PETROLEUM AND NATURAL GAS SYSTEMS

Introduction

In Fall 2017, the U.S. Environmental Protection Agency (EPA) released 2016 greenhouse gas (GHG) data for Petroleum and Natural Gas Systems[1] collected under the Greenhouse Gas Reporting Program (GHGRP). The GHGRP, which was required by Congress in the Fiscal Year 2008 Consolidated Appropriations Act, requires facilities to report data from large emission sources across a range of industry sectors, as well as from suppliers of certain greenhouse gases and products that would emit GHGs if released or combusted.

All emissions presented here reflect the most recent information reported to EPA as of 8/5/2017. The reported emissions exclude biogenic CO_2. GHG data displayed here in units of carbon dioxide equivalent (CO_2e) reflect the global warming potential (GWP) values from Table A-1 of 40 CFR 98, which is generally based on the IPCC AR4, with the addition of GWPs from the IPCC AR5 for fluorinated GHGs that did not have GWPs in the AR4.

The data show 2016 GHG emissions from 2,248 facilities conducting Petroleum and Natural Gas Systems activities, such as production, gathering and boosting, processing, transmission, and distribution. In total, these facilities accounted for GHG emissions of 283 million metric tons of carbon dioxide equivalent (CO_2e). In 2016, reported GHG emissions from Petroleum and Natural Gas Systems represented 9.5% of emissions reported to the GHGRP.

When reviewing these data and comparing them to other data sets or published literature, it is important to understand the GHGRP reporting requirements and the impacts of these requirements on the reported data. Facilities used uniform methods prescribed by the EPA to calculate GHG emissions, such as direct measurement, engineering calculations, or emission factors derived from direct measurement. In some cases, facilities had a choice of calculation methods for an emission source.

Petroleum and Natural Gas Systems is one of the more complex source categories within the GHGRP because of the number of emission sources covered, technical complexity, variability in the calculation methods used for a particular emission source, and variability across facilities. It is expected that there can be differences in reported emissions from one facility to another. As described in more detail below, there is a reporting threshold, and the reporting requirements do not cover certain emission sources. Thus the data do not represent the entire universe of emissions from Petroleum and Natural Gas Systems. Starting with data reported for 2016, facilities reported emissions from select emission sources in gathering and boosting systems, blowdown emissions from natural gas transmission pipelines, emissions from oil well completions and workovers with hydraulic fracturing, and well identification numbers for onshore production wells. While changes in the total number of reporting facilities can cause changes in total reported emissions from year-to-year, a number of factors, such as those detailed above, contribute to differences as well. All of these factors could impact cross-segment, cross-source, or cross-facility comparisons.

There are also considerations to keep in mind when drawing conclusions about the deferred activity data reported for 2011-2013, as part of the reporting year 2014 submissions. While many facilities in this sector submitted deferred data, certain facilities might not have reported this

[1] The implementing regulations of the Petroleum and Natural Gas Systems source category of the GHGRP are located at 40 CFR Part 98 Subpart W.

information for legitimate reasons. These include changes in ownership and not having reported to the GHGRP in a previous year for a valid reason. In addition, the reporting requirements were significantly revised in 2014, so some activity data reported for 2015 and 2016 are not available for previous years. It is important to be aware of these limitations and differences when using this data, particularly when attempting to draw broad conclusions about emissions and activities from this sector.

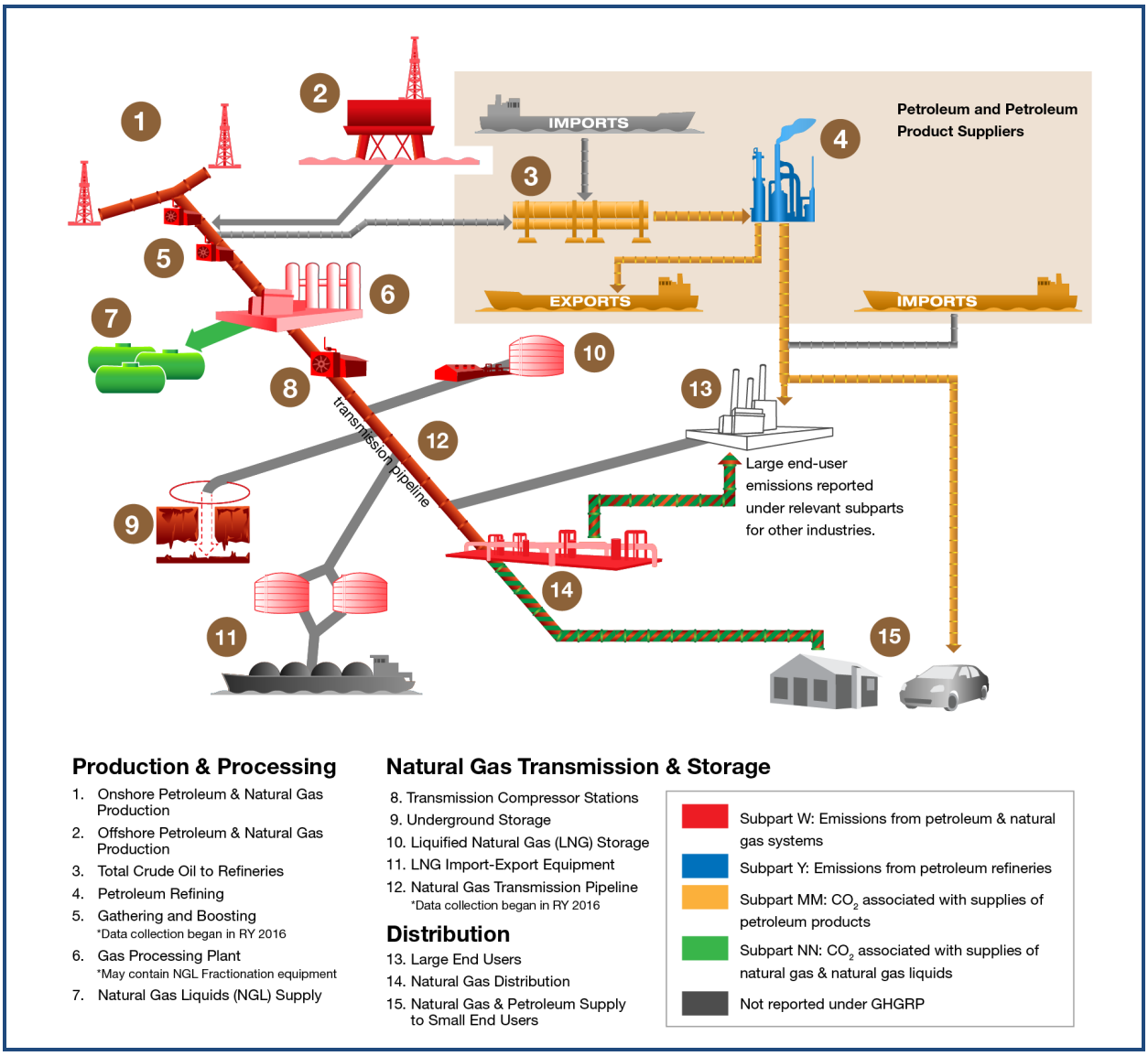
Petroleum and Natural Gas Systems in the GHG Reporting Program

