other fuels category for the Petrochemical Production Sector is fuel gas. Fuel gas is categorized under the "other fuels-gaseous" category within Table C-1 to Subpart C of Part 98.

** Total reported emissions are less than 0.05 MMT CO_2e.

Figure 5 displays emissions per reporter in the Chemicals Sector.

FIGURE 5: AVERAGE EMISSIONS PER REPORTER FROM THE CHEMICALS SECTOR (2017)

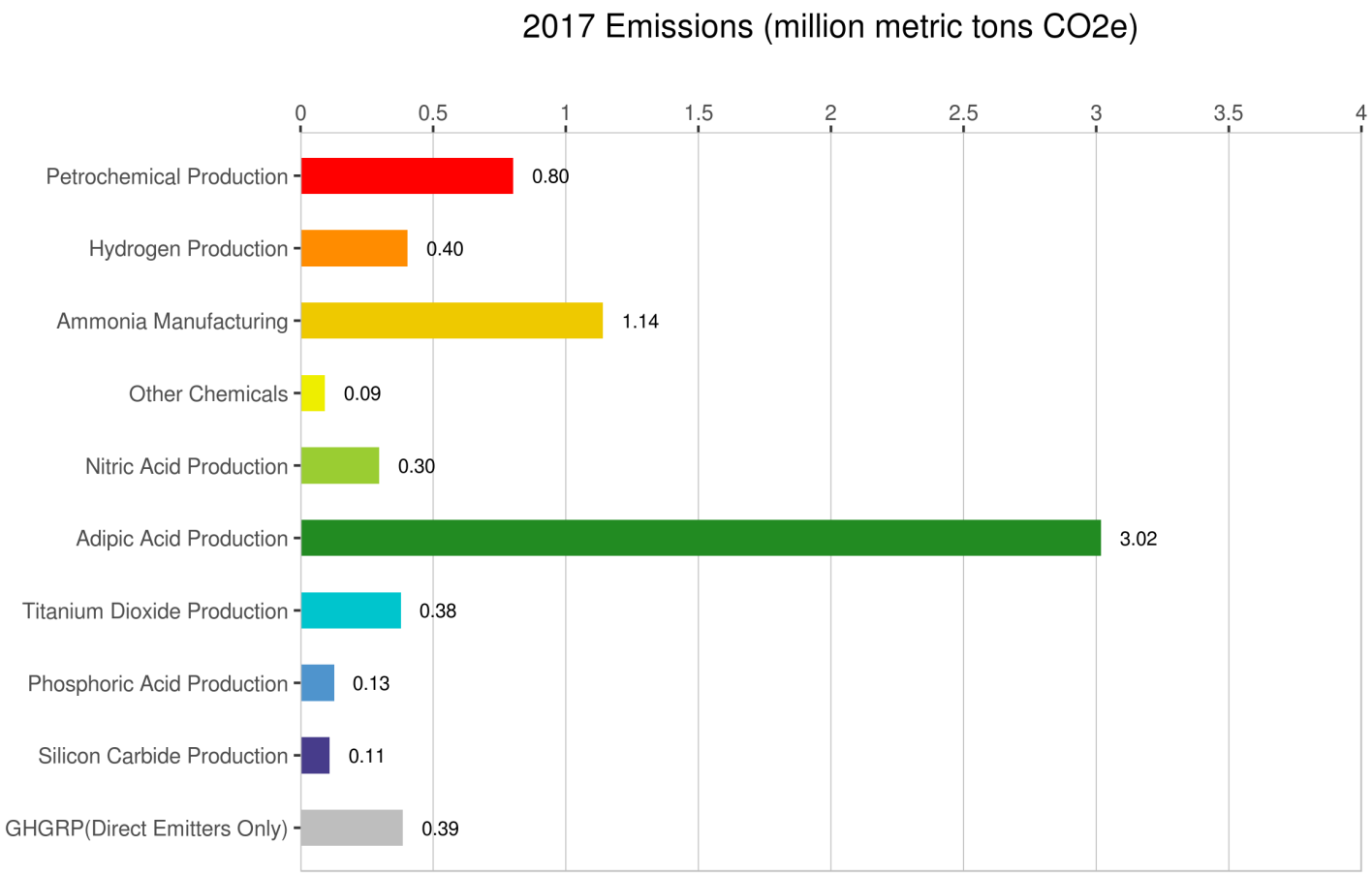


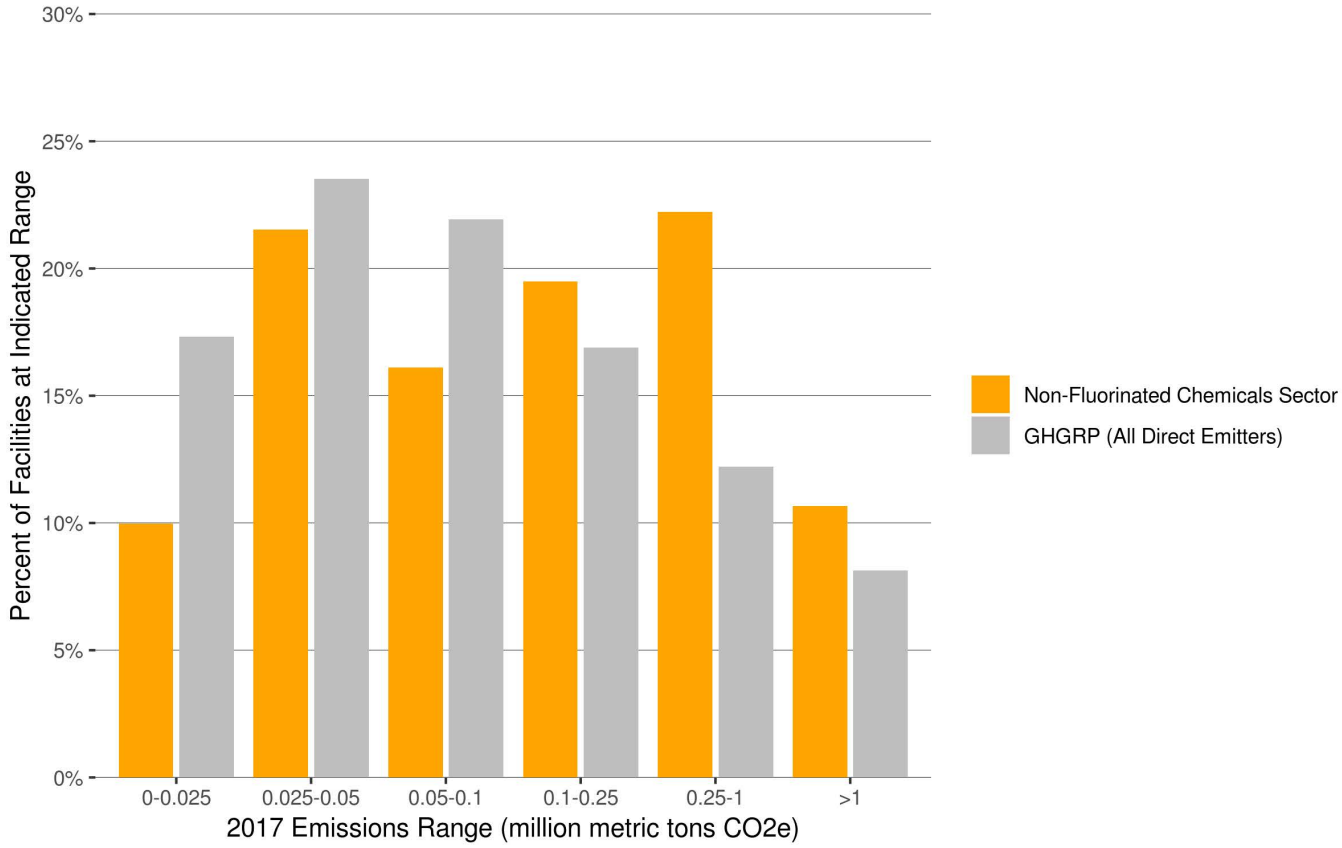
Table 7 and Figure 6 show the number and percent of facilities in each subsector by emission range in MMT CO_2e, respectively.

