October 2017

Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2016: Revisions Under Consideration for CO_2 Emissions

In a previous version of this memo released in June 2017, and during stakeholder webinars and workshops held in June and August 2017, the EPA presented preliminary considerations and sought stakeholder feedback on incorporating these revisions in the 2018 GHGI. This version of the memo is updated to reflect stakeholder feedback. Updates include:

- Assessment of associated gas venting and flaring emissions at the national and regional level (pages 5–10)
- Time series considerations for associated gas venting and flaring (page 16)
- Additional questions (questions 3, 4, and 5) for stakeholder feedback (page 19)
- Time series estimates for updates under consideration, Appendix B (pages 22-26)

This memo discusses CO_2 emission calculation revisions being considered for multiple segments of natural gas and petroleum systems in the 2018 Inventory of U.S. Greenhouse Gas Emissions and Sinks (GHGI). The EPA is considering CO_2 methodological revisions for sources and segments that already rely on a subpart W-based CH_4 emission calculation methodology or where the CH_4 calculation methodology was otherwise recently revised. The subpart W methodology revisions for CH_4 emissions estimates are documented in the following memos: the 2014 HF Completion and Workover memo,[1] 2015 HF Completion and Workover memo,[2] 2016 Transmission memo,[3] 2016 Production memo,[4] 2017 Production memo,[5] and 2017 Processing memo.[6] The revisions discussed in this memo will create consistency between CH_4 and CO_2 calculation methodologies. In addition, the EPA is considering updating the GHGI to include both the CO_2 emissions and the relatively minor CH_4 emissions from flare stacks reported under subpart W in the production and transmission and storage segments.

The sources discussed in this memo include: production segment storage tanks, associated gas venting and flaring, hydraulically fractured (HF) gas well completions and workovers, production segment pneumatic controllers, production segment pneumatic pumps, liquids unloading, production segment miscellaneous flaring, most sources in the gas processing segment, transmission station flares, underground natural gas storage flares, LNG storage flares, LNG import flares, and transmission and storage pneumatic controllers. The EPA is not currently considering revisions to the distribution segment CO_2 emissions calculation methodology, as discussed in Section 1.2.

[1] "Overview of Update to Methodology for Hydraulically Fractured Gas Well Completions and Workovers in the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012 (2014 Inventory)," available at https://www.epa.gov/ghgemissions/natural-gas-and-petroleum-systems-ghg-inventory-updates-1990-2012-inventory-published.

[2] "Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2013: Revision to Hydraulically Fractured Gas Well Completions and Workovers Estimate," available at https://www.epa.gov/ghgemissions/natural-gas-and-petroleum-systems-ghg-inventory-updates-1990-2013-inventory-published.

[3] "Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2014: Revisions to Natural Gas Transmission and Storage Emissions," available at https://www.epa.gov/ghgemissions/natural-gas-and-petroleum-systems-ghg-inventory-additional-information-1990-2014-ghg.

[4] "Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2014: Revisions to Natural Gas and Petroleum Production Emissions," available at https://www.epa.gov/ghgemissions/natural-gas-and-petroleum-systems-ghg-inventory-additional-information-1990-2014-ghg.

[5] "Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2015: Revisions to Natural Gas and Petroleum Systems Production Emissions," available at https://www.epa.gov/ghgemissions/natural-gas-and-petroleum-systems-ghg-inventory-additional-information-1990-2015-ghg.

[6] "Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2015: Revisions to Natural Gas Systems Processing Segment Emissions," available at https://www.epa.gov/ghgemissions/natural-gas-and-petroleum-systems-ghg-inventory-additional-information-1990-2015-ghg.

1. Background and Current GHGI Methodology for CO_2 Emissions

This section discusses the current GHGI methodology for calculating CO_2 emissions. Section 1.1 describes a CO_2-to-CH_4 gas content ratio methodology, which is the default approach used in all GHGI segments. Section 1.2 describes the current GHGI methodology to calculate CO_2 emissions for certain sources that rely on emission source-specific methods. The current GHGI CO_2 EFs are documented in Appendix A.

1.1 CO_2-to-CH_4 Gas Content Ratio Methodology

The current GHGI methodology to calculate CO_2 emission factors (EFs) for the majority of emission sources relies on CH_4 emission factors and an assumed ratio of CO_2-to-CH_4 gas content. The CO_2 EF calculation is shown in equation 1:

$$CO_2\ EF = CH_4\ EF * \left(\frac{CO_2\ content}{CH_4\ content}\right) \qquad \text{Equation 1}$$

The default CH_4 and CO_2 content values for sources in natural gas systems are from the 1996 GRI/EPA study,[7] EIA,[8] and GTI's Gas Resource Database[9] and summarized in Table 1 below.

Table 1. Default Gas Content Values for Natural Gas Systems in the GHGI

Segment	CH_4 Content (vol%)	CO_2 Content (vol%)
Production – North East region	78.8	3.04
Production – Mid Central region		0.79
Production – Gulf Coast region		2.17
Production – South West region		3.81
Production – Rocky Mountain region		7.58
Production – West Coast region		0.16
Processing – Before CO_2 removal	87.0	3.45
Processing – After CO_2 removal		1.0
Transmission and Underground NG Storage	93.4	1.0
LNG Storage and LNG Import/Export	93.4	1.16
Distribution	93.4	1.0

For most of the petroleum production sources evaluated in this memo, the GHGI uses a ratio of CO_2 to CH_4 content, set at 0.017 based on the average flash gas CO_2 and CH_4 content from API TankCalc runs.

The ratio of CO_2-to-CH_4 gas content methodology is used to calculate venting and fugitive CO_2 EFs, because the CH_4 EFs that are referenced for this methodology represent venting and fugitive emissions, which are predominantly CH_4 with minimal CO_2 emissions. EPA does not use this methodology in the GHGI to calculate CO_2 EFs for combustion sources such as flares, for which the inverse is true (CO_2 is predominant, with minimal CH_4 emissions).

[7] Methane Emissions from the Natural Gas Industry, Volume 6: Vented and Combustion Source Summary, Appendix A.
[8] U.S. Energy Information Administration. Emissions of Greenhouse Gases in the United States: 1987-1992, Appendix A. 1994.
[9] GRI-01/0136 GTI's Gas Resource Database: Unconventional Natural Gas and Gas Composition Databases. Second Edition. August, 2001.

1.2 Emission Source-Specific CO_2 Calculation Methodologies

The current GHGI uses emission source-specific methodologies to calculate CO_2 emissions from oil and condensate tanks at production sites, AGR units at natural gas processing plants, and production and processing flaring.

Oil and Condensate Tanks at Production Sites

The current GHGI methodology to calculate CO_2 emissions for oil and condensate tanks uses CO_2 specific EFs. The EFs were developed using API TankCalc software with varying API gravities. The oil tank EF is the average from API TankCalc runs for oils with API gravity less than 45, and the condensate tank EF considered data with API gravity greater than 45. Condensate tank EFs were determined for both controlled and uncontrolled tanks; the controlled tank EF assumed a control efficiency of 80%. The current GHGI calculates oil tank CO_2 emissions by applying the oil tank emission factor (EF) to 20% of stripper well production and 100% of non-stripper oil well production. For gas production, the current GHGI methodology estimates tank emissions by applying the condensate tank EF to condensate production in each NEMS region.

AGR Units at Natural Gas Processing Plants

The current GHGI CO_2 EF for AGR units at natural gas processing plants relies on gas CO_2 content only. The difference in the default CO_2 content before and after CO_2 removal (3.45% - 1.0% = 2.45% of processing plant gas throughput) is assumed to be emitted.

Flaring

Flaring emissions from the production and processing segments are currently calculated under a single line item in the production segment of natural gas systems. Therefore, flaring emissions are not specifically attributed to the natural gas systems processing segment or the petroleum systems production segment. The EF is based on data from EIA's 1996 greenhouse gas emissions inventory, which estimated the amount of CO_2 released per BTU of natural gas combusted (0.055 g/BTU). The activity data are annual EIA "Vented and Flared" gas volumes (MMcf), which are reported under Natural Gas Gross Withdrawals and Production,[10] combined with the estimated national average gas heating value (averaging approximately 1,100 BTU/cf over the time series[11]). The EIA Vented and Flared data represents a balancing factor amount that EIA calculates to reconcile reported upstream and downstream gas volumes, and assumes is potentially emitted to the atmosphere during production or processing operations; the current GHGI methodology assumes it is all flared. Details on how much of the Vented and Flared gas is potentially emitted during natural gas production, petroleum production, and processing are not available, so the current GHGI assigns it all to natural gas production. Also, the EIA data do not account for gas that is flared prior to metering.

Flaring emissions from the transmission and storage segment and distribution segment are not currently calculated in the GHGI. Data are unavailable on flaring emissions in the distribution segment, but they are likely to be insignificant based on the low prevalence of this activity in the industry segment. EPA is not considering revisions to the distribution segment CO_2 emissions calculation methodology for the 2018 GHGI.