The Petroleum and Natural Gas Systems source category of the GHGRP (Subpart W) requires reporting from the following 10 industry segments for 2016:

- Onshore Production – Production of petroleum and natural gas associated with onshore production wells and related equipment;
- Offshore Production – Production of petroleum and natural gas from offshore production platforms;
- Gathering and Boosting – Gathering pipelines and other equipment that collect petroleum/natural gas from onshore production gas or oil wells and then compress, dehydrate, sweeten, or transport the petroleum and/or natural gas;
- Natural Gas Processing – Processing of field quality gas to produce pipeline-quality natural gas;
- Natural Gas Transmission Compression – Compressor stations used to transfer natural gas through transmission pipelines;
- Natural Gas Transmission Pipeline – A rate-regulated interstate or intrastate pipeline, or a pipeline that falls under the "Hinshaw Exemption" of the Natural Gas Act;
- Underground Natural Gas Storage – Facilities that store natural gas in underground formations;
- Liquefied Natural Gas (LNG) Import/Export – Liquefied Natural Gas import and export terminals;
- LNG Storage – Liquefied Natural Gas storage equipment; and
- Natural Gas Distribution – Distribution systems that deliver natural gas to customers.

The diagram below illustrates the segments of the Petroleum and Natural Gas Systems source category that were required to report under the GHGRP for 2016.

Figure 1: Petroleum and Natural Gas operations covered by the GHG Reporting Program



Note: Certain petroleum and/or natural gas operations are covered by subparts of the GHGRP other than Subpart W or began reporting GHG data starting with the 2016 reporting year.

Other segments of the petroleum and natural gas industry are covered by the GHGRP but not included in the Petroleum and Natural Gas Systems (Subpart W) source category, such as Petroleum Refineries (Subpart Y), Petrochemical Production (Subpart X), Suppliers of Petroleum Products (Subpart MM), and Suppliers of Natural Gas and Natural Gas Liquids (Subpart NN).

As noted above, the GHGRP also includes reporting of stationary fuel combustion emissions from facilities that are associated with the petroleum and natural gas industry, but that do not report process emissions from any of the above source categories, such as certain facilities that have a North American Industry Classification System (NAICS) code beginning with 211 (the general NAICS for oil and gas extraction). These facilities are referred to as "Other Oil and Gas Combustion" in this document.

The GHGRP covers a subset of national emissions from Petroleum and Natural Gas Systems. A facility in the Petroleum and Natural Gas Systems source category is required to submit annual reports if total emissions are 25,000 metric tons carbon dioxide equivalent (CO_2e) or more.

The EPA has a multi-step data verification process, including automatic checks during data-entry, statistical analyses on completed reports, and staff review of the reported data.[2] Based on the results of the verification process, the EPA follows up with facilities to resolve mistakes that may have occurred during the reporting period.

The EPA has made available the optional use of best available monitoring methods (BAMM) for targeted circumstances where the EPA made recent changes to GHGRP monitoring requirements for Petroleum and Natural Gas Systems.[3] For the 2016 reporting year, reporters were allowed to use BAMM for the new industry segments and emission sources that were added to 40 CFR Part 98, Subpart W.[4] These include calculating and reporting emissions from oil well completions and workovers with hydraulic fracturing, gathering and boosting systems, and natural gas transmission pipeline blowdowns. In certain previous reporting years, in order to provide facilities with time to adjust to the requirements of the GHGRP, the EPA made available the optional use of BAMM for unique or unusual circumstances. Where a facility used BAMM for any reporting year, it was required to follow emission calculations specified by the EPA but allowed to use alternative methods for determining inputs to calculate emissions. Examples of BAMM include monitoring methods used by the facility that do not meet the specifications of 40 CFR Part 98 Subpart W, supplier data, engineering calculations, and other company records.

Reported GHG Emissions from Petroleum and Natural Gas Systems

The following section provides information on reported GHG emissions by industry segment, greenhouse gas, and combustion and process emissions for the 2016 calendar year.

Reported Emissions by Industry Segment

The 2016 calendar year was the sixth year that GHG emissions from Petroleum and Natural Gas Systems activities were required to be collected. Annual reports were due to the EPA by March 31, 2017. The EPA received reports from 2,248 facilities[5] with Petroleum and Natural Gas Systems activities, with total reported GHG emissions of 283 million metric tons (MMT) CO_2e.