Table 7: Chemical Sector – Number of Facilities by Range of Emissions (2017)

Chemicals Sector	Number of Facilities within Emissions Ranges (MMT CO_2e)					
	0–0.025	0.025–0.05	0.05–0.1	0.1–0.25	0.25–1	> 1
Total Chemicals Sector[a]	**46**	**93**	**71**	**87**	**97**	**47**
Adipic acid production	0	0	1	0	0	2
Ammonia manufacturing	0	1	2	2	13	11
Hydrogen production	13	10	11	25	43	12
Nitric acid production	10	1	2	5	12	2
Petrochemical production	1	2	5	16	25	18
Phosphoric acid production	1	1	2	6	1	0
Silicon carbide production	0	0	0	1	0	0
Titanium dioxide production	0	0	0	1	5	0
Other chemicals	29	81	51	31	13	1

a. For each emission range, the number of facilities in the "Total Chemicals Sector" row might be less than the sum of the number of facilities in the respective individual source categories because some facilities fall in more than one source category.

FIGURE 6: PERCENTAGE OF FACILITIES IN THE CHEMICALS SECTOR AT VARIOUS EMISSION RANGES (2017)



Emission Calculation Methods Available for Use

Emission Calculation Methodologies for Process Emissions Sources

Chemical facilities must calculate GHG process emissions using one of the following methods:

- **CEMS.** Operate a CEMS to measure CO_2 emissions according to requirements specified in 40 CFR Part 98, Subpart C (does not apply to the adipic and nitric acid subsectors).
- **Carbon mass balance.** Calculate process CO_2 emissions based on measurements of the annual mass of process inputs/outputs, and periodic analyses of the weight fraction of carbon in all inputs and outputs.
- **Site-specific emission factor.** Develop an emission factor by conducting performance tests and measuring process feed rates during the tests.
- **Default emission factors.** Use a default emission factor provided in the rule. The default emission factor was calculated as the average emissions for facilities in a source category based on all available data of acceptable quality (i.e., a population average).

- **Alternative method.** For the adipic acid and nitric acid subsectors, facilities may submit a request to EPA for approval of an alternative emission estimation method. For ethylene process units (in the petrochemical subsector), facilities can use an alternative method (without prior approval) based on measuring emissions from the combustion of ethylene process off-gas streams.

Emission Calculation Methodologies for Stationary Fuel Combustion Units

For fuel combustion emissions, facilities must generally follow the applicable tier methodology prescribed in Subpart C (general stationary fuel combustion sources) to calculate CO_2, CH_4, and N_2O emissions. The calculation methodologies for Subpart C are explained here.

Emissions monitored by each methodology type is organized by either process or combustion emissions in Tables 8–16.

Monitoring Methodologies Used for Process and Combustion Emissions Sources

Table 8: Adipic Acid Production – Methodologies

Type of Emissions	Methodology	Percentage of Emissions Monitored by Method (by type)						
		2011	2012	2013	2014	2015	2016	2017
Process emissions	Facility-specific emission factors	5.1%	13.6%	13.6%	27.6%	28.6%	8.0%	8.5%
	Alternative method	95.0%	86.4%	86.4%	72.4%	71.4%	92%	91.5%
Combustion emissions	CEMS (Tier 4, Subpart C)[a]	0%	0%	0%	9.7%	12.7%	0%	14.7%
	Measured carbon content, and, if applicable, molecular weight (Tier 3)	55.3%	54.4%	52.1%	51.6%	46.8%	51.2%	53.5%
	Measured high heating values (HHVs) and default emission factors (Tier 2)	44.7%	45.6%	47.8%	38.6%	40.5%	48.8%	31.8%
	Default HHVs and emission factors (Tier 1)	**	0.1%	0.1%	0.1%	**	**	0%

a. CEMS emissions include CO_2 from fossil fuel combustion plus, if applicable, CO_2 from sorbent.

