

Inventory of U.S. Greenhouse Gas Emissions and Sinks: Revisions under Consideration for Natural Gas and Petroleum Production Emissions

Substantial new data are available on natural gas and petroleum systems from subpart W of the EPA's greenhouse gas reporting program (GHGRP). The data reported to subpart W include activity data (e.g., frequency of certain activities, equipment counts) and emissions. Emissions are estimated using differing methodologies depending on the emission source, including the use of emission factors (EFs) or emissions measurements. The emission sources included in subpart W are similar to those in the GHGI, but there are differences in coverage and emission estimation methods. The EPA is evaluating approaches for incorporating this new data into its emission estimates for the *Inventory of U.S. Greenhouse Gas Emissions and Sinks* (GHGI). This memorandum discusses potential incorporation of GHGRP subpart W data for pneumatic controllers and major equipment (equipment leaks sources) in the onshore production segment into the GHGI. For purposes of simplicity in this memorandum, chemical injection pumps (CIPs) are included under the major equipment category.

Not all onshore production activity nationwide is reported to subpart W—only facilities (defined as unique combination of operator and AAPG basin of operation) that meet the reporting threshold of 25,000 metric tons of CO₂ equivalent (MT CO₂e) report data under the GHGRP subpart W. Facilities that meet this threshold have been reporting under subpart W since 2011; currently, four years of subpart W reporting data are publically available, covering reporting year (RY) 2011 through RY2014.

This memo focuses on updates to activity data in the production segments for natural gas and petroleum systems, specifically to pneumatic controllers and equipment leaks. Other updates to production segment emissions estimates are being considered and may be presented in future memoranda.

Background on Current GHGI Methodology and Available Data

For many sources in the GHGI, direct activity data are not available for every year of the time series. For these sources, generally, activity data drivers are used along with activity data ratios developed for the year with available data (commonly, 1992) to update activity data for each year in the GHGI. Activity data drivers currently used in the GHGI include statistics on gas production, number of wells, system throughput, miles of various types of pipeline, and other statistics that characterize the changes in the U.S. natural gas system infrastructure and operations.

For example, recent data on various types of production field equipment (e.g., heaters, separators, and dehydrators) are not available. The EPA determined that each of these types of field separation equipment relate to the number of non-associated gas wells. Using the number of each type of field separation equipment estimated by GRI/EPA in 1992, and the number of non-associated gas wells in 1992, the EPA developed a factor that is used to estimate the number of each type of field separation equipment throughout the time series based on the count of non-associated gas wells obtained for a given year. Further information on current activity data methodology is provided in Annex 3 of the 2015 GHGI report.¹

¹ <http://www3.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-GHGI-2015-Annex-3-Additional-Source-or-Sink-Categories.pdf>

GHGRP Subpart W

Onshore natural gas and petroleum production facilities that are required to submit annual reports under subpart W of the GHGRP calculate methane (CH₄) and carbon dioxide (CO₂) emissions from *natural gas pneumatic device venting* (using the calculation methodology required by 40 CFR 98.233(a)), CIPs (using the calculation methodology required by 40 CFR 98.233(c)), and *equipment leaks using population counts* (using the calculation methodology required by 40 CFR 98.233(r)). Data for those two types of emission sources are reported at the facility level (i.e., unique combination of operator and AAPG basin). Data reported do not include information on production type (gas or oil).

When subpart W was originally promulgated in November 2010, the EPA deferred the reporting deadline for certain subpart W equation inputs until March 31, 2015. In October 2014, the EPA finalized the approach to collecting these deferred inputs. Subpart W reporters were required to submit both an expanded set of data elements for RY2014 and the deferred data elements for RYs 2011, 2012, and 2013 by March 31, 2015. The GHGRP subpart W data used in the analyses discussed in this memorandum are those reported to the EPA as of August 16, 2015.

The EPA is determining if and how the current GHGI activity data can be updated using data available from GHGRP subpart W for pneumatic controllers, CIPs, and equipment leaks from the onshore natural gas and petroleum production industry segment. There are important considerations for the incorporation of subpart W data into the GHGI. Due to the GHGRP reporting threshold, the subpart W data set is not a national total, and therefore coverage and representativeness must be taken into consideration when using the data to develop national activity or emissions estimates.

- (1) Subpart W activity data need to be scaled up to national activity. Subpart W activity data could be normalized to a scalable basis. For example, subpart W equipment counts per well could be developed from the reported data, and then these counts per well could be multiplied by national well counts obtained from DrillingInfo data in each given year to obtain a national estimate of equipment counts in that year.
- (2) Subpart W reports reflect activities at facilities exceeding the emission threshold. While EPA estimates that subpart W reporting covers the majority of national oil and gas production, the reporting facilities represent approximately 30% of producing wells in the U.S., located within large facilities that exceed the emissions threshold for reporting. The degree to which production segment activity data at reporting facilities is representative of all facilities (including small facilities) nationwide should be considered.
- (3) Subpart W onshore production segment reports reflect activities and equipment on or associated with a single well pad. The GHGI production segment estimates include emissions from centralized production (e.g., tank batteries) and gathering and boosting activities. To avoid omissions or double counting, updates to GHGI production segment data must be considered in conjunction with updates to gathering and boosting methods and data.²

Subpart W Data for Natural Gas-driven Pneumatic Controllers

For onshore production, the calculation of emissions from natural gas-driven pneumatic controller venting is based on counts (which may be estimated based on best available data for the first two RYs) of low-bleed, high-bleed, and intermittent-bleed pneumatic controllers. Counts of each type of

² A companion memo titled "GHGI of U.S. Greenhouse Gas Emissions and Sinks: Revisions under Consideration for Natural Gas Gathering and Boosting Emissions" (February 2016) discusses potential revisions including updating some of the production emission calculation methodologies based on Marchese et al. (2015) measurement data for centralized production and gathering-only facilities.

pneumatic controller are now available for RY2011 through RY2014. These values are shown in Table 1 below. 75% of reporting onshore production facilities for RY2011, 76% for RY2012, and 81% for RY2013 reported pneumatic controller counts.