2. Available Subpart W Data

Subpart W of the EPA's Greenhouse Gas Reporting Program (GHGRP) collects annual operating and emissions data on numerous sources from onshore natural gas and petroleum systems and natural gas processing facilities that meet a reporting threshold of 25,000 metric tons of CO_2 equivalent (MT CO_2e) emissions. Onshore production

[10] EIA Natural Gas Gross Withdrawals and Production, including the Vented and Flared category, is available at https://www.eia.gov/dnav/ng/ng_prod_sum_a_EPG0_VGV_mmcf_m.htm

[11] EIA Monthly Energy Review. Table A4 - Approximate Heat Content of Natural Gas (Btu per Cubic Feet).

facilities in subpart W are defined as a unique combination of operator and basin of operation, a natural gas processing facility in subpart W is each unique processing plant, a natural gas transmission compression facility in subpart W is each unique transmission compressor station, an underground natural gas storage facility in subpart W is the collection of subsurface storage and processes and above ground wellheads, an LNG storage facility in subpart W is the collection of storage vessels and related equipment, and an LNG import and export facility in subpart W is the collection of equipment that handles LNG received from or transported via ocean transportation. Facilities in the above-mentioned industry segments that meet the subpart W reporting threshold have been reporting since 2011; currently, five years of subpart W reporting data are publicly available, covering reporting year (RY) 2011 through RY2015.[12]

Subpart W activity and emissions data are used in the current GHGI to calculate CH_4 emissions for several production, processing, and transmission and storage sources. CO_2 emissions data from subpart W have not yet been incorporated into the GHGI. However, facilities use an identical reporting structure for CO_2 and CH_4. Therefore, where subpart W CH_4 data have been used, the CO_2 data may be incorporated in a parallel manner. The 2014 HF Completion and Workover memo, 2016 Transmission memo, 2016 Production memo, 2017 Production memo, and 2017 Processing memo discuss in greater detail the subpart W data available for those sources.

EPA is also considering GHGI revisions to use subpart W data for CO_2 emission estimates from miscellaneous production flaring, acid gas removal (AGR) vents, and transmission and storage station flares—sources for which the emissions are not currently calculated with subpart W data in the GHGI.

Production segment flare emissions are only reported under the "flare stacks" emission source in subpart W if the flare emissions originate from sources not otherwise covered by subpart W—this emission source is referred to as "miscellaneous flaring" for purposes of this memo. Therefore, the subpart W production flares data do not duplicate flaring emissions reported, for example, under production tank flaring or associated gas flaring. It also ensures all production flaring emissions are reported for facilities that meet the reporting threshold. Flare emissions are calculated using a continuous flow measurement device or engineering calculations, the gas composition, and the flare combustion efficiency. A default flare combustion efficiency of 98% may be applied, if manufacturer data are not available.

Under subpart W, gas processing facilities calculate AGR unit CO_2 emissions using one of four methods: (1) CO_2 CEMS; (2) a vent stream flow meter with CO_2 composition data; (3) calculation using an equation with the inlet or outlet natural gas flow rate and measured inlet and outlet CO_2 composition data; or (4) simulation software (e.g., AspenTech HYSYS or API 4679 AMINECalc). CH_4 emissions for AGR units are not reported in subpart W.

Transmission, underground natural gas storage, LNG storage, and LNG import stations report emissions from all flaring under the "flare stacks" emission source as of RY2015. Prior to that, flare emissions reported under subpart W were included in the reported emissions for the specific source (e.g., reciprocating or centrifugal compressor). Flare emissions are calculated in subpart W using a continuous flow measurement device or engineering calculations, the gas composition, and the flare combustion efficiency. A default flare combustion efficiency of 98% may be applied, if manufacturer data are not available.

[12] The GHGRP subpart W data used in the analyses discussed in this memo are those reported to the EPA as of August 13, 2016.

3. Revisions Under Consideration

For purposes of this memo, EPA calculated preliminary CO_2 EFs using data from the same subpart W reporting years (RY) as were used when developing CH_4 EFs for the 2017 GHGI. While there is an existing methodology for associated gas venting and flaring, the EPA is considering revisions to the methodology for both CO_2 and CH_4 emissions from this source, based on initial stakeholder feedback.

In addition, the EPA is considering updating the GHGI to incorporate subpart W data for CO_2 from AGR units, and both the CO_2 emissions and the relatively minor CH_4 emissions from flare stacks.

3.1 Production CO_2 Emission Factors

The EPA developed preliminary CO_2 EFs for associated gas venting and flaring, oil and condensate tanks, gas well hydraulically fractured completions and workovers, pneumatic controllers, pneumatic pumps, and liquids unloading in the natural gas and petroleum production segments. The CH_4 EFs for these sources were recently revised using subpart W data, and EPA applied the same methodology to calculate CO_2 EFs. A brief summary of the existing methodology and the resulting CO_2 EFs are provided below for each source. The EPA is also considering a CO_2 emissions calculation methodology for miscellaneous production flaring, which is described below.

3.1.1 Associated Gas Venting and Flaring

The EPA has assessed data to identify an approach that best represents national associated gas venting and flaring emissions. The first analysis described below relies on national-level EFs and AFs and was implemented in the 2017 GHGI to calculate CH_4 emissions; the second analysis applies NEMS region-level EFs and AFs.

Stakeholders commented that national-level EFs and AFs in the previous draft of this memo would not take into account differences in associated gas venting and flaring among geographic regions. In particular, over- or under-representation in GHGRP data by geographic regions where associated gas is vented or flared more or less frequently may disproportionately contribute to national-level factors. In response to the stakeholder comments, the EPA has assessed scaled up GHGRP data at a more disaggregated level (NEMS region-level) to assess where certain geographic regions might exhibit notably different dynamics from the rest of the U.S., and whether such regions are disproportionally represented in the subpart W data.

From RY2015 forward, associated gas data are reported to GHGRP at a county level; in earlier years, these data were collected at a basin level only. Basin borders cross state boundaries and NEMS region boundaries; therefore, basin-level data cannot be readily assigned to specific NEMS regions. The analyses presented in this memo focus on RY2015 and RY2016 data.[13] Based on recent stakeholder feedback, the EPA is also considering analyzing data at a more granular level (e.g., state-level or basin-level), which would necessitate further considerations regarding data representativeness and subsequent potential re-aggregation (e.g., for states or basins that have relatively little reported data, or may not be representative).

The analyses conducted for each approach are summarized below, and discussed at the end of section 3.1.1. Note, the EPA used the subpart W well counts reported under the introduction section (40 CFR 98.236(aa)) and not the well counts reported under the equipment leaks section (40 CFR 98.233(r)). The introduction section well counts are reported at a sub-basin level, whereas the equipment leak well counts are provided only at a basin level; sub-basin-level data allow the EPA to determine NEMS region-level well counts.

[13] The GHGRP subpart W RY2011–2014 data presented in this memo were reported to the EPA as of August 13, 2016. The RY2015 and RY2016 data used for the alternate associated gas venting and flaring analyses were reported to the EPA as of August 5, 2017.

National-Level Approach

Based on the CH_4 EF methodology documented in the 2017 Production memo, the EPA calculated oil well associated gas venting and flaring CO_2 EFs using subpart W data for RY2011 through RY2015. The EPA divided the reported associated gas flaring or venting emissions by the number of reported wells with associated gas venting or flaring for each year to calculate EFs. Subpart W CO_2 data are presented in Table 2, and the calculated CO_2 EFs are presented in Table 3.

Table 2. GHGRP Subpart W CO_2 Data for Associated Gas Venting and Flaring

Year	Associated Gas Venting		Associated Gas Flaring	
	#Venting Wells	Venting CO_2 Emissions (MMT)	#Flaring Wells	Flaring CO_2 Emissions (MMT)
2011	8,863	0.012	5,628	3.72
2012	8,554	0.016	7,259	6.88
2013	6,980	0.005	8,880	9.61
2014	7,264	0.013	12,189	11.05
2015	4,286	0.011	21,773	11.12
2016	3,249	0.005	27,412	7.31

Table 3. GHGRP Subpart W-based National Average Associated Gas Venting and Flaring CO_2 EFs (kg/well/yr)

Year	Venting EF	Flaring EF
2011	1,336	661,723
2012	1,902	948,057
2013	773	1,081,842
2014	1,754	906,608
2015	2,674	510,909
2016	1,590	266,751

The activity data used for the CH_4 methodology in the 2017 GHGI relies on two components, which are provided for comparison to the alternate approaches discussed below. First, EPA calculated that 12% of all oil wells vent or flare associated gas based on RY2015 subpart W data; this activity factor was applied for all years of the time series through RY2015. For RY2016, 15% of oil wells vent or flare associated gas. Second, those wells that vent or flare associated gas were split into specific fractions that vent and flare associated gas using year-specific subpart W data; these data are presented in Table 4. The increase in flaring prevalence is generally consistent with industry trends due to regulatory and voluntary actions. National total emissions are presented in Table 5.

Table 4. GHGRP Subpart W-based National-Level AFs (for split between venting and flaring) for Oil Wells with Associated Gas Venting and Flaring

Year	% that Vent	% that Flare
2011	61%	39%
2012	54%	46%
2013	44%	56%
2014	37%	63%
2015	16%	84%

Table 5. National Emissions Estimates using National AF and EF Approach (mt)

Year	Total CO_2	Total CH_4
2015	31,047,074	148,280
2016	20,245,701	98,547

NEMS Region-Level Approach

EPA also evaluated associated gas venting and flaring data at the NEMS region level. The EPA grouped the data into the six NEMS regions and calculated EFs and AFs using subpart W RY2015 and RY2016 data, following the same general methodology as presented above for the national-level analysis.

Table 6 and Table 7 summarize reported data at the NEMS region level for RY2015 and RY2016, respectively. There is a range of reporting coverage and associated gas emissions across the NEMS regions. For example, for RY2016, subpart W oil well coverage in the Rocky Mountain, Southwest, and West Coast regions is over 50%. Coverage of oil wells for the Midcontinent and North East regions are 8% and 7%, respectively. In the Rocky Mountain, Southwest, and West Coast regions, overall, 17% of oil wells have associated gas venting and flaring, while the overall rate of associated gas venting and flaring in the remaining regions is around 8%.