** Value is less than 0.05%.

Table 9: Ammonia Manufacturing – Methodologies

Type of Emissions	Methodology	Percentage of Emissions Monitored by Method (by type)						
		2011	2012	2013	2014	2015	2016	2017
Process emissions	Mass balance	100%	100%	100%	100%	100%	100%	100%
Combustion emissions	CEMS (Tier 4, Subpart C)[a]	0%	0%	0%	0%	0%	0%	4.4%
	Measured carbon content, and, if applicable, molecular weight (Tier 3)	27.3%	26.0%	19.7%	14.0%	25.1%	27.1%	23.0%
	Measured HHVs and default emission factors (Tier 2)	68.2%	66.1%	71.4%	77.9%	67.6%	65.0%	61.8%
	Default HHVs and emission factors (Tier 1)	4.5%	7.9%	8.9%	8.1%	7.2%	7.9%	10.7%

a. CEMS emissions include CO_2 from fossil fuel combustion plus, if applicable, CO_2 from sorbent.

Table 10: Hydrogen Production – Methodologies

Type of Emissions	Methodology	Percentage of Emissions Monitored by Method (by type)						
		2011	2012	2013	2014	2015	2016	2017
Process emissions	CEMS	3.5%	2.1%	2.7%	2.9%	2.5%	2.7%	2.8%
	Mass balance	96.5%	97.9%	97.4%	97.1%	97.5%	97.3%	97.2%
Combustion emissions	Alternative Part 75 Methodology: CEMS per §98.33(a)(5)(iii)	22.4%	24.4%	20.9%	23.5%	24.5%	20.9%	16.1%
	Measured carbon content, and, if applicable, molecular weight (Tier 3)	24.1%	23.0%	25.3%	22.9%	22.8%	27.6%	26.5%
	Measured HHVs and default emission factors (Tier 2)	46.1%	45.4%	41.4%	47.9%	45.1%	45.4%	51.0%
	Default HHVs and emission factors (Tier 1)	7.4%	7.2%	12.4%	5.7%	7.6%	6.0%	6.4%

Table 11: Nitric Acid Production – Methodologies

Type of Emissions	Methodology	Percentage of Emissions Monitored by Method (by Type)						
		2011[a]	2012	2013	2014	2015	2016	2017
Process emissions	Facility-specific emission factors	92.4%	96.0%	93.4%	94.4%	92.4	85.0%	90.0%
	Alternative method	7.6%	4.0%	6.6%	5.6%	7.6%	15.0%	10.0%
Combustion emissions	Measured HHVs and default emission factors (Tier 2)	71.0%	71.7%	85.4%	40.4%	71.3%	59.1%	91.9%
	Default HHVs and emission factors (Tier 1)	29.0%	28.3%	14.6%	59.6%	28.7%	40.9%	8.1%

a. Process emissions based on data as of 8/18/14.

Table 12: Petrochemical Production – Methodologies[a]

Type of Emissions	Methodology	Percentage of Emissions Monitored by Method (by type)						
		2011	2012	2013	2014	2015	2016	2017
Process emissions	Mass balance	87.6%	85.4%	82.7%	75.3%	84.3%	82.7%	76.3%
	Optional method – Ethylene[b]	11.7%	14.0%	16.6%	24.1%	15.1%	16.6%	20.3%
	CEMS	0.6%	0.6%	0.7%	0.6%	0.6%	0.7%	3.4%
Combustion emissions	CEMS (Tier 4, Subpart C)[c]	8.7%	9.5%	8.8%	8.5%	8.5%	7.8%	7.7%
	Measured carbon content, and, if applicable, molecular weight (Tier 3)	44.6%	44.8%	45.7%	45.8%	46.7%	47.1%	46.6%
	Measured HHVs and default emission factors (Tier 2)	43.0%	41.6%	42.0%	41.2%	39.1%	40.3%	41.2%
	Default HHVs and emission factors (Tier 1)	3.7%	4.1%	3.4%	4.6%	5.7%	4.8%	4.5%

a. Combustion emissions from five ethylene plants are not included here because the plants are co-located within refineries, and thus their combustion emissions are attributed to the Petroleum Refining Sector.