Table 1. Reported Natural Gas Pneumatic Controller Counts for RY2011-2014

Number of Reporting Facilities	RY2011	RY2012	RY2013	RY2014
Number of Onshore Production Facilities Reporting Under Subpart W	458	504	507	564
Reported Actual and Estimated Pneumatic Controller Counts, by Bleed Type:				
Low-Bleed Pneumatic Controllers	214,211	218,570	159,586	204,246
High-Bleed Pneumatic Controllers	55,846	49,707	32,939	27,615
Intermittent-Bleed Pneumatic Controllers	304,000	360,613	515,449	553,252

Subpart W Data for Major Equipment

Onshore production facilities have two options for calculating emissions from major equipment leaks. The first option ("Methodology 1," per 98.233(r)(2)(i), 76 FR 80554, Dec. 23, 2011) is based on estimated component counts (utilizing a table provided in the rule of typical component counts per major equipment) and includes reporting of major equipment counts for facilities using this methodology. The second option "Methodology 2," per 98.233(r)(2)(ii), 76 FR 80554, Dec. 23, 2011) uses actual component counts to calculate equipment leak emissions and does not include reporting of major equipment counts.

Major equipment counts for RY2011 through RY2014 are therefore available from those onshore production facilities that calculated equipment leak emissions using Methodology 1, which includes 83% of reporting facilities for RY2011, 85% for RY2012, 93% for RY2013, and 98% for RY2014. For wellheads, the subpart W data do not distinguish primary production type (i.e., natural gas production wells versus crude oil production wells). These reported major equipment counts are shown in Table 2 below.

Table 2. Reported Methodology 1 Equipment Leak Major Equipment Counts for RY2011-2014

Number of Reporting Facilities	RY2011	RY2012	RY2013	RY2014
Number of Onshore Production Facilities Reporting Under Subpart W	458	504	507	564
Number of Onshore Production Facilities Reporting Equipment Leak Major Equipment Counts	381	429	469	552
Reported Number of Major Equipment, By Equipment Type:				
Natural Gas and Petroleum Wellheads	375,445	406,262	425,125	499,023
Natural Gas and Petroleum Separators	204,990	230,109	243,531	269,391
Natural Gas and Petroleum Chemical Injection Pumps ^a	64,490	77,538	77,355	79,881
Natural Gas Compressors	22,232	20,986	21,318	23,740
Natural Gas Dehydrators	6,758	9,545	7,974	8,380
Petroleum Headers	32,491	29,647	32,559	44,880
Petroleum Heater-treaters	25,057	22,721	26,350	34,902
Natural Gas In-Line Heaters	51,459	56,033	49,319	48,460
Natural Gas Meters/Piping	242,074	238,174	222,802	256,340

a – As stated above, CIP data are presented within the major equipment leaks discussion for simplicity. In the GHGI, emissions from CIPs are categorized as vented emissions whereas equipment leaks are fugitive emissions.

Alignment between GHGI and Subpart W Activity Data

Appendix A documents GHGI production segment emission sources in natural gas systems and petroleum systems, respectively, aligned with data collected under GHGRP subpart W for equipment leak and natural gas pneumatic controller emissions. The description of “GHGI Activity Basis” in the Appendix A table indicates whether the activity data element is obtained directly from a data source for each year in the time series (indicated by “direct”) or some other methodology involving use of an activity data driver. In the current GHGI, all of the emission sources in Appendix A are driven from data elements that are available for each GHGI year: counts of wells by production type, and total oil and gas production.

Revisions under Consideration for Incorporating Subpart W Data into the GHGI

As discussed in the introduction to this memorandum, subpart W provides substantial new data on oil and gas GHG-emitting activities in the U.S., but does not represent total national-level emissions due to the reporting threshold. Both the coverage and the representativeness of the GHGRP data are being evaluated for use in the GHGI. This section discusses two approaches under consideration for scaling subpart W activity data to a national level for use in the GHGI, as well as an approach under consideration for revising natural gas and petroleum systems current GHGI methodology to stratify pneumatic controller emission estimates by bleed type.

Table 3 below summarizes major equipment and pneumatic controller emission sources in the current GHGI. For natural gas systems, relevant subpart W data elements include counts of heaters, dehydrators, meters/piping, and compressors. For petroleum systems, relevant subpart W data elements include counts of heater-treaters and headers. Equipment that applies to both natural gas and petroleum production segments (according to the current GHGI structure) and for which subpart W reported activity could be allocated between production types includes counts of pneumatic controllers, wellheads, separators, and CIPs.

Table 3. Summary of Activity Data Alignment between GHGI and Subpart W

Emission Source	GHGI		Subpart W Potential Allocation		
	Natural Gas	Petroleum	Allocated to NG	Allocated to Petroleum	Allocated between Prod. Types
Pneumatic Controllers	•	•			•
Wellheads	•	•			•
Separators	•	•			•
Chemical Injection Pumps	•	•			•
Heaters	•		•		
Dehydrators	•		•		
Meters/Piping	•		•		
Compressors	•		•		
Heater-treaters		•		•	
Headers		•		•	

Table 4 below compares reported activity data under subpart W to national activity estimates in the current GHGI for years 2011 through 2013.