Table 6. NEMS Region-Level Oil Well and Associated Gas Venting and Flaring Overview – RY2015

NEMS Region	National Data		Subpart W Data							
	# Oil Wells	% of Total Natl. Oil Wells	# Reported Oil Wells	% of Total Subpart W Oil Wells	% of NEMS Oil Wells Reported in Subpart W	# Assoc. Gas Venting & Flaring Wells	% of Assoc. Gas Venting & Flaring Wells	CO_2 Emissions (mt)	CH_4 Emissions (mt)	% of Total Reported Mass Emissions
Gulf Coast	87,516	15%	23,152	11%	26%	1,853	7%	679,082	4,463	6%
Midcontinent	148,339	25%	16,110	8%	11%	599	2%	179,330	4,643	2%
North East	65,196	11%	4,620	2%	7%	261	1%	102,873	1,405	1%
Rocky Mountain	66,573	11%	29,933	14%	45%	12,940	50%	8,076,358	27,265	72%
South West	167,767	28%	92,655	44%	55%	9,627	37%	2,097,570	14,024	19%
West Coast	54,626	9%	45,148	21%	83%	779	3%	261	1,382	0%
TOTAL	**590,017**	**100%**	**211,618**	**100%**	**36%**	**26,059**	**100%**	**11,135,475**	**53,183**	**100%**

Table 7. NEMS Region-Level Oil Well and Associated Gas Venting and Flaring Overview – RY2016

NEMS Region	National Data		Subpart W Data							
	# Oil Wells	% of Total Natl. Oil Wells	# Reported Oil Wells	% of Total Subpart W Oil Wells	% of NEMS Oil Wells Reported in Subpart W	# Assoc. Gas Venting & Flaring Wells	% of Assoc. Gas Venting & Flaring Wells	CO_2 Emissions (mt)	CH_4 Emissions (mt)	% of Total Reported Mass Emissions
Gulf Coast	83,057	15%	21,349	10%	26%	1,812	6%	396,459	4,030	5%
Midcontinent	139,428	25%	11,712	6%	8%	787	3%	7,038	2,159	0%
North East	64,431	11%	4,800	2%	7%	351	1%	73,964	937	1%
Rocky Mountain	63,508	11%	31,438	15%	50%	12,655	41%	5,148,040	16,865	70%
South West	160,208	29%	90,507	44%	56%	14,723	48%	1,691,801	11,111	23%
West Coast	51,332	9%	44,927	22%	88%	333	1%	52	298	0%
TOTAL	**561,964**	**100%**	**204,733**	**100%**	**36%**	**30,661**	**100%**	**7,317,354**	**35,400**	**100%**

Table 8 provides the venting and flaring EFs for each NEMS region. Table 9 presents the percent of oil wells that flare or vent associated gas and, for those wells that vent or flare associated gas, the specific fractions that vent and flare. The resulting year 2015 and 2016 total emissions for each NEMS region are shown in Table 10. Figure 1 illustrates the total estimated CO_2 emissions by NEMS region.

Table 8. GHGRP Subpart W Associated Gas Venting and Flaring EFs for Each NEMS Region (kg/well/yr)

NEMS Region	Venting CO_2 EF	Venting CH_4 EF	Flaring CO_2 EF	Flaring CH_4 EF
RY2015				
Gulf Coast	25,527	4,631	438,186	1,941
Midcontinent	256	7,981	1,659,300	6,707
North East	139	6,981	598,028	4,559
Rocky Mountain	825	12,070	634,770	1,937
South West	1,118	2,441	289,550	1,131
West Coast	321	1,783	3,053	23
RY2016				
Gulf Coast	10,648	5,725	285,149	1,108
Midcontinent	91	4,230	24,794	82
North East	166	5,285	337,635	1,094
Rocky Mountain	848	12,198	413,185	1,162
South West	132	2,641	129,346	517
West Coast	156	895	-- (a)	-- (a)

a. Associated gas flaring data were not reported for the West Coast region.

Table 9. GHGRP Subpart W Associated Gas Venting and Flaring Activity Data and AFs for Each NEMS Region

NEMS Region	Total Oil Wells	# Venting & Flaring Wells	% of Total that Vent or Flare	% that Vent	% that Flare
RY2015					
Gulf Coast	23,152	1,853	8%	17%	83%
Midcontinent	16,110	599	4%	82%	18%
North East	4,620	261	6%	34%	66%
Rocky Mountain	29,933	12,940	43%	2%	98%
South West	92,655	9,627	10%	25%	75%
West Coast	45,148	779	2%	99%	1%
RY2016					
Gulf Coast	21,349	1,812	8%	24%	76%
Midcontinent	11,712	787	7%	64%	36%
North East	4,800	351	7%	38%	62%
Rocky Mountain	31,438	12,655	40%	2%	98%
South West	90,507	14,723	16%	11%	89%
West Coast	44,927	333	1%	100%	0%

Table 10. Estimated Total Associated Gas Venting and Flaring Emissions for Each NEMS Region (mt)

NEMS Region	2015		2016	
	CO_2	CH_4	CO_2	CH_4
Gulf Coast	2,566,972	16,870	1,542,401	15,677
Midcontinent	1,651,250	42,754	83,785	25,705
North East	1,451,714	19,833	992,829	12,581
Rocky Mountain	17,962,363	60,640	10,399,571	34,069
South West	3,797,993	25,392	2,994,686	19,668
West Coast	316	1,672	0	0
NEMS Region-Level Approach National Total	**27,430,609**	**167,162**	**16,013,331**	**108,039**

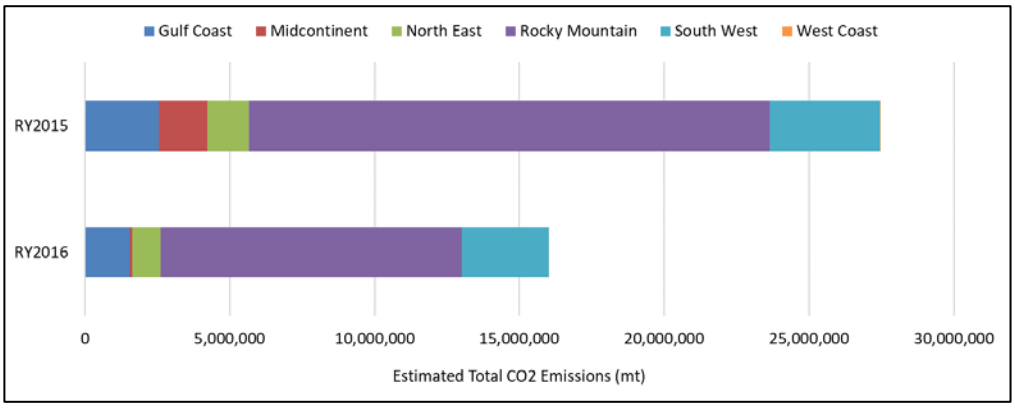

Figure 1. Estimated Total CO_2 Emissions by NEMS Region Scaling Approach

Discussion of Approaches under Consideration

Table 11 and Figure 2 below compare total national emissions calculated using the national-level versus the NEMS region-level methodology

The NEMS region-level analysis was conducted to address a potential issue of certain geographic regions having unique operational practices and being over or underrepresented in subpart W, leading to a disproportionate impact on calculated national-level EFs and AFs. For CO_2 emissions, in 2016, the NEMS region approach results in 21% lower emissions than the national-level approach. For CH_4 emissions, in 2016, the NEMS region approach resulted in 10% higher emissions than the national approach.

The EPA requests feedback on the approaches under consideration in Section 5.

Table 11. Comparison of National CO_2 and CH_4 Emissions (mt)

Year	National-Level Approach		NEMS Region-Level Approach	
	Total CO_2	Total CH_4	Total CO_2	Total CH_4
2015	31,047,074	148,280	27,430,609	167,162
2016	20,245,701	98,547	16,013,331	108,039

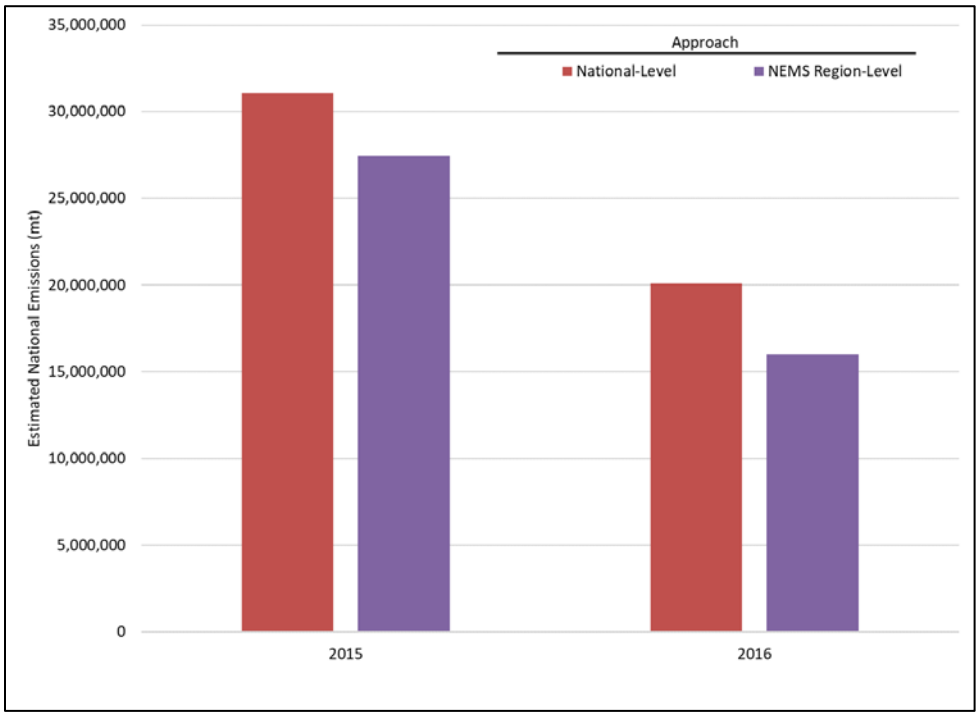

Figure 2. Estimated National CO_2 Emissions by Various Approaches

Stakeholders have suggested additional methods, including scaling up at the basin-level, and using production data rather than well counts. EPA is assessing these options.