b. The optional method is specified in the rule and can be used for ethylene processes without prior approval by EPA. Process emissions reported by facilities utilizing this optional method include only flare emissions. Emissions from process off-gas combustion are included in combustion emissions. Tier 3 is generally required to estimate process off-gas combustion emissions from facilities using this optional method, which accounts for the relatively high use of Tier 3 for this subsector.

c. CEMS emissions include CO_2 from fossil fuel combustion plus, if applicable, CO_2 from sorbent.

Table 13: Phosphoric Acid Production – Methodologies

Type of Emissions	Methodology	Percentage of Emissions Monitored by Method (by Type)						
		2011	2012	2013	2014	2015	2016	2017
Process emissions	Mass balance	100%	100%	100%	100%	100%	100%	100%
Combustion emissions	Measured HHVs and default emission factors (Tier 2)	35.9%	42.9%	45.6%	44.1%	49.0%	42.9%	38.3%
	Default HHVs and emission factors (Tier 1)	64.1%	57.1%	54.4%	55.9%	51.0%	57.1%	61.7%

Table 14: Silicon Carbide Production – Methodologies

Type of Emissions	Methodology	Percentage of Emissions Monitored by Method (by Type)						
		2011	2012	2013	2014	2015	2016	2017
Process emissions	Facility-specific emission factor	100%	100%	100%	100%	100%	100%	100%
Combustion emissions	Default HHVs and emission factors (Tier 1)	100%	100%	100%	100%	100%	100%	100%

Table 15: Titanium Dioxide Production – Methodologies

Type of Emissions	Methodology	Percentage of Emissions Monitored by Method (by Type)						
		2011	2012	2013	2014	2015	2016	2017
Process emissions	Mass balance	100%	100%	100%	100%	100%	100%	100%
Combustion emissions	Measured HHVs and default emission factors (Tier 2)	75.4%	74.7%	75.1%	63.1%	63.6%	65.4%	61.0%
	Default HHVs and emission factors (Tier 1)	24.6%	25.3%	24.9%	36.9%	36.4%	34.6%	39.0%

Table 16: Other Chemicals – Methodologies

Type of Emissions	Methodology	Percentage of Emissions Monitored by Method (by Type)						
		2011	2012	2013	2014	2015	2016	2017
Combustion emissions	CEMS (Tier 4)[a]	4.5%	2.8%	2.1%	2.5%	3.9%	3.8%	2.6%
	Alternative Part 75 Methodology: CEMS per §98.33(a)(5)(iii)	5.2%	12.7%	12.5%	12.5%	12.0%	12.5%	11.7%
	Measured carbon content, and, if applicable, molecular weight (Tier 3)	18.3%	11.1%	10.3%	12.5%	12.0%	10.2%	9.4%
	Measured HHVs and default emission factors (Tier 2)	42.0%	43.1%	40.8%	37.0%	36.5%	35.7%	36.3%
	Default HHVs and emission factors (Tier 1)	29.9%	30.3%	34.2%	35.3%	35.6%	37.8%	40.0%

a. CEMS emissions include CO_2 from fossil fuel combustion plus, if applicable, CO_2 from sorbent.

Data Verification and Analysis

As a part of the reporting and verification process, EPA evaluates annual GHG reports with electronic checks and staff review as needed. EPA contacts facilities regarding potential substantive errors and facilities resubmit reports as errors are identified. Additional information on EPA's verification process is available here.