Table 4. Comparison between Production Segment GHGI and Subpart W Activity Data

Equipment	2011		2012		2013		2014
	GHGI	Subpart W	GHGI	Subpart W	GHGI	Subpart W	Subpart W
Pneumatic Controllers (NG and Petro)	894,968	574,057	909,777	628,890	911,474	707,974	785,113
Wellheads (NG and Petro)	1,296,534	375,445	1,320,426	406,262	1,315,196	425,125	499,023
Separators (NG and Petro)	390,503	204,990	394,136	230,109	388,222	243,531	269,391
CIPs (NG and Petro)	66,623	64,490	67,256	77,538	66,878	77,355	79,881
Heaters (NG)	110,423	51,459	109,428	56,033	107,735	49,319	48,460
Dehydrators (NG)	65,124	6,758	64,753	9,545	62,919	7,974	8,380
Meters/piping (NG)	397,862	242,074	395,686	238,174	390,586	222,802	256,340
Compressors (NG)	36,368	22,232	36,052	20,986	35,354	21,318	23,740
Heater-treaters (Petro)	78,281	25,057	81,941	22,721	84,262	26,350	34,902
Headers (Petro)	88,708	32,491	91,548	29,647	92,395	32,559	44,880

National Scale-up Approach 1: Simplistic scale up using percent coverage of wells

One approach the EPA is considering is a simplistic approach to scaling subpart W data to estimate national activity. This approach does not take into account how dominant production type (natural gas versus petroleum) may impact major equipment counts per well, or the degree to which major equipment counts per well reported under subpart W are representative of activity for facilities that do not report under subpart W. For year 2013, subpart W data cover 32% of active wellheads (total producing natural gas and petroleum wells) nationally. The EPA developed the Approach 1 estimates in

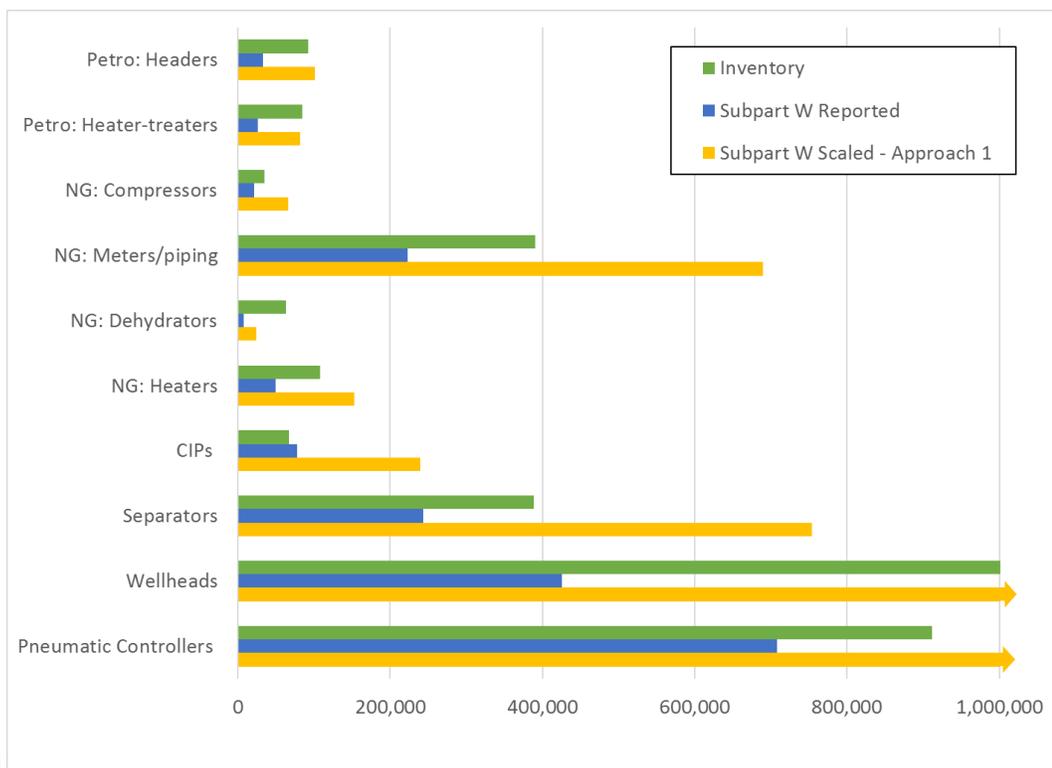


Table 5 and

Figure 1 below using an assumption that the subpart W data set also represents 32% of other national equipment counts (in other words, that the ratio of each type of equipment-per-wellhead is the same for nonreporting wells as it is for reporting wells) in the onshore production segment. The percent of calculated well coverage varies from year to year, so an estimate based on a different reporting year might result in different scale up results.

Table 5. Subpart W Production Segment Major Equipment Counts Scaled to National Activity Representation for Year 2013, by Approach 1

Equipment	GHGI	Subpart W Reported	Subpart W Scaled	Change from GHGI Estimate
Pneumatic Controllers	911,474	707,974	2,190,237	+140%
Wellheads	1,315,196	425,125	n/a	n/a
Separators	388,222	243,531	753,404	+94%
Chemical Injection Pumps	66,878	77,355	239,311	+258%
Heaters (NG)	107,735	49,319	152,577	+42%
Dehydrators (NG)	62,919	7,974	24,669	-61%
Meters/piping (NG)	390,586	222,802	689,276	+76%
Compressors (NG)	35,354	21,318	65,951	+87%
Heater-treaters (Petro)	84,262	26,350	81,518	-3%
Headers (Petro)	92,395	32,559	100,727	+9%