3.1.2 Production Tanks

Based on the CH_4 EF methodology documented in the 2017 Production memo, the EPA calculated oil and condensate tank CO_2 EFs for several tank categories, using RY2015 subpart W data: large tanks with flaring; large tanks with a vapor recovery unit (VRU); large tanks without controls; small tanks with flaring; small tanks without flaring; and malfunctioning separator dump valves. EPA applied several steps described in the 2017 Production memo to apportion the reported subpart W data to each of the categories. EPA then summed the emissions and divided by the throughput for each tank category. Table 12 presents the resulting CO_2 EFs.

Table 12. GHGRP Subpart W-based Oil and Condensate Tank CO_2 EFs (kg/bbl/yr)

Tank Category	Oil Tanks EF	Condensate Tanks EF
Large Tanks with Flaring	7.16	8.44
Large Tanks with VRU	0.040	0.12
Large Tanks without Controls	0.016	0.020
Small Tanks with Flaring	0.26	1.95
Small Tanks without Flares	0.078	0.28
Malfunctioning Dump Valves	0.013	8.28E-05

3.1.3 HF Gas Well Completions and Workovers

Based on the CH_4 EF methodology documented in the 2014 HF Completion and Workover memo and 2015 HF Completion and Workover memo, the EPA calculated CO_2 EFs for four categories of HF gas well completions and workovers, using RY2011-RY2013 subpart W data: HF gas well completions and workovers that vent; flared HF gas well completions and workovers; HF gas well completions and workovers with reduced emissions completions (RECs); and HF gas well completions and workovers with RECs that flare. Average emissions per completion and workover were calculated for each category by summing the emissions in each category and dividing by the

number of completions and workovers in each category using facility-level records that could be assigned to a single unambiguous category. Table 13 presents the subpart W activity and emissions data for those HF gas well completions and workovers that could be assigned to a specific category, along with the calculated CO_2 EFs.

Table 13. GHGRP Subpart W Activity and Emissions Data and Calculated EFs for HF Gas Well Completions and Workovers

Category	# of Events			CO_2 Emissions (mt)			CO_2 EF (kg/event)
	2011	2012	2013	2011	2012	2013	
HF Completions and Workovers that Vent	3,901	2,370	1,308	11,700	2,681	7,214	**2,849**
Flared HF Completions and Workovers	1,171	538	422	1,203,235	363,631	192,235	**825,481**
HF Completions and Workovers with RECs	2,224	1,283	1,566	3,745	151	995	**964**
HF Completions and Workovers with RECs that Flare	818	968	1,129	485,313	387,280	460,691	**457,387**

3.1.4 Pneumatic Controllers

Based on the CH_4 EF methodology documented in the 2016 Production memo, the EPA calculated pneumatic controller CO_2 EFs for low, intermittent, and high bleed controllers using Subpart W RY2014 data. EPA divided the reported emissions by the number of reported controllers for each controller type to calculate EFs. All pneumatic controllers data were considered together, and thus pneumatic controller EFs for natural gas and petroleum systems are identical. Table 14 presents the subpart W activity and emissions data, along with the calculated CO_2 EFs.

Table 14. GHGRP Subpart W RY2014 Activity and Emissions Data and Calculated EFs for Pneumatic Controllers

Controller Type	# Controllers	Total CO_2 Emissions (mt)	CO_2 EF (kg/controller/yr)
Low Bleed	200,337	2,391	**12**
Intermittent Bleed	572,407	98,393	**172**
High Bleed	29,567	10,013	**339**

3.1.5 Pneumatic Pumps

Based on the CH_4 EF methodology documented in the 2016 Production memo, the EPA calculated a pneumatic pump CO_2 EF using Subpart W RY2014 data. EPA divided the reported emissions by the number of reported pneumatic pumps to calculate the EF. All pneumatic pumps data were considered together, and thus the EF for natural gas and petroleum systems is identical. Table 15 presents the subpart W activity and emissions data, along with the calculated CO_2 EF.

Table 15. GHGRP Subpart W RY2014 Activity and Emissions Data and Calculated EF for Pneumatic Pumps

# Pumps	Total CO_2 Emissions (mt)	CO_2 EF (kg/pump/yr)
79,885	11,650	**146**

3.1.6 Liquids Unloading

Based on the CH_4 EF methodology documented in the 2017 Production memo, the EPA calculated liquids unloading CO_2 EFs using Subpart W RY2011-RY2015 data. Separate EFs were calculated for liquids unloading activities that vent with and without plunger lifts. The EPA calculated an average EF by summing the emissions

reported in each category for RY2011-RY2015 and dividing by the total number of wells in each category over those years. Table 16 presents the subpart W activity and emissions data, along with the calculated CO_2 EFs.

Table 16. GHGRP Subpart W RY2011-RY2015 Activity and Emissions Data and Calculated EFs for Liquids Unloading

Year	With Plunger Lifts		Without Plunger Lifts	
	CO_2 Emissions (mt)	# Wells Vented	CO_2 Emissions (mt)	# Wells Vented
2011	17,671	42,826	20,294	26,679
2012	18,869	34,136	26,300	25,262
2013	4,233	30,922	5,617	27,723
2014	2,430	26,859	5,113	23,068
2015	1,782	30,757	3,348	20,886
Total	**44,985**	**165,500**	**60,673**	**123,618**
EF (kg CO_2/well/yr)	***272***		***491***	

3.1.7 Miscellaneous Production Flaring

The EPA is considering the use of subpart W RY 2015 miscellaneous production flaring (reported under "flare stacks") emissions data to revise the GHGI and more fully account for flare emissions in the production segment. Subpart W data for this source were not previously considered. The EPA calculated the CO_2 and CH_4 EFs using the following approach.

Miscellaneous production flaring emissions are not reported separately for gas and oil production. Therefore, to use reported emissions data for separate natural gas and petroleum systems GHGI estimates, the EPA calculated the fraction of wells that were gas and oil wells for each facility, using the well counts reported in the Equipment Leaks section of subpart W for RY2015.[14] The EPA then apportioned each facility's reported miscellaneous flaring CO_2 and CH_4 emissions by production type. The EPA summed the facility-level CO_2 and CH_4 emissions for each production type to estimate total reported miscellaneous flaring CO_2 and CH_4 emissions from natural gas and oil production. The EPA then divided the reported CO_2 and CH_4 emissions for natural gas and oil production by total reported gas wells and oil wells, respectively. These emissions data, well counts, and calculated EFs are provided in Table 17 and Table 18 below. To calculate national emissions, the EFs would be multiplied by the national gas and oil well counts already estimated in the GHGI.

Table 17. GHGRP Subpart W RY2015 CO_2 Emissions and Activity Data and Calculated EFs for Miscellaneous Production Flaring

Total CO_2 Emissions (mt)	Natural Gas Production			Oil Production		
	CO_2 Emissions (mt)	Total Gas Wells	CO_2 EF (kg/well/yr)	CO_2 Emissions (mt)	Total Oil Wells	CO_2 EF (kg/well/yr)
3,779,110	1,299,672	307,737	**4,223**	2,479,438	219,433	**11,299**

Table 18. GHGRP Subpart W RY2015 CH_4 Emissions and Activity Data and Calculated EFs for Miscellaneous Production Flaring

	Natural Gas Production	Oil Production

[14] RY2015 is the first year in which total oil and gas well counts are reported. However, six facilities did not report these data. Therefore, for these six facilities, the EPA determined the fraction of sub-basins applicable to gas production (i.e., sub-basins with *high permeability gas*, *shale gas*, *coal seam,* or *other tight reservoir rock* formation types) and oil production (i.e., sub-basins with the *oil* formation type).

Total CH_4 Emissions (mt)	CH_4 Emissions (mt)	Total Gas Wells	CH_4 EF (kg/well/yr)	CH_4 Emissions (mt)	Total Oil Wells	CH_4 EF (kg/well/yr)
14,058	5,443	307,737	**17.7**	8,614	219,433	**39.3**

3.2 Processing CO_2 Emission Factors

The EPA developed preliminary gas processing CO_2 EFs for the plant grouped emission sources (reciprocating compressors, centrifugal compressors with wet seals, centrifugal compressors with dry seals, dehydrators, flares, and plant fugitives), blowdowns and venting, and AGR vents. The CH_4 EFs for the grouped sources and blowdowns and venting were recently revised using subpart W data, and the EPA applied the same methodology to calculate CO_2 EFs. While AGR vent emissions are not currently calculated from subpart W data (as CH_4 emissions are not reported for this source), the EPA has calculated a subpart W-based EF and determined the corresponding activity data for this source.

Based on the CH_4 EF methodology documented in the 2017 Processing memo, the EPA calculated the plant grouped source CO_2 EFs using subpart W RY2015 data (the purpose of the plant grouped EF is discussed in Section 3.4). Subpart W data and calculated CO_2 EFs for the plant grouped sources are presented in Table 19.

Table 19. GHGRP Subpart W RY2015 Emissions and Activity Data and Calculated EFs for Gas Processing Plant Grouped Sources

Emission Source	CO_2 Emissions (mt)	Activity Count (plants or compressors)		CO_2 EF (kg/compressor/yr or kg/plant/yr)
Reciprocating compressors	7,818	2,662	compressors	2,937
Centrifugal compressors with wet seals	1,259	264	compressors	4,768
Centrifugal compressors with dry seals	20	214	compressors	400
Dehydrators	7,433	467	plants	15,916
Flares	4,503,224	467	plants	9,642,878
Plant fugitives	2,291	467	plants	4,906
Plant Grouped Sources	**4,522,046**	**467**	**plants**	**9,683,181**

Based on the CH_4 EF methodology documented in the 2017 Processing memo, the EPA also calculated the blowdown and venting CO_2 EF using subpart W RY2015 data. Subpart W data and the calculated CO_2 EF for blowdowns and venting are presented in Table 20.