The largest industry segment in terms of reported GHG emissions was onshore production, with a total of 85 MMT CO_2e, followed by gathering and boosting, with reported emissions of 83 MMT CO_2e. Natural gas processing accounted for 56 MMT CO_2e. The next largest segment was natural gas

[2] For more information on verification, see:
http://www.epa.gov/ghgreporting/ghgrp-methodology-and-verification

[3] For more information on BAMM, see:
http://www.epa.gov/ghgreporting/ghgrp-methodology-and-verification

[4] 80 FR 64262 (October 22, 2015)

[5] In general, a "facility" for purposes of the GHGRP means all co-located emission sources that are commonly owned or operated. However, the GHGRP has developed specialized facility definitions for onshore production, gathering and boosting, natural gas transmission pipeline, and natural gas distribution. For onshore production, the "facility" includes all emissions associated with wells owned or operated by a single company in a specific hydrocarbon producing basin (as defined by the geologic provinces published by the American Association of Petroleum Geologists). For gathering and boosting, a "facility" means all gathering pipelines and other equipment located along those pipelines that are under common ownership or common control by a gathering and boosting system owner or operator and that are located in a single hydrocarbon basin. For natural gas transmission pipeline, a "facility" means the total U.S. mileage of natural gas transmission pipelines, owned and operated by an onshore natural gas transmission pipeline owner or operator. For natural gas distribution, a "facility" is a local distribution company as regulated by a single state public utility commission.

transmission compression, with reported emissions of 22 MMT CO_2e. Reported emissions from natural gas distribution totaled 14 MMT CO_2e. The remaining segments accounted for total reported emissions of approximately 23 MMT CO_2e.

Table 1: 2016 Reported Emissions by Industry Segment

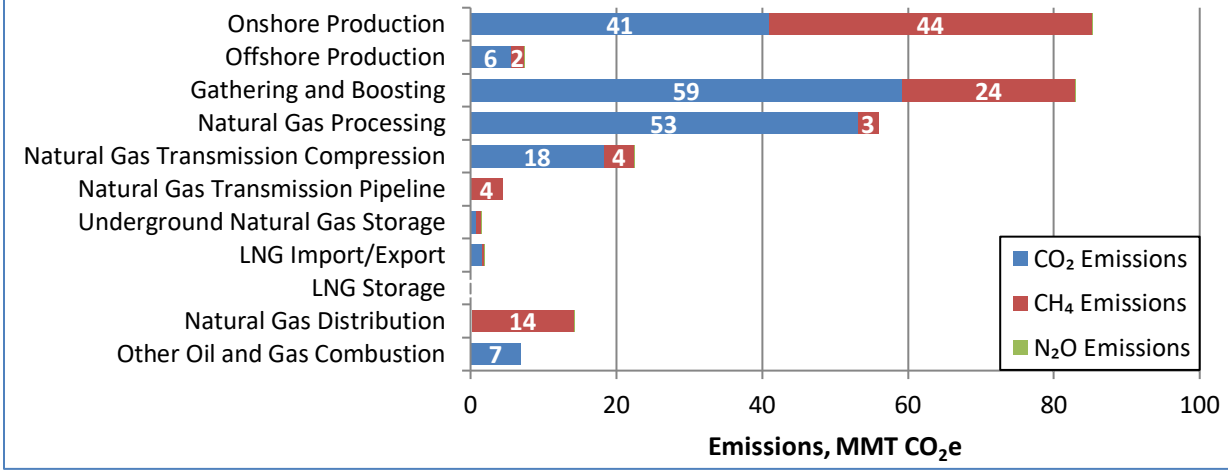
Industry Segment	Number of Facilities	Reported Emissions (Million Metric Tons CO_2e)
Onshore Production	512	85
Offshore Production	134	7
Gathering and Boosting	299	83
Natural Gas Processing	447	56
Natural Gas Transmission Compression	525	22
Natural Gas Transmission Pipeline	27	4
Underground Natural Gas Storage	53	2
LNG Import/Export	6	2
LNG Storage	6	<1
Natural Gas Distribution	169	14
Other Oil and Gas Combustion	92	7
Total	**2,248**	**283**

Note: Total number of facilities is smaller than the sum of facilities from each segment because some facilities reported under multiple segments. A facility is included in the count of number of facilities if it reported emissions (even if the reported emissions were zero) under a given segment.

Reported Emissions by Greenhouse Gas

For all segments combined, carbon dioxide (CO_2) emissions accounted for 187 MMT CO_2e of reported emissions and methane (CH_4) emissions accounted for 96 MMT CO_2e of reported emissions.

Figure 2: 2016 Reported Emissions by Greenhouse Gas



Reported Combustion and Process Emissions

Each segment of Petroleum and Natural Gas Systems includes a combination of emission sources. Emissions may result from the combustion of fossil fuels or from process sources that result in the direct emission of GHGs. Reported combustion emissions in Petroleum and Natural Gas Systems totaled 150 MMT CO_2e and reported process emissions totaled 132 MMT CO_2e.