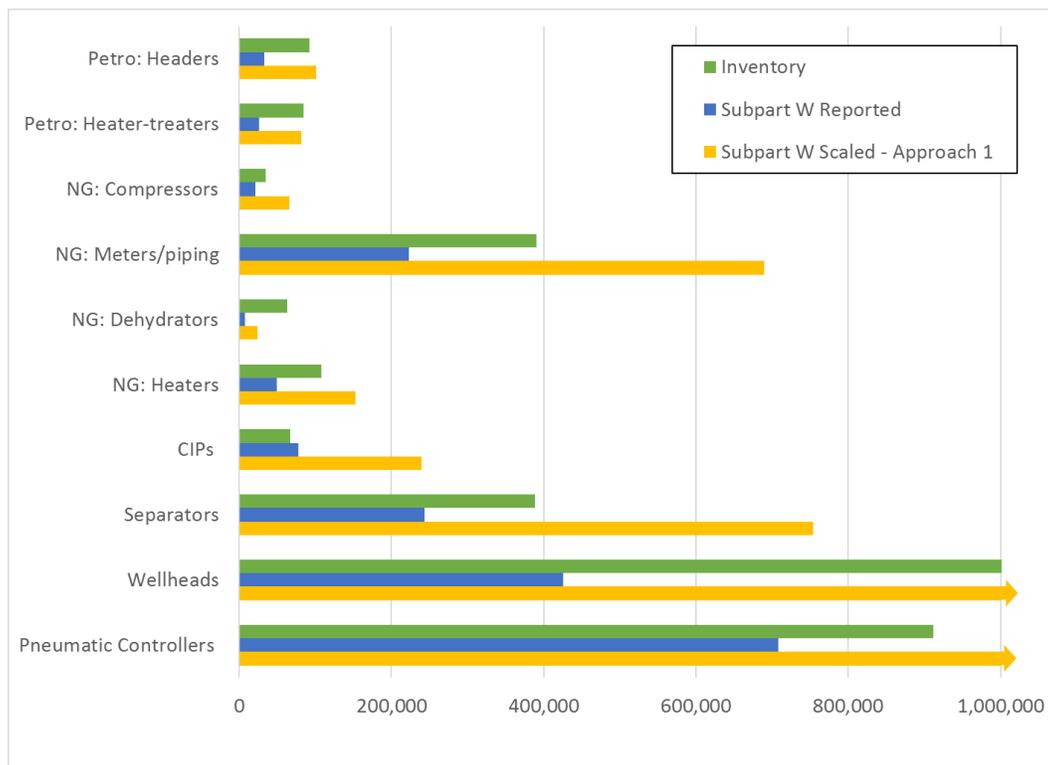


Figure 1. Subpart W Production Segment Major Equipment Counts Scaled to National Activity Representation for Year 2013, by Approach 1

National Scale-up Approach 2: Production type-specific scaling

The EPA is considering an approach building on Approach 1 that would allocate subpart W reported counts of pneumatic controllers, wellheads, and separators to either the natural gas or petroleum systems GHGI source categories. Each facility that reports under subpart W for onshore production reports certain data elements at the sub-basin level, which is defined as operations within a single geographic county of a common production classification. The production classifications used in subpart W are identified in Table 6 below. The EPA analyzed the sub-basin data for each facility in order to estimate the fraction of the facility’s activity that is attributable to natural gas versus petroleum. For example, if a facility reported activities in 10 total sub-basins, 4 of which are natural gas producing and 6 of which are oil producing (based on the second column in Table 6), then the EPA assigns 40% of the reported equipment to natural gas activities and 60% of equipment to petroleum activities.

Table 6. Subpart W Sub-basin Production Classification and GHGI Source Category Assignment

Subpart W Production Classification	GHGI Source Category
Shale gas	Natural gas
High permeability gas	Natural gas
Coal seam	Natural gas
Oil	Petroleum
Tight reservoir rock ^a	Natural gas or Petroleum, dependent on particular county ^a

a – Tight reservoir rock may be a gas or oil formation. The EPA’s National Emissions Inventory program developed a crosswalk using 2011 production data from DrillingInfo’s DI Desktop® to classify each individual county with tight reservoir rock as primarily gas-producing or oil-producing.

The EPA then analyzed counts of each type of major equipment per wellhead at each facility by production type. The EPA calculated AFs using two data sets: all available data (RY 2011–2014) and RY2014 only (since the data for previous RYs were back-reported). To calculate average AFs for each data set, EPA weighted facility-level reported activity data by facility well count. Calculated AFs are shown in Table 7 below.

The EPA used the RY 2014 Only AFs in subsequent “Approach 2” national scaling calculations. The EPA’s estimates of major equipment counts by Approach 2 are presented in Table 8 and Figure 2 below.

Table 7. AF Calculation for Approach 2, from Various Data Sets

Source Category & Major Equipment	RYs 2011–2014	RY 2014 Only
NG: Pneumatic Controllers/Well	1.67	1.83
NG: Separators/Well	0.69	0.67
NG: Chemical Injection Pumps/Well	0.19	0.18
NG: Compressors/Well	0.11	0.11
NG: Dehydrators/Well	0.04	0.04
NG: Heaters/Well	0.25	0.22
NG: Meters/piping per well	1.15	1.15
Petro: Pneumatic Controllers/Well	1.36	1.35
Petro: Separators/Well	0.42	0.43
Petro: Chemical Injection Pumps/Well	0.16	0.14
Petro: Headers/Well	0.16	0.16

Petro: Heater-treaters/Well	0.13	0.13
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Table 8. Subpart W Production Segment Major Equipment Counts Scaled to National Activity Representation for Year 2013, by Approach 2

Equipment	GHGI	Subpart W Reported	Subpart W Scaled	Change from GHGI Estimate
Pneumatic Controllers	911,474	707,974	1,991,902	+119%
Pneumatic Controllers (NG)	459,304	371,607	826,053	+80%
Pneumatic Controllers (Petro)	452,170	336,367	1,165,849	+158%
Wellheads	1,315,196	425,125	n/a	n/a
Wellheads (NG)	451,296	208,991	n/a	n/a
Wellheads (Petro)	863,900	216,134	n/a	n/a
Separators	388,222	243,531	677,330	+74%
Separators (NG)	265,586	152,429	303,124	+14%
Separators (Petro)	122,636	91,102	374,206	+205%
Chemical Injection Pumps	66,878	77,355	204,972	+206%
Chemical Injection Pumps (NG)	35,812	40,501	82,365	+130%
Chemical Injection Pumps (Petro)	31,066	36,854	122,607	+295%
Heaters (NG)	107,735	49,319	97,986	-9%
Dehydrators (NG)	62,919	7,974	16,944	-73%
Meters/piping (NG)	390,586	222,802	518,321	+33%
Compressors (NG)	35,354	21,318	48,002	+36%
Heater-treaters (Petro)	84,262	26,350	109,313	+30%
Headers (Petro)	92,395	32,559	140,564	+52%