Table 20. GHGRP Subpart W RY2015 Emissions and Activity Data and Calculated EF for Gas Processing Blowdown and Venting

CO2 Emissions (mt)	Activity Count (plants)	CO_2 EF (kg/plant/yr)
11,084	467	**23,733**

For AGR vent emissions, the existing CH_4 EF methodology does not rely on subpart W, but the EPA is considering applying a similar methodology as the other processing sources to develop CO_2 EFs and activity data from subpart W data. The EPA summed the reported AGR vent CO_2 emissions for gas processing plants and divided by the total reported count of plants for each RY from 2011 to 2015 to calculate CO_2 EFs. Note, the current GHGI methodologies for gas processing segment sources that use subpart W-based CH_4 EFs rely on RY2015 only. To calculate national CO_2 emissions, the CO_2 EF would be multiplied by the number of gas plants each year. Subpart W data and the calculated CO_2 EFs for AGR vents are presented in Table 21.

Table 21. GHGRP Subpart W RY2015 Emissions and Activity Data and Calculated EF for Gas Processing AGR Vents

Year	CO_2 Emissions (mt)	Activity Count (plants)	CO_2 EF (kg/plant/yr)
2011	16,093,040	374	**43,029,519**
2012	15,692,240	403	**38,938,561**
2013	13,201,139	438	**30,139,587**
2014	12,559,555	479	**26,220,366**
2015	10,048,285	467	**21,516,669**

3.3 Transmission and Storage CO_2 Emission Factors

3.3.1 Pneumatic Controllers

Based on the CH_4 EF methodology documented in the 2016 Transmission memo, the EPA calculated transmission station and storage station pneumatic controller CO_2 EFs for low, intermittent, and high bleed controllers using Subpart W RY2011 - RY2015 data. The EPA divided the reported emissions by the number of reported controllers for each controller type to calculate EFs. Table 22 and Table 23 present the subpart W activity and emissions data, along with the calculated CO_2 EFs.

Table 22. GHGRP Subpart W Activity and Emissions Data and Calculated EFs for Transmission Station Pneumatic Controllers

Controller Type	Data Element	2011	2012	2013	2014	2015
High Bleed	Total Count	2,203	1,114	1,158	1,173	1,483
	CO_2 Emissions (mt)	203	106	106	107	120
	CO_2 EF (kg/controller/yr)	**92**	**95**	**91**	**91**	**81**
Intermittent Bleed	Total Count	8,343	9,114	9,903	11,141	10,857
	CO_2 Emissions (mt)	673	736	747	134	103
	CO_2 EF (kg/controller/yr)	**81**	**81**	**75**	**12**	**10**
Low Bleed	Total Count	644	880	857	1,078	1,032
	CO_2 Emissions (mt)	4.6	6.2	6.2	6.7	4.3
	CO_2 EF (kg/controller/yr)	**7.1**	**7.0**	**7.3**	**6.2**	**4.2**

Table 23. GHGRP Subpart W Activity and Emissions Data and Calculated EFs for Underground Natural Gas Storage Station Pneumatic Controllers

Controller Type	Data Element	2011	2012	2013	2014	2015
High Bleed	Total Count	1,253	1,100	1,089	1,271	1,024
	CO_2 Emissions (mt)	116	118	116	117	64
	CO_2 EF (kg/controller/yr)	**92**	**107**	**106**	**92**	**63**
Intermittent Bleed	Total Count	1,391	1,539	1,601	2,045	2,098
	CO_2 Emissions (mt)	16	21	21	24	22
	CO_2 EF (kg/controller/yr)	**12**	**13**	**13**	**12**	**10**
Low Bleed	Total Count	250	319	366	319	320
	CO_2 Emissions (mt)	1.9	2.4	2.8	2.2	1.4
	CO_2 EF (kg/controller/yr)	**7.5**	**7.4**	**7.6**	**7.0**	**4.4**

3.3.2 Flares

The EPA is considering developing updated GHGI flare CO_2 EFs for transmission station, underground natural gas storage, LNG storage, and LNG import stations using subpart W data. As discussed in Section 1.3, the GHGI CO_2 emissions calculation methodology does not calculate CO_2 emissions from flares. Therefore, the EPA is considering supplementing the current methodology to calculate CO_2 emissions with new line items for station flares.

The EPA divided the reported flare CO_2 and CH_4 emissions by the number of reported stations for RY2015 to calculate the EFs. Subpart W transmission station, underground natural gas storage, LNG storage, and LNG import station flare data are presented in Table 24 through Table 27. The applicable activity data to calculate national emissions are the national number of stations, which are already calculated in the GHGI.

Stakeholders suggested that EPA include additional explanation in the 2018 GHGI on the use of flares and transmission compression at underground storage facilities compared to transmission compressor stations, to put the emissions in context.

Table 24. GHGRP Subpart W RY2015 Emissions and Activity Data and Calculated EFs for Transmission Station Flares

Total # Stations	# Stations With Flares	# Flares	Total CO_2 Emissions (mt)	CO_2 EF (kg/station/yr)	Total CH_4 Emissions (mt)	CH_4 EF (kg/station/yr)
521	16	24	28,511	54,723	124	238

Table 25. GHGRP Subpart W RY2015 Emissions and Activity Data and Calculated EFs for Underground Natural Gas Storage Flares

Total # Stations	# Stations With Flares	# Flares	Total CO_2 Emissions (mt)	CO_2 EF (kg/station/yr)	Total CH_4 Emissions (mt)	CH_4 EF (kg/station/yr)
53	8	21	3,576	67,479	34	650

Table 26. GHGRP Subpart W RY2015 Emissions and Activity Data and Calculated EFs for LNG Storage Flares

Total # Stations	# Stations With Flares	# Flares	Total CO_2 Emissions (mt)	CO_2 EF (kg/station/yr)	Total CH_4 Emissions (mt)	CH_4 EF (kg/station/yr)
7	2	2	259	37,042	1.9	266

Table 27. GHGRP Subpart W RY2015 Emissions and Activity Data and Calculated EFs for LNG Import Flares

Total # Stations	# Stations With Flares	# Flares	Total CO_2 Emissions (mt)	CO_2 EF (kg/station/yr)	Total CH_4 Emissions (mt)	CH_4 EF (kg/station/yr)
7	2	3	77,420	11,059,970	268	38,238

3.4 Time Series Considerations

For the production segment sources discussed in Section 3.1, in general, the EPA would apply the same methodology to calculate CO_2 over the time series as used for calculating CH_4 emissions over the time series.[15] For oil and condensate tanks, the EPA applies category-specific EFs for every year of the time series; for liquids unloading, the average 2011-2015 EFs developed from subpart W data are applied to each year of the time series;

[15] Additional details on current time series calculations for production segment sources are provided in the 2014 HF Completion and Workover memo, 2015 HF Completion and Workover memo, 2016 Production memo, and 2017 Production memo.

for pneumatic controllers and pumps, category-specific EFs are applied for each year of the time series; and for HF gas well completions and workovers, category-specific EFs are applied for each year of the time series.

For associated gas venting and flaring, for CH_4, the EPA currently applies the subpart W 2011 EFs for years prior to 2011 and year-specific subpart W EFs are applied for 2011 and forward. Depending on the approach implemented in the 2018 GHGI for associated gas venting and flaring CO_2, the EPA may maintain this approach for CH_4 and CO_2, or apply subpart W 2015 EFs for years prior to 2015 and year-specific subpart W EFs for 2015 and forward.

For the production miscellaneous flaring time series, the current GHGI flare emission estimate (representing both production and processing), fluctuates based on activity data (EIA's estimated annual vented and flared volumes). Assessment of subpart W CO_2 data over the time series for this source indicates that miscellaneous flaring emissions per well do not show a clear trend. See the Requests for Stakeholder Feedback section for more information. In a revised approach to use subpart W-based CO_2 EFs (kg/well), the EF could be held constant for each year and flare emission estimates would fluctuate with active gas or oil well count over the time series.

For certain processing sources discussed in Section 3.1, the EPA would apply the same methodology to calculate CO_2 over the time series as used for calculating CH_4 emissions over the time series.[16] For plant grouped emission sources and blowdowns and venting, GRI/EPA 1996 EFs are used for 1990 through 1992; EFs calculated from subpart W are used for 2011 forward; and EFs for 1993 through 2010 are developed through linear interpolation. For CO_2 from AGR vents, the EPA is considering adopting a similar methodology as the other processing sources (maintain the current GRI/EPA 1996 EFs for 1990 through 1992, apply the subpart W-based EFs for 2011 forward, and develop EFs for 1993 through 2010 using linear interpolation).

For transmission and storage flares, the EPA is evaluating the prevalence of flares over the 1990–2016 time series. The EPA is considering applying a subpart W-based EF (kg/station) for all years of the time series. However, few transmission and storage stations reported flares for RY2015 (see Table 24 through Table 27). Therefore, the EPA might alternatively assume that flares did not operate in 1990 (i.e., an EF of 0), apply the subpart W-based EF for 2011 forward, and apply linear interpolation from 1991 through 2010.

4. National Emissions Estimates

The EPA calculated national CO_2 emissions using each of the subpart W-based approaches discussed in Section 3 in conjunction with activity data for year 2015 from the 2017 GHGI. These emissions are compared against 2015 emissions from the 2017 GHGI in Table 28 and Table 29. The EPA also calculated national CO_2 emissions for each year of the time series using each of the subpart W-based approaches discussed in Section 3 in conjunction with activity data from the 2017 GHGI; see Appendix B.