Other Information

CO_2 emissions typically are uncontrolled. However, some facilities in this sector collect CO_2 either for use in other production processes or for sale; they report these quantities under Subpart PP (Suppliers of CO_2). Facilities that reported both as a direct emitter and a supplier of CO_2 include ammonia and petrochemical manufacturing facilities, hydrogen producers, and nitric acid facilities. Some of the CO_2 that is later consumed on site for urea production. Some of the N_2O emissions at nitric acid and adipic acid facilities are routed to an abatement technology; emissions that are abated are not counted in a facility's total. Methane emissions are typically uncontrolled in these industries.

The EPA currently tracks greenhouse gases and their sources through two complementary programs: GHGRP data and the Inventory of U.S. Greenhouse Gas Emissions and Sinks (Inventory). The Inventory estimates the total greenhouse gas emissions across all sectors of the economy using a "top down" approach generally using aggregated national data, while the GHGRP uses a "bottom up" approach collecting emissions data from the nation's largest GHG emitting facilities. The processes and industries covered by the Chemicals Sector are also covered by the Inventory, but the emissions are not directly correlated due to differences in coverage and difference in calculation methodologies. More details about the differences between the Inventory and the GHGRP are provided here: https://www.epa.gov/ghgreporting/greenhouse-gas-reporting-program-and-us-inventory-greenhouse-gas-emissions-and-sinks

GHGRP GHG emissions summaries presented here for some petrochemical production subsectors differ from those presented in the Inventory, due to methodological differences for some petrochemical types. The GHGRP uses a mass balance approach (and assumes all carbon is emitted as CO2), to determine process emissions from the production of all six petrochemicals covered. Additionally, the GHGRP uses an optional method to determine process emissions from the production of ethylene. Under the optional ethylene combustion methodology, facilities determine process emissions by calculating GHG emissions from the combustion of process off-gas.

In the Inventory, the CO2 emissions from production of four of the six petrochemicals – carbon black, ethylene, ethylene dichloride and ethylene oxide – were obtained by aggregating facility-level emissions reported under the GHGRP. The CO2 and CH4 emissions from acrylonitrile and methanol processes presented in the Inventory were calculated using a basic method based on internationally-accepted guidance (i.e. a "Tier 1" method based on national production of those petrochemicals) due to the confidential nature of reported GHGRP data. For future Inventories, EPA is evaluating alternate data aggregation approaches to possibly allow direct integration of GHGRP data for these additional petrochemical types.

Glossary

Adipic acid is a white crystalline solid used in the manufacture of synthetic fibers, plastics, coatings, urethane foams, elastomers, and synthetic lubricants. Food-grade adipic acid is used to provide some food products with a tangy flavor.

Ammonia is mainly used as fertilizer; directly applied as anhydrous ammonia; or further processed into urea, ammonium nitrates, ammonium phosphates, and other nitrogen compounds. Ammonia also is used to produce plastics, synthetic fibers and resins, and explosives.

Direct emitters are facilities that combust fuels or otherwise put GHGs into the atmosphere directly from their facilities. Alternatively, **Suppliers** are entities that supply certain fossil fuels or fluorinated gases into the economy that – when combusted, released, or oxidized – emit GHGs into the atmosphere.

FLIGHT refers to EPA's GHG data publication tool, named the Facility Level Information on Greenhouse Gases Tool (https://ghgdata.epa.gov/ghgp/main.do).

The **Fluorinated Chemicals Sector** is separate from the Chemicals Sector. This sector includes facilities that produce hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, nitrogen trifluoride, other fluorinated GHGs such as fluorinated ethers, and chlorofluorocarbons and hydrochlorofluorocarbons, including chlorodifluoromethane. The category also includes facilities that destroy HFC-23, a by-product of HCFC-22 production that may be emitted from the destruction process.

Fuel gas means gas generated at a petroleum refinery or petrochemical plant and that is combusted separately or in any combination with any type of gas.

GHGRP means EPA's Greenhouse Gas Reporting Program (40 CFR Part 98).