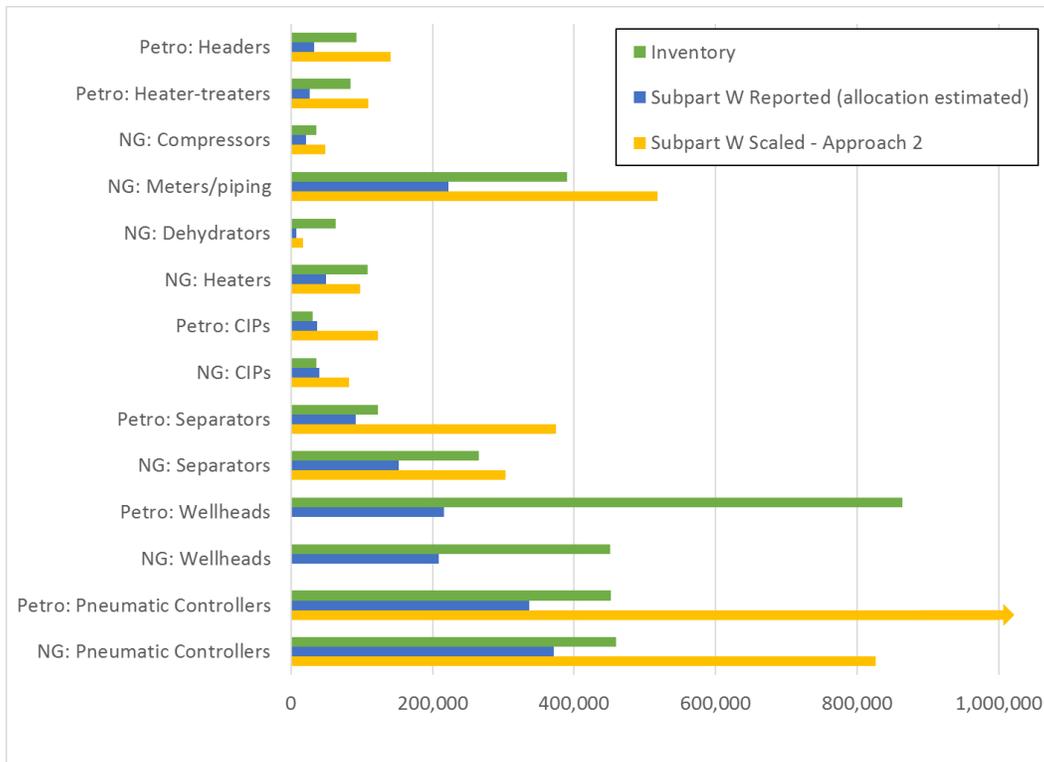


Figure 2. Subpart W Production Segment Major Equipment Counts Scaled to National Activity Representation for Year 2013, by Approach 2

Pneumatic Controller Stratification by Bleed Type

As shown in Appendix A, the current GHGI does not stratify pneumatic controller emissions by bleed type within natural gas production, and stratifies by high versus low bleed within petroleum production. Using reported subpart W data could allow EPA to calculate pneumatic controller emissions using activity data and EFs specific to each bleed rate category in the GHGRP: high bleed, intermittent bleed, and low bleed. This revised approach would improve current GHGI estimates by providing “net” rather than “potential” emissions for each year of the time series, and therefore the calculation would no longer require incorporation of Gas STAR voluntary reductions data.

Table 9 below presents estimates of pneumatic controller counts in natural gas and petroleum production segments, nationally scaled and stratified by production type according to “Approach 2” discussed above—then stratified by bleed type based on subpart W data, for year 2013. The far-right column labeled “Change” indicates the relative difference between “Subpart W Scaled” and “2015 GHGI” values.

Table 9. Subpart W Production Segment Pneumatic Controller Counts Scaled to National Activity Representation for Year 2013

Controller Type	2015 GHGI	Subpart W Reported, and Allocated to NG and Petro	Subpart W Scaled	Change ^a
Low Bleed	-	159,586	511,843	n/a
Natural Gas Production	-	69,483	223,863	n/a
Petroleum Production	293,910	90,103	287,980	-2%
High Bleed	-	32,939	69,250	n/a
Natural Gas Production	-	13,431	28,524	n/a
Petroleum Production	158,259	19,508	40,726	-74%
Intermittent Bleed	-	515,449	1,410,809	n/a
Natural Gas Production	-	209,508	573,666	n/a
Petroleum Production	-	305,941	837,143	n/a
Natural Gas Prod. Total	459,304	292,422	826,053	+80%
Petroleum Prod. Total	452,170	415,552	1,165,849	+158%
Production Segment Total	911,474	707,974	1,991,902	+119%

a – Relative difference between “Subpart W Scaled” and “2015 GHGI” values.

“-“ means not estimated.

“n/a” means not applicable.

The EPA developed EFs using subpart W reported data for pneumatic controllers stratified by bleed type and production type to be used in conjunction with revised activity data. These EFs are presented in Table 10 below and compared to current GHGI EFs.

Table 10. Production Segment Pneumatic Controller Methane EF Comparison (scfd/device)

Data Source	Data Source Base Year	Low-Bleed	High-bleed	Intermittent Bleed	Population Average
Subpart W RYs 2011-2014 ^a	2011–2014	23	617	215	183
Subpart W RY 2014 ^a	2014	23	622	218	182
Current GHGI: Natural Gas Production ^b	1992	-	654	323	345 ^d
Current GHGI: Petroleum Production ^c	2002	52	330	-	149

a – Subpart W EFs are calculated as a weighted average based on the number of devices of the given type at each reporting facility.

b – The current GHGI uses the population EF from the 1996 GRI/EPA report. This population EF represents an observed mix of 65% intermittent bleed and 35% continuous bleed natural gas-driven pneumatic controllers; the bleed type-specific EFs from the GRI/EPA report (which are not directly used in the current GHGI) are shown for comparison to other data sources. The continuous bleed EF from the GRI/EPA report is most appropriately compared to the high-bleed subcategorization for purposes of this analysis (versus low-bleed continuous).

c – The current GHGI uses high bleed and low bleed EFs developed in 2002 in conjunction with an assumed mix of 65% low bleed and 35% high bleed natural gas-driven pneumatic controllers. The petroleum systems production segment average EF (which is not directly used in the current GHGI) is shown for comparison to other data sources.

d – Potential factor. In the current GHGI, Gas STAR reductions are subtracted from potential emissions to reflect net emissions from the actual mix of controllers in place. This is further discussed below under “Impact on National Emission Estimates.”