Figure 3: 2016 Reported Combustion and Process Emissions

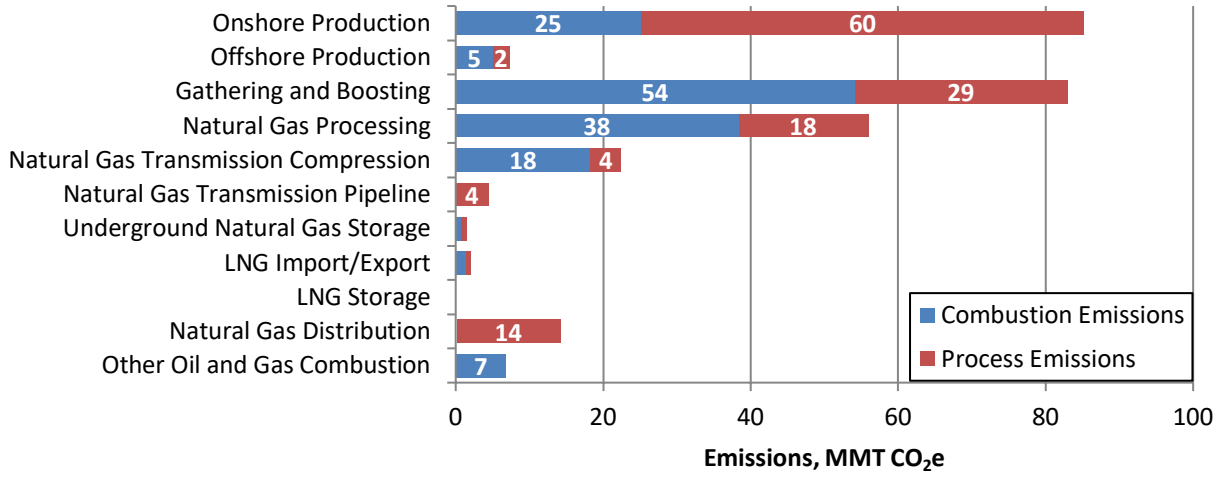
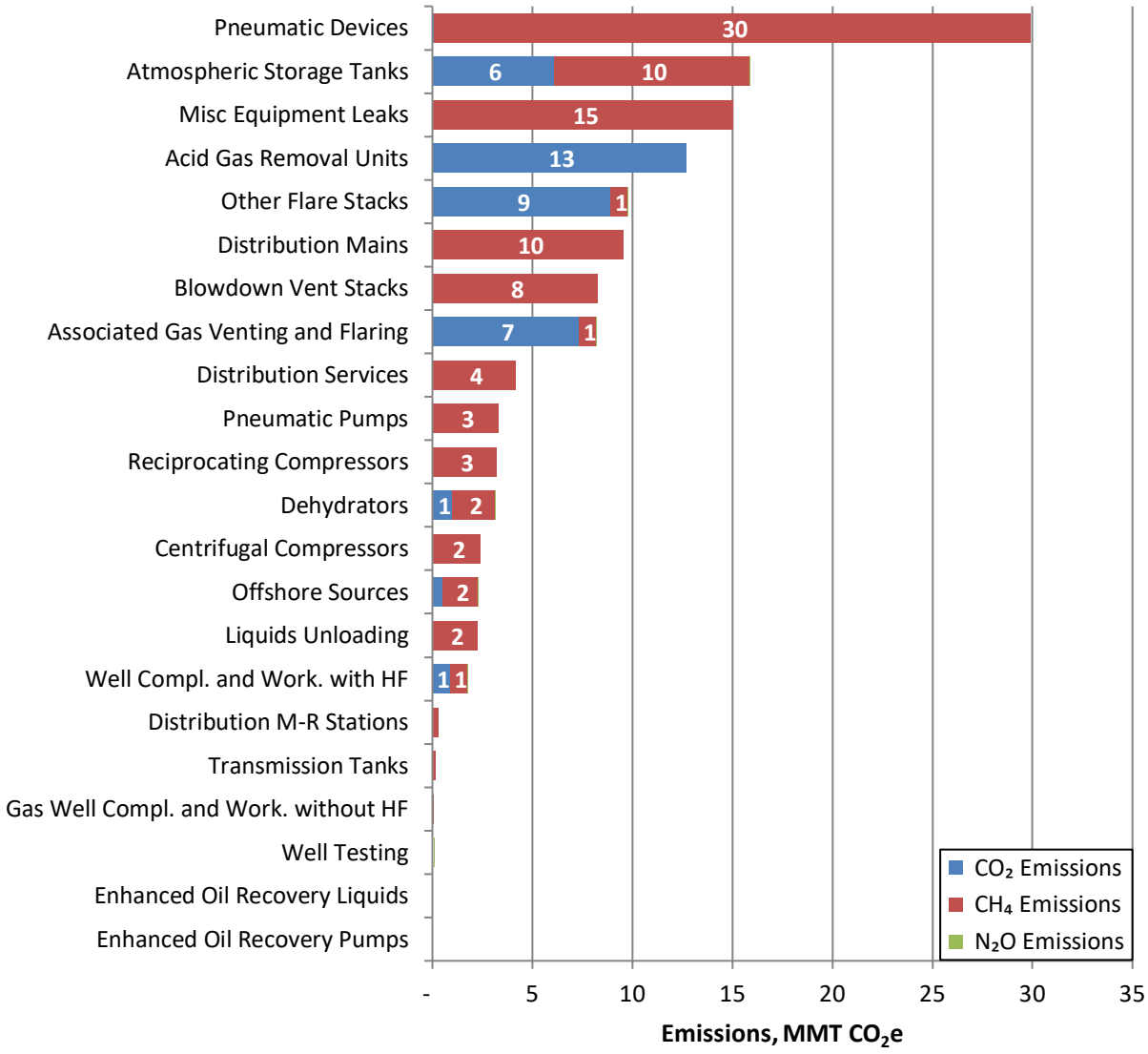