Table 28. Natural Gas Systems Estimated Year 2015 National CO_2 Emissions (mt) Using Subpart W-based EFs Compared to 2017 GHGI

Industry Segment and Emission Source	2017 GHGI	Scaled Up Subpart W (Draft Update)
Production	***18,585,048***	***4,886,152***
Tanks	**30,426**	**1,108,346**
Large Tanks w/Flares		1,059,701
Large Tanks w/VRU		2,840
Large Tanks w/o Control		632
Small Tanks w/Flares		35,173

[16] Additional details on current time series calculations are provided in the 2017 Processing memo.

Industry Segment and Emission Source	2017 GHGI	Scaled Up Subpart W (Draft Update)
Small Tanks w/o Flares		9,984
Malfunctioning Separator Dump Valves		15
Miscellaneous Flaring (a)	**17,628,522**	**1,860,355**
Gas HF Completions/Workovers	**91,965**	**1,129,883**
Non-REC with Venting		397
Non-REC with Flaring		281,489
REC with Venting		3,203
REC with Flaring		844,794
Liquids Unloading	**39,485**	**9,282**
w/Plunger Lifts	13,780	4,169
w/o Plunger Lifts	25,705	5,112
Pneumatic Controllers	**119,970**	**109,857**
Low-Bleed		2,252
Intermittent Bleed		100,265
High-Bleed		7,339
Pneumatic Pumps	**14,021**	**7,770**
Other Production Sources (b)	**660,659**	**660,659**
Processing	***23,712,956***	***20,826,478***
AGR Vents	23,643,456	14,351,618
Plant Grouped Sources	63,662	6,458,775
Blowdowns/Venting	5,586	15,830
Pneumatics	250	255
Transmission & Storage	***38,694***	***250,095***
Transmission Flares	0	100,357
Underground Storage Flares	0	23,542
LNG Storage Flares	0	2,603
LNG Import Flares	0	85,162
Pneumatic Controllers	1,649	1,386
Other Transmission & Storage Sources (b)	37,045	37,045
Distribution (b)	***13,988***	***13,988***
Natural Gas Systems Total	**42,350,685**	**25,976,714**

a. Also represents flaring from petroleum production and gas processing.
b. Set 2018 GHGI value equal to 2017 GHGI value.

Table 29. Petroleum Systems Estimated Year 2015 National CO_2 Emissions (mt) Using Subpart W-based EFs Compared to Current GHGI

Industry Segment and Emission Source	2017 GHGI	Scaled Up Subpart W (Draft Update)
Production	***640,443***	***46,668,513***
Tanks	**519,934**	**8,643,876**
Large Tanks w/Flares		8,576,672
Large Tanks w/VRU		17,229
Large Tanks w/o Control		5,928
Small Tanks w/Flares		10,581
Small Tanks w/o Flares		8,271
Malfunctioning Separator Dump Valves		25,194
Miscellaneous Flaring	**incl. w/NG**	**6,864,989**
Associated Gas (a,b)	**826**	**31,047,074**
Flaring		31,015,120
Venting		31,954
Pneumatic Controllers	**87,576**	**79,608**
Low-Bleed	2,697	1,842
Intermittent Bleed	74,341	71,177
High-Bleed	10,538	6,589
Pneumatic Pumps	**10,779**	**11,639**
Other Production Sources (c)	**21,327**	**21,327**
Refining (c)	***2,926,666***	***2,926,666***
Petroleum Systems Total	**3,567,110**	**49,595,179**

a. 2017 GHGI is estimate for stripper well venting.
b. Scaled Up Subpart W emissions in this table represent the national-level approach. Section 3.1.1 also discusses the NEMS region approach under consideration. The NEMS region approach results in 27,430,609 tons CO_2 from associated gas venting and flaring, which would result in a national total CO_2 emission estimate of 45,978,714 tons CO_2.
c. Set draft 2018 GHGI value for 2015 equal to 2017 GHGI value for 2015.

The CO_2 revisions under consideration will result in an overall shift of CO_2 emissions from Natural Gas systems to Petroleum systems. This is due to the availability of industry segment-specific and emission source-specific data in subpart W, whereas previous data sources were not as granular. The current GHGI accounts for all onshore production and gas processing flaring emissions under a single line item in the production segment of natural gas systems. Using the revised approach, these flaring emissions would be specifically calculated for natural gas production, petroleum production, and gas processing (within the plant grouped emission sources). The shift in CO_2 emissions from Natural Gas systems to Petroleum systems is also due to the inclusion of associated gas flaring as a specific line item under Petroleum systems; this is the largest source of CO_2 emissions for the revisions under consideration.

5. Requests for Stakeholder Feedback

General

1. EPA seeks stakeholder feedback on the general approach of using subpart W reported CO_2 emissions data to revise the current CO_2 emissions calculation methodology (described in Section 1) in the GHGI.

2. EPA seeks feedback on using consistent calculation methodologies for both CH_4 and CO_2, when GHGI relies on subpart W data. Are there sources where the CH_4 and CO_2 methodologies based on subpart W should differ?

Associated Gas Venting and Flaring (Section 3.1.1)

3. EPA seeks feedback on the methodology to calculate national emissions from associated gas venting and flaring. In particular, which methodology discussed in Section 3.1.1 (national-level, or NEMS region-level) or other approach best reflects national-level emissions from associated gas venting and flaring by taking into account variability of this source?

4. What scale-up assumptions should EPA make regarding associated gas venting or flaring for regions that do not report any oil well data to GHGRP? Should EPA assume that these regions have no such activity, or should EPA assign surrogate EF and AF values (e.g., average from all other reported regions, or some other methodology)?

5. Should EPA consider an approach not presented in Section 3.1.1?
    a. For example, scaling subpart W-based estimates using production rather than oil well counts?
    b. For example, disaggregating to the AAPG basin-level?

GHGI Sources that Are Not Currently Estimated Using subpart W data

6. Section 3.1.7 discusses considerations for developing EFs and associated activity data for miscellaneous production flaring that facilitate scaling reported subpart W data to a national level. The EPA has presented a preliminary approach that develops an EF in units of emissions per well. National active well counts would be paired with such EF to calculate emissions in the GHGI. The EPA seeks feedback on this approach, or suggestions of other approaches that would facilitate scaling to a national level and time series population.

7. For sources discussed in this memo that do not currently estimate CH_4 emissions using subpart W, EPA is considering which year(s) of subpart W data to use in developing the CO_2 emissions methodologies. For miscellaneous production flaring, the EPA reviewed reported emissions and activity data for RY2011 - RY2014. However, wellhead counts for RY2011 - RY2014 are only reported by those facilities that calculated equipment leak emissions using Methodology 1, and as such, are not comprehensive. At the time of the 2016 Production memo, 83% of reporting facilities for RY2011, 85% of RY2012 reporting facilities, 93% of RY2013 facilities, and 98% of RY2014 reporting facilities reported wellhead counts under Methodology 1. In addition, facilities only reported total wellheads and did not report gas and oil wellhead counts separately for RY2011 - RY2014. The EPA calculated the CO_2 EFs under consideration using RY2015 only, because well counts from all reporting facilities are reported. However, the EPA requests feedback on whether it is appropriate to consider data from prior reporting years, which would have more uncertainty due to incomplete coverage, in order to show a trend over the time series. Table 30 provides the reported subpart W emissions and activity data for RY2011-RY2015.

Table 30. GHGRP Subpart W Emissions and Activity Data for Miscellaneous Production Flaring

Year	CO_2 Emissions (mt)	# Flares	# Wells (a)	CO_2 EF (kg/well)
2011	2,252,297	13,509	371,604	6,061
2012	3,616,326	16,356	398,137	9,083
2013	4,596,329	21,098	415,355	11,066
2014	4,841,116	22,155	502,391	9,636
2015	3,779,110	20,293	527,170	7,169

a. Total gas and oil wellheads. Wellhead counts for RY2011 through RY2014 are available from those onshore production facilities that calculated equipment leak emissions using Methodology 1.

For transmission and storage segment flares, the EPA relies on RY2015 data for the revisions under consideration, because all flaring emissions are reported under the flare stacks source. Whereas, for RY2011 - RY2014, flare emissions are reported under flare stacks and each individual emission source.

8. Section 3.4 discusses time series considerations for transmission and storage flares. The EPA is considering applying a subpart W-based EF (kg/station) for all years of the time series. However, few transmission and storage stations reported flares for RY2015 (see Table 24 through Table 27). Therefore, EPA might alternatively assume that flares did not operate in 1990 (i.e., an EF of 0), apply the subpart W-based EF for 2011 forward, and apply linear interpolation from 1991 through 2010. The EPA seeks feedback on these approaches, or suggestions of other approaches to time series population.

Appendix A – Current (2017) GHGI CO_2 Emission Factors

All EFs are presented in the same units as the EFs under consideration for the 2018 GHGI; kg/[unit].