Impact on National Emission Estimates

Approach 1 discussed above provides an informative high-level comparison between scaled subpart W data and current GHGI estimates. For implementation in the GHGI, the EPA is considering a methodology such as discussed for Approach 2 because it would provide AFs specific to natural gas or petroleum systems for all types of equipment. Table 13 below presents activity and emissions estimates from the most recent GHGI (2015 GHGI) compared to Approach 2 under consideration for using scaled subpart W data.

The AFs derived from subpart W data by both Approach 1 and Approach 2 result in generally higher equipment counts per well (for example, approximately twice as high as the current GHGI for separators and meters), though dehydrator counts per well are less than calculated in the current GHGI. Subpart W reporting does not cover centralized production facilities which may lead to underrepresentation of dehydrators population; however, proposed updates to gathering and boosting sources in the GHGI (see companion memo titled “GHGI of U.S. Greenhouse Gas Emissions and Sinks: Revisions under Consideration for Natural Gas Gathering and Boosting Emissions” (February 2016)) would help mitigate this discrepancy because emissions from dehydrators at centralized gathering locations would be included within the gathering stations EF. The revision under consideration for using subpart W activity and emissions data to update GHGI pneumatic controller estimates would result in significant increases to current emissions estimates.

Currently, the GHGI calculates potential emissions for pneumatic controllers and major equipment fugitives (column 2 in Table 13), then subtracts Gas STAR reductions (column 3) to obtain net emission estimates (column 4). Gas STAR reductions for pneumatic controllers are applied to the pneumatic controller categories, but the current GHGI methodology does not assign Gas STAR reductions specifically to major equipment fugitive sources. The approaches under consideration that rely on

subpart W data reflect net emissions, and therefore it would no longer be appropriate to subtract Gas STAR reductions for these source estimates.

The activity data from Approach 2 shown in Table 13 below are consistent with values shown in Table 8 above. The “revised net” emissions shown for Approach 2 uses bleed rate-specific activity stratification from Table 9 (pneumatics stratified by bleed type) and associated EFs from Table 10; this approach is comparable to the 2015 GHGI’s approach of calculating potential emissions then subtracting Gas STAR reductions to account for increased adoption of lower bleed rate controllers in 2013 compared to the 1992 base year. For major equipment fugitives, the “revised net” emissions in Table 13 use GHGI EFs unchanged.

Time Series Considerations

Subpart W annual reporting data are available beginning in year 2011. The EPA is considering approaches to revise the GHGI time series (1990–2014) that will create consistency between earlier years’ estimates that generally rely on studies conducted in the 1990s, and more recent years’ estimates that rely on subpart W data.

Activity Data

For natural gas systems major equipment and natural gas-driven pneumatic controller counts in each year after the current GHGI base year (1992) and before the first year of subpart W data (2011), the EPA might apply an interpolation approach that reflects dynamics of well development activity. The inherent assumption would be that equipment counts in each such year are directly dependent on active well counts in the given year. For each year between the base year and 2011, the EPA would use the percent of “ Δ active wells” as the assumed percent of “ Δ equipment”, where:

- Δ active wells = difference in count of active wells in 2011 compared to base year (all years are directly calculated from DrillingInfo data); and
- Δ equipment = difference in count of each type of major equipment in 2011 compared to base year (counts in base year are taken from existing GHGI, and counts in 2011 are developed using AFs developed from subpart W data using Approach 2).

For petroleum systems, major equipment and natural gas-driven pneumatic controller counts derived from subpart W data for recent time series years have increased compared to base year estimates (1993 for major equipment and 1995 for pneumatic controllers) whereas the count of active wells and oil production have decreased over the same time frame. This might reflect the evolution of unconventional production and decrease in conventional oil production over time, and/or might reflect high uncertainties in the early 1990s data. Therefore, an interpolation approach that uses an independent parameter as a driver (e.g., active well count) such as that under consideration for natural gas systems cannot be applied. The EPA is considering using simple linear interpolation to develop activity data for these sources between the base year and 2011.

For natural gas-driven pneumatic controllers, the EPA will develop a bleed rate categorization for each time series year. Currently, the GHGI natural gas production segment assumes the controller population comprises 35% high bleed and 65% intermittent bleed controllers in year 1992, and this stratification is carried forward to represent potential emissions in all years. The EPA is considering linearly interpolating from these to the proportions observed in 2011 GHGRP, which would represent net emissions in each year. The EPA would retain the current GHGI methodology for years 1990–1992. Similarly, the current GHGI petroleum production segment assumes the controller population comprises 35% high bleed and 65% low bleed controllers HB for all years. The activity data methodology for calculating total pneumatic

controller count is based on consensus of an industry review panel for base year 1995. The EPA is considering linearly interpolating from the 1995 subpopulations to the proportions observed in 2011 GHGRP. The EPA would retain the current GHGI methodology for years 1990–1995.

To develop national activity estimates for major equipment and total pneumatic controller counts for year 2011 and beyond, the EPA might apply AFs (count of each type of equipment and total natural gas-driven pneumatic controllers per well) developed using Approach 2 discussed above. This approach could use AFs developed from RY2014 data to calculate activity data in the GHGI for recent years, could use an average of RY2011–2014 data, or could use year-specific data from GHGRP for these years in the GHGI. As shown in Table 7 above, AFs do not significantly vary over this time period based on reported data. If the EPA uses the approach of developing AF from RY2014 data or from an average of a number of reporting years, as future years of subpart W data become available, the EPA will reconsider at what frequency it is appropriate to recalculate AFs. The EPA is considering calculating pneumatic controller bleed rate stratification for each year of available data to allow the GHGI to reflect changes in these populations and resulting emissions—including changes resulting from NSPS OOOO implementation. See Table 11 below.