Figure 4: 2016 Reported Process Emission Sources



Reported GHG Emissions by Industry Segment and Source

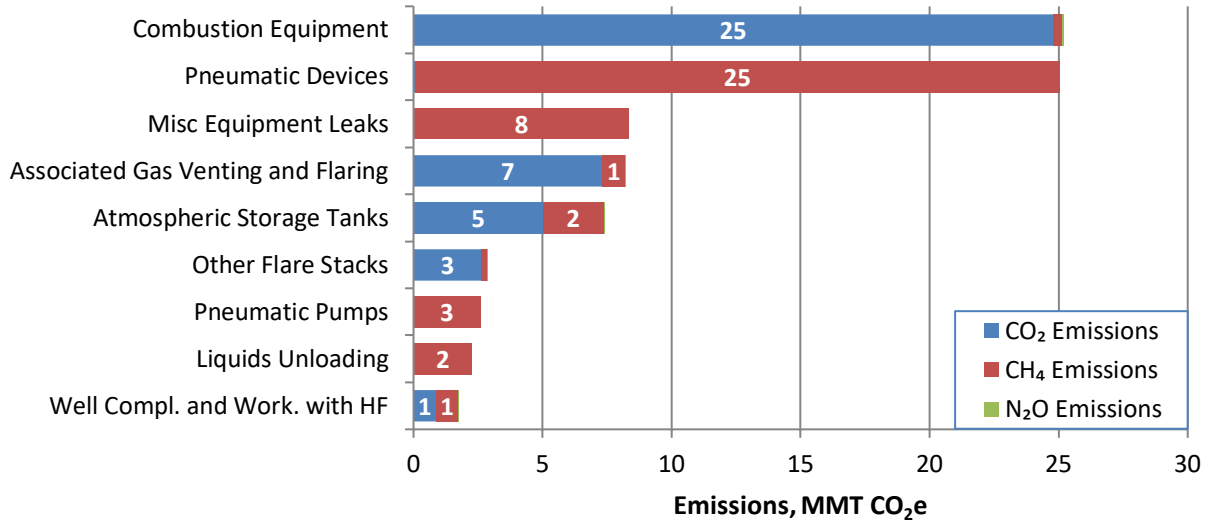
The following section provides information on reported GHG emissions organized by industry segment. For each segment, the top reported emission sources are presented.

Onshore Production

The EPA received annual reports from 512 facilities in the onshore production segment and reported emissions totaled 85.4 MMT CO_2e. Methane emissions totaled 44.2 MMT CO_2e and carbon dioxide emissions totaled 41.2 MMT CO_2e. Combustion equipment (25.2 MMT CO_2e) and pneumatic devices (25 MMT CO_2e) were the top reported emission sources, followed by miscellaneous equipment leaks (8.3 MMT CO_2e), associated gas venting and flaring (8.2 MMT CO_2e), atmospheric tanks (7.4 MMT CO_2e), and other flare stacks (2.9 MMT CO_2e).

Starting with data reported for 2016, onshore production facilities reported well identification numbers and certain emission source types associated with wells. A well identification number is either the US Well Number (formerly referred to as the API Well Number, or API Number), or the unique well number assigned by its permitting authority if the well does not have a US Well Number.[6]

Figure 5: 2016 Onshore Production: Top Reported Emission Sources

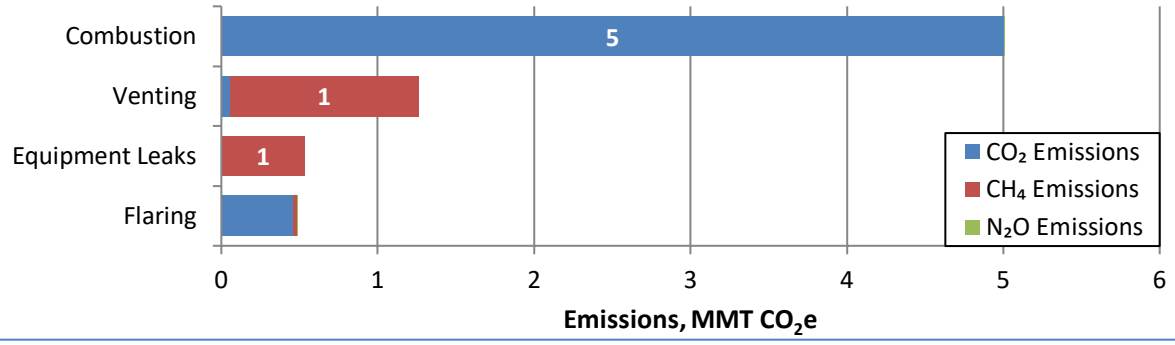


Offshore Production

The EPA received annual reports from 134 facilities in the offshore production segment that totaled 7.3 MMT CO_2e. For offshore production, facilities calculate process emissions using requirements that were established by the Bureau of Ocean Energy Management (BOEM). In addition, the GHGRP collects data on combustion emissions. While the full list of process emission sources is extensive, it can generally be categorized into vented emissions, flaring and equipment leaks. The top reported source of emissions for offshore production was from combustion (5 MMT CO_2e), followed by venting (1.3 MMT CO_2e).

[6] Professional Petroleum Data Management Association. The US Well Number Standard: An Identifier for Petroleum Industry Wells in the USA. Version 2013 rev 1, published June 19, 2014. Available at https://dl.ppdm.org/dl/1209.

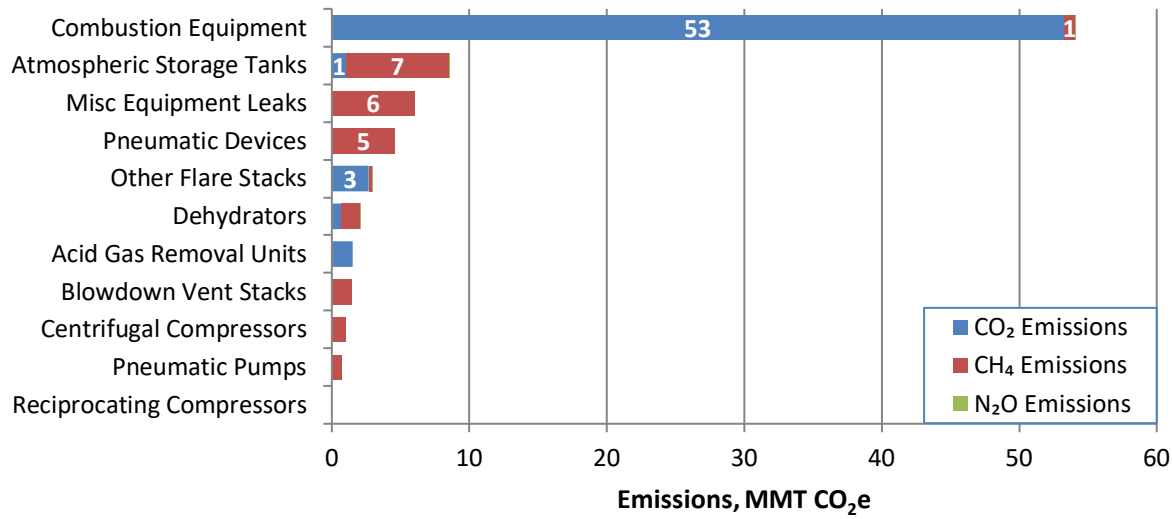
Figure 6: 2016 Offshore Production: Top Reported Emission Sources