Emission Source	GHGI CO_2 EF	EF Units
Natural Gas & Petroleum Production		
Stripper Wells (for Associated Gas Venting)	2.47	kg/well
Condensate Tank Vents - Without Control Devices	0.18	kg/bbl
Condensate Tank Vents - With Control Devices	0.037	kg/bbl
Oil Tanks	0.18	kg/bbl
HF Gas Well Completions and Workovers	18,367[a]	kg/event
Pneumatic Controllers, all bleed types (Natural Gas)	144[a]	kg/controller
Low Bleed Pneumatic Controllers (Petroleum)	8.8	kg/controller
Intermittent Bleed Pneumatic Controllers (Petroleum)	83.9	kg/controller
High Bleed Pneumatic Controllers (Petroleum)	238.9	kg/controller
Pneumatic Pumps (Natural Gas)	168.4[a]	kg/pump
Pneumatic Pumps (Petroleum)	82.8	kg/pump
Liquids Unloading with Plunger Lifts	613[a]	kg/well
Liquids Unloading without Plunger Lifts	678[a]	kg/well
Onshore Production & Processing - Flaring Emissions	40,624	kg/well
Natural Gas Processing		
Reciprocating compressors - before CO2 removal	4,764	kg/compressor
Reciprocating compressors - after CO2 removal	1,058	kg/compressor
Centrifugal compressors with wet seals - before CO2 removal	21,859	kg/compressor
Centrifugal compressors with wet seals - after CO2 removal	4,854	kg/compressor
Centrifugal compressors with dry seals - before CO2 removal	10,719	kg/compressor
Centrifugal compressors with dry seals - after CO2 removal	2,380	kg/compressor
Plant fugitives - before CO2 removal	3,364	kg/plant
Plant fugitives - after CO2 removal	747	kg/plant
Kimray pumps	859	kg/plant
Dehydrator vents	5,291	kg/plant
Plant Grouped Sources	**95,303**	**kg/plant**
AGR vents	35,394,396	kg/plant
Blowdowns and venting	8,363	kg/plant
Transmission		
High Bleed Pneumatic Controllers	84.43	kg/controller
Intermittent Bleed Pneumatic Controllers	10.95	kg/controller
Low Bleed Pneumatic Controllers	6.22	kg/controller
Underground NG Storage		
High Bleed Pneumatic Controllers	82.21	kg/controller
Intermittent Bleed Pneumatic Controllers	10.74	kg/controller
Low Bleed Pneumatic Controllers	6.34	kg/controller

a. Average EF based on data from all NEMS regions.

Appendix B – Draft Update: National Emissions Estimates Over the GHGI Time Series (mt CO_2)

Appendix B-1: 1990-2002 Emissions - For All Sources, Except Associated Gas Venting and Flaring

Emission Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
ONSHORE PRODUCTION													
Condensate Tanks													
Large Tanks w/Flares	289,378	284,105	275,779	288,780	302,062	270,536	292,225	302,830	313,622	336,623	311,349	350,222	364,957
Large Tanks w/VRU	0	49	94	145	199	219	279	332	386	459	464	566	634
Large Tanks w/o Control	678	633	585	582	578	491	503	493	483	490	427	452	442
Small Tanks w/Flares	0	609	1,162	1,793	2,459	2,707	3,451	4,105	4,782	5,685	5,752	7,010	7,850
Small Tanks w/o Flares	5,659	5,370	5,038	5,100	5,156	4,464	4,661	4,668	4,673	4,847	4,332	4,708	4,740
Malfunctioning Separator Dump Valves	5.7	5.5	5.2	5.4	5.5	4.9	5.2	5.3	5.4	5.7	5.2	5.7	5.9
Oil Tanks													
Large Tanks w/Flares	0	321,196	621,086	889,536	1,154,002	1,420,416	1,679,815	1,955,844	2,165,961	2,292,110	2,521,239	2,763,359	2,984,953
Large Tanks w/VRU	0	645	1,248	1,787	2,318	2,853	3,374	3,929	4,351	4,604	5,065	5,551	5,996
Large Tanks w/o Control	24,505	23,757	22,046	20,169	18,766	17,634	16,547	15,683	14,392	12,781	11,903	11,114	10,265
Small Tanks w/Flares	0	396	766	1,097	1,424	1,752	2,072	2,413	2,672	2,828	3,111	3,409	3,683
Small Tanks w/o Flares	8,923	8,879	8,470	7,978	7,655	7,433	7,222	7,104	6,784	6,287	6,131	6,016	5,865
Malfunctioning Separator Dump Valves	19,648	19,814	19,157	18,291	17,797	17,524	17,271	17,236	16,702	15,711	15,553	15,497	15,345
Miscellaneous Production Flaring													
Natural Gas Systems Flaring	0	0	0	53,385	110,121	166,899	233,289	297,411	370,478	440,296	513,006	628,379	716,871
Petroleum Systems Flaring	0	0	0	683,631	997,973	1,300,116	1,617,227	1,943,637	2,160,740	2,348,108	2,658,824	2,936,235	3,206,917
HF Gas Well Completions and Workovers													
HF Completions and Workovers that vent	10,724	10,682	8,383	10,393	10,468	9,715	12,216	16,339	14,846	14,554	20,629	24,345	20,600
Flared HF Completions and Workovers	345,215	343,871	269,851	334,542	336,972	312,720	393,231	525,977	477,907	468,518	664,072	823,211	733,567
HF Completions and Workovers with RECs	0	0	0	0	0	0	0	0	0	0	0	304	541
HF Completions and Workovers with RECs that flare	0	0	0	0	0	0	0	0	0	0	0	53,011	94,477
Pneumatic Controllers													
Natural Gas Systems Controllers													
Low-Bleed	0	0	0	99	162	220	313	394	502	595	691	921	1,058
Intermittent Bleed	23,156	24,540	24,487	26,187	28,323	28,620	32,340	33,646	36,448	37,514	38,385	45,704	47,347
High-Bleed	24,564	26,032	25,976	26,152	27,385	26,748	29,165	29,223	30,426	30,028	29,387	33,372	32,868
Petroleum Systems Controllers													
Low-Bleed	3,627	3,651	3,546	3,492	3,473	3,453	3,431	3,409	3,384	3,359	3,332	3,304	3,275
Intermittent Bleed	0	0	0	0	1,933	3,909	5,928	7,991	10,096	12,245	14,437	16,672	18,950
High-Bleed	55,427	55,785	54,192	53,364	51,814	50,216	48,570	46,876	45,135	43,345	41,507	39,621	37,687

Emission Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Pneumatic Pumps													
Natural Gas Pumps	2,319	2,372	2,382	2,707	3,071	3,143	3,770	3,970	4,531	4,703	4,839	6,007	6,318
Petroleum Pumps	4,716	4,745	4,613	4,561	4,705	4,849	4,994	5,138	5,283	5,427	5,571	5,716	5,860
Liquids Unloading													
Liquids Unloading with Plunger Lifts	0	300	593	914	1,257	1,585	1,996	2,376	2,824	3,239	3,673	4,414	4,950
Liquids Unloading without Plunger Lifts	55,941	59,293	55,976	54,896	53,885	51,602	51,271	49,354	48,251	46,069	43,818	44,386	42,033
NATURAL GAS PROCESSING													
Plant Grouped Emission Sources	48,746	48,249	48,597	415,679	782,081	1,069,810	1,302,740	1,597,307	1,731,708	2,097,172	2,407,721	2,634,502	3,025,582
Flares	0	0	0	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*
Plant Fugitives	3,193	3,080	3,072	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*
Recip. Compressors	24,534	24,327	24,519	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*
Centrifugal Compressors (wet seals)	18,143	17,990	18,132	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*
Centrifugal Compressors (dry seals)	0	0	0	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*
Dehydrators	2,875	2,851	2,874	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*
AGR Vents	28,282,226	27,278,783	27,204,454	26,383,553	25,750,121	23,418,339	21,101,174	20,323,714	17,980,499	18,243,135	17,886,943	16,958,867	17,068,007
Pneumatic Devices	291	281	280	278	277	258	238	235	213	222	224	218	226
Blowdowns/Venting	6,496	6,265	6,248	6,778	7,348	7,382	7,311	7,709	7,441	8,212	8,737	8,969	9,755
TRANSMISSION AND STORAGE													
Flares (a)													
Transmission Station Flares	94,828	95,458	94,680	93,965	93,250	92,535	91,820	91,105	90,390	89,675	88,960	88,245	87,530
Underground NG Storage Flares	24,388	25,300	26,047	25,822	25,597	25,372	25,147	24,922	24,697	24,472	24,247	24,022	23,797
LNG Storage Flares	2,264	2,290	2,316	2,342	2,368	2,394	2,420	2,446	2,472	2,498	2,524	2,550	2,576
LNG Import Flares	15,484	15,484	15,484	15,484	15,484	15,484	15,484	15,484	15,484	15,484	15,484	23,226	23,226
Pneumatic Controllers													
Transmission: All Controllers	6,274	6,315	6,264	6,078	5,895	5,714	5,534	5,357	5,182	5,009	4,839	4,670	4,503
High Bleed													
Intermittent Bleed													
Low Bleed													
Underground NG Storage: All Controllers	1,308	1,358	1,398	1,388	1,377	1,365	1,351	1,335	1,318	1,300	1,280	1,259	1,237
High Bleed													
Intermittent Bleed													
Low Bleed													
NATURAL GAS SYSTEMS													
TOTAL	**29,239,945**	**28,237,644**	**28,076,080**	**27,757,047**	**27,565,904**	**25,518,327**	**23,611,935**	**23,340,740**	**21,169,570**	**21,880,807**	**22,081,789**	**21,773,547**	**22,325,697**
PETROLEUM SYSTEMS													
TOTAL	**116,846**	**438,869**	**735,123**	**1,683,905**	**2,261,861**	**2,830,158**	**3,406,452**	**4,009,260**	**4,435,500**	**4,746,804**	**5,286,672**	**5,806,493**	**6,298,794**

Notes:

NE = Not Estimates

(a) The subpart W-based EF was applied across the time series for each industry segment.