Table 11. Subpart W Production Segment Pneumatic Controller Bleed Rate Stratification

Controller Type	RY2011	RY2012	RY2013	RY2014
Natural Gas Production				
Low Bleed	33%	28%	17%	27%
High Bleed	10%	9%	5%	3%
Intermittent Bleed	57%	62%	78%	69%
Petroleum Production				
Low Bleed	44%	42%	28%	25%
High Bleed	9%	7%	4%	4%
Intermittent Bleed	47%	51%	68%	72%

Emission Factors

The proposed pneumatic controller EFs were similarly developed from RY 2014 subpart W data and would be applied for all years of the time series. Currently, the GHGI methodology relies on Gas STAR reductions to account for industry advancements in adoption of lower bleed rate controllers over time. The proposed revision takes this dynamic into account through EFs stratified by bleed type and development of bleed type-specific activity data.

Revisions to Subpart W Effective RY2015

Revisions to subpart W that became effective January 1, 2015 (79 FR 70352, Nov. 25, 2014) include additional data elements related to equipment leaks that onshore production facilities must begin reporting in RY2015. Onshore petroleum and natural gas production facilities must report the following separately by component type, service type, and geographic location (i.e., Eastern U.S. or Western U.S.) for both calculation methods (Methodology 1 and Methodology 2):

- total number of the emission source type at the facility (e.g., valves, connectors, PRVs, etc.) (note, this is already reported for facilities using Methodology 1 as of RY2014);
- average estimated time that the emission source type was operational in the calendar year; and
- calculation method used (i.e., Methodology 1 using major equipment counts or Methodology 2 using actual component counts).

Additionally, for each major equipment type, production type (i.e., natural gas or crude oil) and geographic location combination in Tables W-1B and W-1C of subpart W, facilities must report an indication of whether the facility contains the major equipment type and if the facility does contain the equipment type, the count of the major equipment type.

Gas STAR Reductions Considerations

Approach 2 for revising GHGI methodology to incorporate subpart W data would result in net emissions being directly calculated in each time series year. As discussed above, this obviates the need to apply Gas STAR reductions data for these sources. Table 12 below presents production segment emissions by source in the 2015 GHGI. There are significant Gas STAR reductions in the production segment that are not classified as applicable to specific emission sources (“Other voluntary reductions” are 16 MMT CO₂e CH₄ in year 2013). Some portion of the “other voluntary reductions” might apply to the emission sources for which the EPA is considering revising the activity data basis to reflect the subpart W definition of an onshore production facilities (excluding centralized production and gathering-only facilities). The EPA is investigating potential disaggregation of “other voluntary reductions.”

Table 12. Year 2013 Production Segment CH₄ Emissions by Source in the 2015 GHGI Inventory

All Production Emission Sources	Potential Emissions (MMT CO₂e)	Reduction (MMT CO₂e)	Net Emissions (MMT CO₂e)
Pneumatic Controllers (Vented)	40.8	22.6	18.2
Major Equipment (Fugitive)	12.0	-	12.0
Chemical Injection Pumps (Vented)	3.0	0.1	2.9
Other Vented	36.6	0.01 ^a	36.5
Other Fugitive	6.9	-	6.9
Combustion	9.0	3.5 ^b	5.5
Offshore	8.4	-	8.4
Upsets	0.1	-	0.1
Other Voluntary Reductions	n/a	16.5	n/a
Regulatory Reductions	n/a	3.0 ^c	n/a
Total	116.9	45.7	71.2

a – Natural gas systems, compressor starts.

b – Natural gas systems, compressor gas engine exhaust.

c – Due to NESHAP regulations addressing condensate storage tanks and dehydrators, in effect for year 1999 forward.

Table 13. Year 2013 Production Segment CH₄ Emissions from Pneumatic Controllers and Equipment Leaks

Emission Source (Production Type)	2015 GHGI potential estimate (MMT CO₂e)	2015 GHGI reduction estimate (MMT CO₂e)	2015 GHGI net estimate (MMT CO₂e)	2015 GHGI Activity	Approach 2: Subpart W Scaled Activity	Approach 2: Revised net (MMT CO₂e)
Pneumatic Controllers (NG)	29.0	15.5	13.5	459,304	826,053	26.0
Pneumatic Controllers (Petro)	11.9	7.1	4.7	452,170	1,165,849	37.7
Wellheads (NG)	1.3	-	1.3	451,296	n/a	1.3
Wellheads (Petro)	1.5	-	1.5	863,900	n/a	1.5
Separators (NG)	2.6	-	2.6	265,586	303,124	2.9
Separators (Petro)	0.3	-	0.3	122,636	374,206	0.8
Chemical Injection Pumps (NG)	1.6	-	1.6	35,812	82,365	3.7
Chemical Injection Pumps (Petro)	1.4	-	1.4	31,066	122,607	5.3
Heaters (NG)	0.8	-	0.8	107,735	97,986	0.7
Dehydrators (NG)	0.8	-	0.8	62,919	16,944	0.2
Meters/piping (NG)	2.6	-	2.6	390,586	518,321	3.5
Wellpad Compressors (NG)	1.7	-	1.7	35,354	48,002	2.4
Heater-treaters (Petro)	0.3	-	0.3	84,262	109,313	0.4
Headers (Petro)	0.1	-	0.1	92,395	140,564	0.2

Requests for Stakeholder Feedback

General use of Subpart W data

- 1) The EPA seeks feedback on how to take into account the reporting threshold when using subpart W data, and the appropriateness of using subpart W-based AFs for the national population of major equipment and pneumatic controllers.
 - a. Are other data sources available that would help the EPA determine characteristics of the non-reporting population?
 - b. Are other approaches available for scaling up this data for use in the GHGI?
- 2) The EPA seeks feedback on other data sources (e.g., Allen et al. 2013 and 2014, the Prasiino Group 2013) that could be considered for the development of emission factors for equipment leaks and/or pneumatic controllers.
 - a. Allen et al. 2014 study did not differentiate between controller types. Is it possible to disaggregate the Allen emissions data in a way that would allow the EPA to calculate emissions for various control types?
- 3) The EPA seeks feedback on how to take into account reported emissions data under subpart W for major equipment fugitives in the GHGI. For reporters using equipment leak methodology 1 (98% of reporters in RY2014), emissions data are reported at the facility level based on use of component-level EFs specified in the rule, not at the equipment level. The EPA seeks feedback on how to use such data in developing equipment-specific fugitive EFs that could be applied in the natural gas and petroleum systems segments of the GHGI. The subpart W specified EF for reporting vented emissions from CIPs uses the same basis (GRI/EPA) as the current GHGI. The EPA is considering adjusting the GHGI emission factor for CIP using subpart W reported data, which takes into account operating hours.