Gathering and Boosting

The gathering and boosting segment was first reported in 2016. The EPA received annual reports from 299 facilities in the gathering and boosting segment and reported emissions totaled 83 MMT CO_2e. Methane emissions totaled 23.7 MMT CO_2e and carbon dioxide emissions totaled 59.2 MMT CO_2e. Combustion equipment (54.1 MMT CO_2e) was the top reported emission source, followed by atmospheric tanks (8.5 MMT CO_2e), miscellaneous equipment leaks (6 MMT CO_2e) and pneumatic devices (4.6 MMT CO_2e).

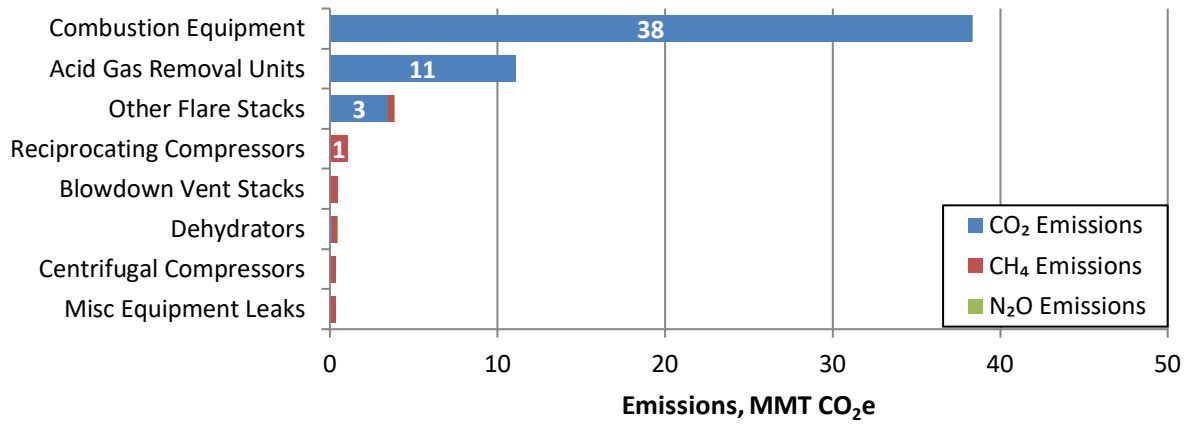
Figure 7: 2016 Gathering and Boosting: Top Reported Emission Sources



Natural Gas Processing

The EPA received annual reports from 447 facilities in the natural gas processing segment, and reported emissions totaled 55.9 MMT CO_2e. Methane emissions totaled 2.8 MMT CO_2e, and carbon dioxide emissions totaled 53.1 MMT CO_2e. The top reported emission sources were combustion equipment (38.4 MMT CO_2e), acid gas removal units (11.1 MMT CO_2e), and other flare stacks (3.8 MMT CO_2e).

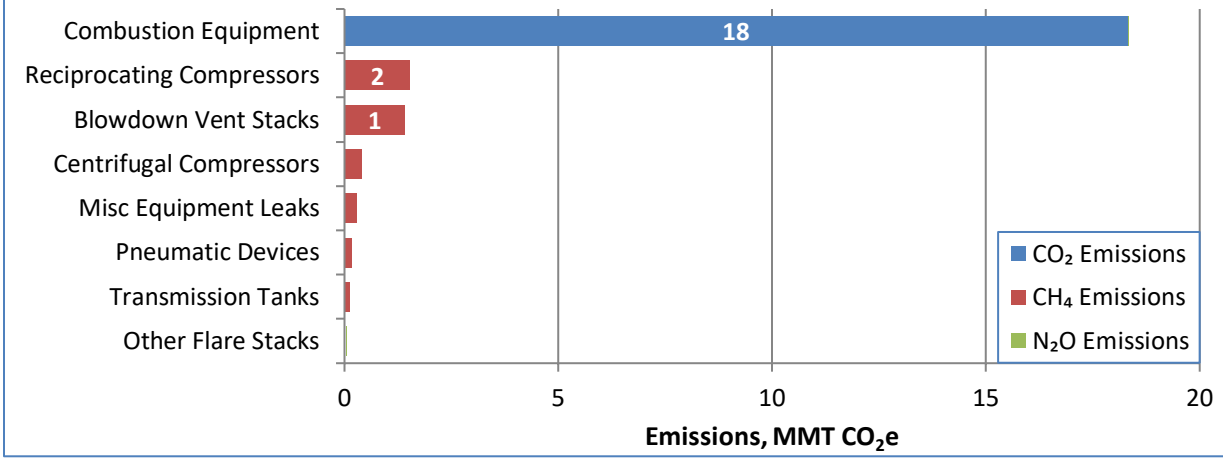
Figure 8: 2016 Natural Gas Processing: Top Reported Emission Sources



Natural Gas Transmission Compression

The EPA received annual reports from 525 facilities in the natural gas transmission compression segment, and reported emissions totaled 22.4 MMT CO_2e. Methane emissions totaled 4 MMT CO_2e and carbon dioxide emissions totaled 18.4 MMT CO_2. Combustion emissions (18.3 MMT CO_2e) were larger than process emissions. Following combustion equipment, the top reported emission sources were reciprocating compressors (1.5 MMT CO_2e) and blowdown vent stacks (1.4 MMT CO_2e).