Appendix B-2: 2003-2015 Emissions - For All Sources, Except Associated Gas Venting and Flaring

Emission Source	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
ONSHORE PRODUCTION													
Condensate Tanks													
Large Tanks w/Flares	357,622	346,672	368,121	413,374	415,806	448,990	448,182	616,201	677,923	831,348	999,045	1,045,429	1,059,701
Large Tanks w/VRU	663	682	765	903	952	1,074	1,116	1,594	1,817	2,228	2,678	2,802	2,840
Large Tanks w/o Control	406	368	364	380	354	352	323	405	405	496	596	624	632
Small Tanks w/Flares	8,211	8,448	9,474	11,189	11,792	13,298	13,822	19,738	22,501	27,594	33,160	34,699	35,173
Small Tanks w/o Flares	4,486	4,200	4,306	4,668	4,531	4,720	4,544	6,024	6,387	7,832	9,412	9,849	9,984
Malfunctioning Separator Dump Valves	5.7	5.4	5.7	6.3	6.2	6.6	6.5	8.9	9.6	11.8	14.2	14.9	15.1
Oil Tanks													
Large Tanks w/Flares	3,180,217	3,298,743	3,367,426	3,524,711	3,737,643	3,898,263	4,405,282	4,742,804	5,126,360	5,889,357	6,778,763	7,919,167	8,576,672
Large Tanks w/VRU	6,389	6,627	6,765	7,081	7,508	7,831	8,849	9,527	10,298	11,831	13,617	15,908	17,229
Large Tanks w/o Control	9,368	8,323	7,262	6,472	5,805	5,075	4,744	4,147	3,543	4,071	4,686	5,474	5,928
Small Tanks w/Flares	3,924	4,070	4,155	4,349	4,611	4,809	5,435	5,851	6,325	7,266	8,363	9,770	10,581
Small Tanks w/o Flares	5,678	5,382	5,044	4,869	4,778	4,626	4,867	4,890	4,944	5,680	6,538	7,637	8,271
Malfunctioning Separator Dump Valves	15,091	14,535	13,849	13,590	13,563	13,360	14,303	14,629	15,059	17,300	19,913	23,263	25,194
Miscellaneous Production Flaring													
Natural Gas Systems Flaring	829,349	943,899	1,073,169	1,230,674	1,368,469	1,565,171	1,687,847	1,817,648	1,942,507	1,934,213	1,904,704	1,912,615	1,860,355
Petroleum Systems Flaring	3,492,603	3,805,215	4,144,115	4,525,412	4,823,253	5,395,641	5,692,554	6,142,207	6,327,662	6,604,608	6,798,447	7,003,507	6,864,989
HF Gas Well Completions and Workovers													
HF Completions and Workovers that vent	22,785	24,909	28,370	29,365	27,671	27,599	16,211	14,777	13,042	9,329	6,141	5,861	397
Flared HF Completions and Workovers	856,915	992,486	1,201,835	1,327,873	1,341,774	1,442,661	919,056	915,134	1,134,233	613,559	573,983	461,571	281,489
HF Completions and Workovers with RECs	949	1,465	2,217	2,940	3,466	4,259	3,052	3,377	3,801	2,650	2,926	1,738	3,203
HF Completions and Workovers with RECs that flare	165,544	255,646	386,963	513,053	604,828	743,205	532,646	589,304	663,375	948,729	1,000,872	1,474,442	844,794
Pneumatic Controllers													
Natural Gas Systems Controllers													
Low-Bleed	1,267	1,470	1,719	2,038	2,291	2,729	2,953	3,218	3,456	2,956	1,977	2,352	2,252
Intermittent Bleed	51,551	54,774	58,975	64,722	67,638	75,196	76,197	78,001	78,911	87,514	104,464	101,476	100,265
High-Bleed	33,901	33,985	34,364	35,228	34,174	35,008	32,397	29,961	27,013	23,190	13,281	9,806	7,339
Petroleum Systems Controllers													
Low-Bleed	3,244	3,212	3,179	3,144	3,108	3,071	3,032	2,993	2,952	3,301	2,105	2,038	1,842
Intermittent Bleed	21,271	23,635	26,042	28,493	30,986	33,523	36,103	38,726	41,392	43,213	65,900	70,412	71,177
High-Bleed	35,705	33,675	31,597	29,471	27,297	25,075	22,805	20,487	18,121	12,637	7,518	6,515	6,589

Emission Source	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Pneumatic Pumps													
Natural Gas Pumps	7,040	7,609	8,330	9,316	9,831	11,158	11,442	11,900	12,149	12,102	11,916	11,971	11,639
Petroleum Pumps	6,004	6,149	6,293	6,437	6,582	6,726	6,871	7,015	7,159	7,472	7,692	7,926	7,770
Liquids Unloading													
Liquids Unloading with Plunger Lifts	5,640	6,338	7,131	8,092	8,915	10,130	10,856	11,635	12,377	11,500	10,388	10,648	11,461
Liquids Unloading without Plunger Lifts	40,441	38,259	36,043	33,941	30,633	27,979	23,436	18,802	13,922	15,367	16,817	16,514	14,054
NATURAL GAS PROCESSING													
Plant Grouped Emission Sources	3,234,075	3,512,336	3,761,987	4,084,244	4,396,245	4,711,283	5,020,686	5,368,824	5,868,291	5,868,316	6,294,303	6,458,907	6,458,775
Flares	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	5,843,584	6,267,871	6,431,800	6,431,800
Plant Fugitives	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	2,973	3,189	3,273	3,273
Recip. Compressors	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	10,145	10,882	11,167	11,167
Centrifugal Compressors (wet seals)	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	1,878	1,910	1,942	1,798
Centrifugal Compressors (dry seals)	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	91	106	110	122
Dehydrators	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	9,645	10,345	10,616	10,616
AGR Vents	16,132,415	15,605,121	14,975,288	14,637,319	14,241,492	13,840,723	13,411,849	13,069,042	13,039,102	13,039,102	13,985,835	14,351,618	14,351,618
Pneumatic Devices	219	219	216	218	219	221	221	224	232	232	249	255	255
Blowdowns/Venting	9,950	10,373	10,717	11,268	11,786	12,310	12,815	13,416	14,382	14,382	15,427	15,830	15,830
TRANSMISSION AND STORAGE													
Flares (a)													
Transmission Station Flares	86,815	86,100	85,385	84,670	83,955	83,240	82,525	81,810	81,095	86,845	93,808	100,550	100,357
Underground NG Storage Flares	23,572	23,347	23,122	23,302	23,122	23,602	23,662	23,722	23,902	23,902	24,022	24,022	23,542
LNG Storage Flares	2,603	2,603	2,603	2,603	2,603	2,603	2,603	2,603	2,603	2,603	2,603	2,603	2,603
LNG Import Flares	30,968	30,968	30,968	30,968	30,968	77,420	85,162	85,162	85,162	85,162	85,162	85,162	85,162
Pneumatic Controllers													
Transmission: All Controllers	4,339	4,177	4,017	3,858	3,702	3,549	3,397	3,247	3,100	2,939	3,023	871	799
High Bleed									716	367	373	375	421
Intermittent Bleed									2,368	2,551	2,628	473	363
Low Bleed									16	21	22	24	15
Underground NG Storage: All Controllers	1,213	1,187	1,160	1,132	1,102	1,071	1,038	1,004	968	957	974	944	587
High Bleed									836	801	809	770	431
Intermittent Bleed									119	140	146	159	146
Low Bleed									13	16	20	15	9
NATURAL GAS SYSTEMS													
TOTAL	**21,912,943**	**21,997,644**	**22,117,614**	**22,567,342**	**22,728,324**	**23,169,554**	**22,428,045**	**22,786,778**	**23,732,665**	**23,655,057**	**25,197,778**	**26,143,174**	**25,285,122**
PETROLEUM SYSTEMS													
TOTAL	**6,779,492**	**7,209,565**	**7,615,727**	**8,154,028**	**8,665,136**	**9,398,001**	**10,204,846**	**10,993,277**	**11,563,815**	**12,606,734**	**13,713,540**	**15,071,617**	**15,596,243**

Notes:

NE = Not Estimates

(a) The subpart W-based EF was applied across the time series for each industry segment.

Appendix B-3: 1990-2015 Emissions - For Associated Gas Venting and Flaring

Emission Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
ONSHORE PRODUCTION													
Associated Gas Venting and Flaring													
National-Level Approach Flaring	13,534,267	13,600,338	13,211,144	13,054,006	12,702,588	12,403,974	12,347,579	12,393,980	11,883,225	11,339,336	11,413,349	11,369,733	11,284,383
National-Level Approach Venting	111,552	112,097	108,889	107,594	104,697	102,236	101,771	102,154	97,944	93,461	94,071	93,712	93,008
NEMS Region-Level Approach Flaring	18,849,559	19,085,338	18,945,755	19,016,524	18,806,354	18,402,709	18,305,701	18,464,570	17,913,025	17,033,975	17,300,504	17,428,277	17,357,530
NEMS Region-Level Approach Venting	42,400	42,274	41,240	40,422	38,970	37,830	36,853	36,416	34,073	31,460	31,463	31,107	30,093

Emission Source	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
ONSHORE PRODUCTION													
Associated Gas Venting and Flaring													
National-Level Approach Flaring	11,268,623	11,348,646	11,475,241	11,691,585	11,673,796	12,327,347	12,256,511	12,528,077	12,919,005	15,956,821	20,066,958	23,236,830	31,015,120
National-Level Approach Venting	92,878	93,538	94,581	96,365	96,218	101,605	101,021	103,259	106,481	98,414	82,555	72,477	31,954
NEMS Region-Level Approach Flaring	17,441,251	17,802,827	18,292,720	19,050,718	19,589,129	20,888,683	21,124,671	21,945,960	23,138,480	24,702,170	25,910,206	27,248,749	27,392,663
NEMS Region-Level Approach Venting	30,015	29,345	29,357	29,707	30,163	30,932	30,688	30,844	31,679	33,743	35,457	37,502	37,946