GHGRP vs. GHG Inventory: EPA's Greenhouse Gas Reporting Program (GHGRP) collects and disseminates annual GHG data from individual facilities and suppliers across the U.S. economy. EPA also develops the annual Inventory of U.S. Greenhouse Gas Emissions and Sinks (GHG Inventory) to track total national emissions of GHGs to meet U.S. government commitments to the United Nations Framework Convention on Climate Change. The GHGRP and Inventory datasets are complementary; however, there are also important differences in the data and approach. For more information, please see https://www.epa.gov/ghgreporting/greenhouse-gas-reporting-program-and-us-inventory- greenhouse-gas-emissions-and-sinks.

Hydrogen production: Hydrogen is mostly used in the production of ammonia and other chemicals or in industrial applications such as hydrocracking or hydrotreating processes during petroleum refining, metals treating, and food processing. Hydrogen production processes are classified as either captive or merchant. A captive process is owned by the facility that uses the hydrogen in a production process. A merchant plant sells hydrogen to another entity. The hydrogen production subsector comprises emissions from all merchant hydrogen production facilities and from captive processes at petroleum refineries. The GHG emissions from captive hydrogen processes at ammonia manufacturing facilities are included in the ammonia manufacturing subsector.

IPCC AR4 refers to the Fourth Assessment Report by the Intergovernmental Panel on Climate Change. *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K. and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 2007.* The AR4 values also can be found in the current version of Table A-1 in Subpart A of 40 CFR Part 98.

MMT means million metric tons.

NAICS means the North American Industry Classification System, the standard used by federal statistical agencies to classify business establishments into industrial categories for collecting and publishing statistical data related to the U.S. economy.

Nitric acid is used in the manufacture of nitrogen-based fertilizers, adipic acid, and explosives. Nitric acid is also used for metal etching and processing of ferrous metals.

The **other chemicals** subsector comprises facilities that reported under Subpart C (stationary fuel combustion sources) only and reported NAICS codes starting with 325. This subsector excludes NAICS codes 325193 (ethyl alcohol), 3252XX (synthetic rubber/fibers), 325510 (paints/coatings), and 325920 (explosives), which are included in the sector called "Miscellaneous Combustion Sources."

The **petrochemical production** source category consists of processes that produce acrylonitrile, carbon black, ethylene, ethylene dichloride, ethylene oxide, or methanol.

- The primary use of acrylonitrile is in the production of synthetic fibers.
- Carbon black is used primarily as a reinforcing agent in tires and other rubber compounds, and also has applications as a pigment.
- Ethylene is used as a feedstock in the production of polyethylene and other chemicals such as ethylene oxide, ethylene dichloride, and ethylbenzene.
- Nearly all ethylene dichloride is used in the production of vinyl chloride monomer, which is used in the production of polyvinyl chloride, a common plastic.
- Ethylene oxide is used as a feedstock in the manufacture of glycols, glycol ethers, alcohols, and amines.
- Methanol is used as a feedstock in the production of acetic acid, formaldehyde, and other chemicals.

Petroleum products means all refined and semi-refined products that are produced at a refinery by processing crude oil and other petroleum-based feedstocks, including petroleum products derived from co-processing biomass and petroleum feedstock together, but not including plastics or plastic products. Petroleum products may be combusted for energy use, or they may be used either for non-energy processes or as non-energy products. Fuel gas is included in the petroleum product fuel category for all sectors other than petrochemical production. For petrochemical production, fuel gas is classified separately.

Process emissions means the emissions from industrial processes involving chemical or physical transformations other than fuel combustion. For example, the calcination of carbonates in a kiln during cement production or the oxidation of methane in an ammonia process results in the release of process CO_2 emissions to the atmosphere. Emissions from fuel combustion to provide process heat are not part of process emissions, whether the combustion is internal or external to the process equipment.

Phosphoric acid is used primarily in the manufacture of phosphate fertilizers, but it is also used in food and animal feed additives.

Silicon carbide is used as an industrial abrasive and to produce ceramics for applications requiring high endurance. Applications of silicon carbide include semiconductors; body armor; brakes; clutches; and the manufacture of Moissanite, a diamond substitute.

Titanium dioxide is used as a white pigment in paint manufacturing, paper, plastics, and other applications.