Figure 9: 2016 Natural Gas Transmission Compression: Top Reported Emission Sources



Natural Gas Transmission Pipeline

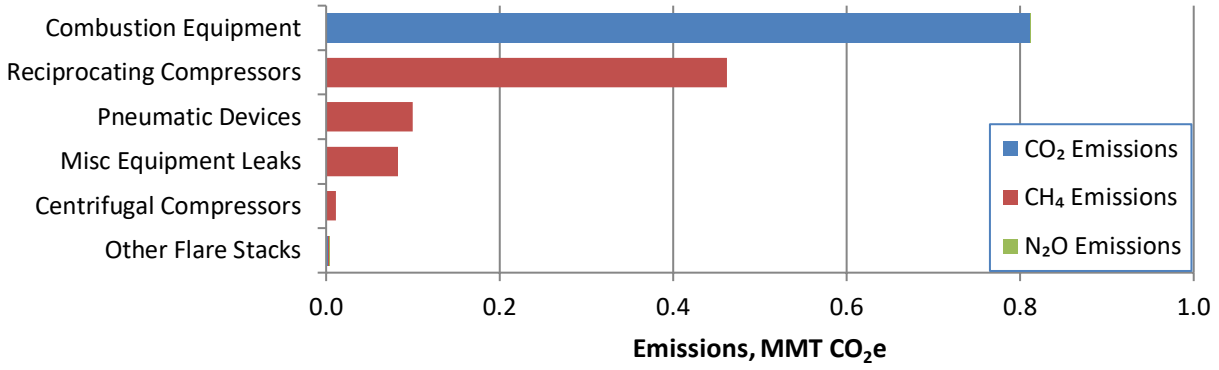
GHG emissions from the natural gas transmission pipeline segment were first reported in 2016 and contains one reported emission source, blowdown vent stacks. The EPA received annual reports from 27 facilities in the natural gas transmission pipeline segment and reported emissions totaled

4.4 MMT CO_2e. Methane emissions totaled 4.4 MMT CO_2e and carbon dioxide emissions totaled less than 0.01 MMT CO_2e.

Underground Natural Gas Storage

The EPA received annual reports from 53 facilities in the underground natural gas storage segment and reported emissions totaled 1.5 MMT CO_2e.[7] Methane emissions totaled 0.7 MMT CO_2e and carbon dioxide emissions totaled 0.8 MMT CO_2e. Combustion equipment (0.8 MMT CO_2e) was the top reported source of emissions for underground natural gas storage, followed by reciprocating compressors (0.5 MMT CO_2e).

Figure 10: 2016 Underground Natural Gas Storage: Top Reported Emission Sources



LNG Import/Export

The EPA received emission reports from six LNG import/export terminals and reported emissions totaled 2 MMT CO_2e. Methane emissions totaled 0.5 MMT CO_2e and carbon dioxide emissions totaled 1.5 MMT CO_2e. The top reported source of emissions was combustion equipment (1.4 MMT CO_2e).

LNG Storage

The EPA received emission reports from six LNG storage facilities. Total reported emissions from LNG storage were less than 0.01 MMT CO_2e.

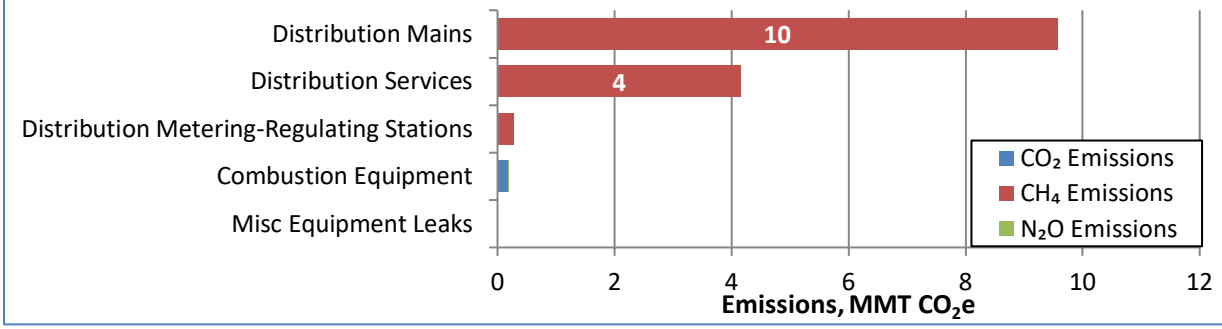
Natural Gas Distribution

The EPA received annual reports from 169 facilities in the natural gas distribution segment, and reported emissions totaled 14.2 MMT CO_2e. Methane emissions totaled 14 MMT CO_2e and carbon

[7] The Southern California Gas Company - Aliso Canyon facility's actual 2015 and 2016 emissions were higher than those reported to the GHGRP. The GHGRP provides well-vetted average emission factors to calculate emissions. The facility followed these GHGRP calculation methods for 2015 and 2016 reporting. Actual emissions differ from those reported due to an exceptional leak event. The well was permanently sealed in February 2016. See California Air Resource Board's Aliso Canyon Natural Gas Leak webpage for more information: https://www.arb.ca.gov/research/aliso_canyon_natural_gas_leak.htm.

dioxide emissions totaled 0.2 MMT CO_2e. For the Natural Gas Distribution segment, combustion emissions (0.2 MMT CO_2e) were relatively low compared to other industry segments. The primary emission sources for natural gas distribution were distribution mains (9.6 MMT CO_2e) and distribution services (4.2 MMT CO_2e), which are caused by natural gas equipment leaks and calculated by multiplying mileage by default population emission factors that are specific to pipe material.

Figure 11: 2016 Natural Gas Distribution: Top Reported Emission Sources



Changes from 2011 to 2016

The following section describes the reported data for the 2011 through 2016 calendar years for Petroleum and Natural Gas Systems.[8]

Changes in Number of Facilities

Annual reported facility counts from 2011 to 2016 are shown in Table 2. The change in number of facilities is primarily a result of facilities reporting under two new industry segments: gathering and boosting and natural gas transmission pipeline. It should also be noted that emissions can be variable in the Petroleum and Natural Gas Systems sector and it is not unexpected that emissions for a facility may go above 25,000 metric tons CO_2e in a given year. Once the reporting threshold is triggered, facilities must report to the GHGRP until emissions are below the threshold for a period of time specified in the regulations, or until all emission sources at a facility cease operation. As a result, the number of facilities reporting to the GHGRP may vary from year-to-year.

Changes in Reported Emissions

Annual reported emissions values from 2011 to 2016 by industry segment are shown in Table 3. The change in total reported emissions is generally attributable to the addition of two new industry segments: gathering and boosting and natural gas transmission pipeline. Emission changes are the result of a number of factors, such as changes in the number of facilities, operational changes (e.g., increased flaring), calculation changes (e.g., reduced BAMM use), and changes in the reporting landscape, including the addition of new industry segments and new emission sources within existing industry segments (e.g., oil well completions and workovers with hydraulic fracturing).

[8] The EPA received resubmissions of 2011 through 2015 data from certain facilities and this section describes the 2011-2016 time series updated to include the resubmitted data.

Table 2: Number of Facilities by Industry Segment: 2011 to 2016

Industry Segment[1]	2011 Number of Facilities	2012 Number of Facilities	2013 Number of Facilities	2014 Number of Facilities	2015 Number of Facilities	2016 Number of Facilities
Onshore Production[2]	459	507	508	570	535	512
Offshore Production	101	108	109	129	133	134
Gathering and Boosting[3]	N/A	N/A	N/A	N/A	N/A	299
Natural Gas Processing	374	403	438	479	466	447
Natural Gas Transmission Compression	421	458	487	522	520	525
Natural Gas Transmission Pipeline[3]	N/A	N/A	N/A	N/A	N/A	27
Underground Natural Gas Storage	49	52	51	54	53	53
LNG Import/Export	8	8	8	8	7	6
LNG Storage	6	5	5	5	7	6
Natural Gas Distribution	183	183	176	181	177	169
Other Oil and Gas Combustion[4]	338	388	419	490	544	92
Total	**1,921**	**2,096**	**2,186**	**2,419**	**2,415**	**2,248**

Notes:

1. Total number of facilities is smaller than the sum of facilities from each segment because some facilities reported under multiple segments. A facility is included in the count of number of facilities if it reported emissions (even if the reported emissions were zero) under a given segment.

2. Beginning in Reporting Year 2016, Onshore Production facilities began reporting emissions from oil well completions and workovers with hydraulic fracturing. These emissions were not reported for prior reporting years.

3. This industry segment began reporting data for the first time in Reporting Year 2016.

4. Beginning in Reporting Year 2016, facilities that met the definition of Gathering and Boosting reported emissions for applicable sources. This includes certain stationary and portable fuel combustion equipment emissions that may have been published for Reporting Years 2011-2015 as Other Petroleum and Natural Gas Systems.

Table 3: Reported Emissions by Industry Segment: 2011 to 2016

Industry Segment	2011 Reported Emissions (MMT CO_2e)	2012 Reported Emissions (MMT CO_2e)	2013 Reported Emissions (MMT CO_2e)	2014 Reported Emissions (MMT CO_2e)	2015 Reported Emissions (MMT CO_2e)	2016 Reported Emissions (MMT CO_2e)
Onshore Production[1]	92	93	98	102	99	85
Offshore Production	6	7	6	7	7	7
Gathering and Boosting[2]	N/A	N/A	N/A	N/A	N/A	83
Natural Gas Processing	59	61	59	60	59	56
Natural Gas Transmission Compression	24	24	23	22	23	22
Natural Gas Transmission Pipeline[2]	N/A	N/A	N/A	N/A	N/A	4
Underground Natural Gas Storage	2	2	2	2	2	2
LNG Import/Export	1	1	<1	1	1	2
LNG Storage	<1	<1	<1	<1	<1	<1
Natural Gas Distribution	16	16	15	15	14	14
Other Oil and Gas Combustion[3]	23	25	25	28	29	7
Total	**222**	**226**	**228**	**236**	**233**	**283**

Notes:

1. Beginning in Reporting Year 2016, Onshore Production facilities began reporting emissions from oil well completions and workovers with hydraulic fracturing. These emissions were not reported for prior reporting years.

2. This industry segment began reporting data for the first time in Reporting Year 2016.

3. Beginning in Reporting Year 2016, facilities that met the definition of Gathering and Boosting reported emissions for applicable sources. This includes certain stationary and portable fuel combustion equipment emissions that may have been published for Reporting Years 2011-2015 as Other Petroleum and Natural Gas Systems.

Additional Information

Access GHGRP data: http://www.epa.gov/ghgreporting/

Additional information about Petroleum and Natural Gas Systems in the GHGRP, including reporting requirements and calculation methods:
https://www.epa.gov/ghgreporting/subpart-w-petroleum-and-natural-gas-systems

GHGRP Petroleum and Natural Gas Systems Data Highlights Page:
https://www.epa.gov/ghgreporting/ghgrp-petroleum-and-natural-gas-systems

Facility Level Information on Greenhouse Gases Tool (FLIGHT): http://ghgdata.epa.gov/

Glossary

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.

IPCC AR5 refers to the Fifth Assessment Report by the Intergovernmental Panel on Climate Change. *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.*