Calculations using Subpart W data

- 4) The EPA seeks feedback on the methodology for allocating subpart W data between the natural gas and petroleum production segments. Are other approaches available for allocating subpart W equipment and pneumatic controller counts between production types? For example, one limitation in the current methodology is that for facilities covering both oil and gas sub-basins and having separators, the count of separators-per-gas well is equivalent to separators-per-oil well.
- 5) The EPA seeks feedback on whether and how to use subpart W data to reflect geographic variation of activity factors and/or emission factors. In the current GHGI, emissions from natural gas systems are calculated separately for six NEMS regions, and emissions from petroleum systems do not have geographic variation. The update under consideration is applied at the national level. The EPA plans to explore options to reflect geographic variation in future GHGIs.
- 6) The EPA seeks stakeholder feedback on year-to-year trends in reported subpart W data, and whether it is more appropriate to recalculate activity factors and/or emission factors separately for each RY, or to use another approach (e.g., combine data from multiple early RYs such as the current methodology for hydraulically fractured gas well completions which uses combined RY2011 through RY2013 data to calculate the emission factor).
- 7) The EPA seeks feedback on how to address time series consistency in using AFs derived from subpart W data—i.e., calculating activity in years between the early 1990s base year and recent

subpart W-era years. As discussed under “Time Series Considerations” the EPA might use the count of active production wells as an activity data driver for major equipment and total pneumatic controller counts in natural gas systems, and simple linear interpolation for petroleum systems. The EPA could consider taking into account other factors (e.g., year to year production changes). The EPA seeks stakeholder feedback on other factors that impact equipment counts and potential methods to incorporate these factors into the GHGI calculations.

Other Emission Sources

- 8) The EPA discusses potential revisions to the GHGI production segment structure in a companion memo titled “GHGI of U.S. Greenhouse Gas Emissions and Sinks: Revisions under Consideration for Natural Gas Gathering and Boosting Emissions” (February 2016). Potential revisions would include updating some of the production emission calculation methodologies based on Marchese et al. (2015) measurement data for centralized production and gathering-only facilities. With such revisions, certain emission sources would overlap with the Marchese et al. facility-level EF if current methodology were retained: dehydrator vents, kimray pumps, and storage tanks. The EPA seeks feedback on how to improve GHGI activity, emissions, and controls data for sources located at non-gathering production sites based on available subpart W data.
- 9) The EPA seeks stakeholder feedback on production segment sources not discussed in this memorandum.
 - a. For sources where GHGRP data are currently available, the EPA seeks stakeholder feedback on how GHGRP data may be used to revise current GHGI methodologies. For example, the EPA seeks stakeholder feedback on whether similar methods to those discussed in this memorandum could be used to scale up subpart W activity data for sources such as liquids unloading and hydraulically fractured (HF) gas well completions
 - b. For sources where GHGRP data are not currently available, the EPA seeks stakeholder feedback on data sources available for updates to those methodologies. The EPA is considering including emissions from hydraulically fractured oil well completions and workovers in the GHGI, using information from the 2015 NSPS OOOOa proposal. In addition, the EPA seeks stakeholder feedback on any currently available or upcoming activity and/or emissions data on abandoned wells.
- 10) Recent production segment studies have detected the presence of superemitters in the production segment. The EPA seeks stakeholder feedback on how to incorporate information on superemitters into estimates for the production segment. The EPA also seeks stakeholder feedback on which GHGI sources are more likely than others to act as superemitters and whether and how to apply a superemitter factor or other methodology to those sources.

APPENDIX A

Table A-1. Alignment of GHGI and Subpart W Activity Data Elements

GHGI Emission Source	GHGI Activity	GHGI Activity Basis	Corresponding Subpart W Data Element
Natural Gas Systems			
Natural Gas-driven Pneumatic Controllers			
Pneumatic Controllers	Controllers	Calculated using 1992 data on pneumatic controller counts per gas well	Annual counts of low-bleed, high-bleed, and intermittent bleed NG pneumatic controllers from reporting facilities
Equipment Leaks/Fugitives			
Associated Gas Wells	Wells	direct	Annual count of wellheads from reporting facilities using EL Methodology 1
Non-associated Gas Wells (less fractured wells)	Wells	direct	
Gas Wells with Hydraulic Fracturing	Wells	direct	
Heaters	Heaters	Calculated using 1992 data on heaters per non-associated gas well	Annual count of in-line heaters from reporting facilities using EL Methodology 1
Separators	Separators	Calculated using 1992 data on separators per non-associated gas well	Annual count of separators from reporting facilities using EL Methodology 1
Dehydrators	Dehydrators	Calculated using 1992 data on dehydrators per non-associated gas well	Annual count of dehydrators from reporting facilities using EL Methodology 1
Meters/Piping	Meters	Calculated using 1992 data on meters per all gas wells	Annual count of meters/piping from reporting facilities using EL Methodology 1
Petroleum Systems			
Natural Gas-driven Pneumatic Controllers			
Pneumatic Controllers, High Bleed	controller	Calculated based on total number of separators + heater/treaters and assumed percent of population that is high bleed versus low bleed	Annual count of high-bleed NG pneumatic controllers
Pneumatic Controllers, Low Bleed	controller		Annual count of low-bleed NG pneumatic controllers
Pneumatic Controllers, Intermittent Bleed	N/A		N/A
Equipment Leaks/Fugitives			
Oil Wellheads (heavy crude)	Oil well	Calculated based on total producing oil wells (less 80% of stripper wells) and ratio of heavy crude wells to total crude wells	Annual count of wellheads from facilities using EL Methodology 1
Oil Wellheads (light crude)	Oil well		
Separators (heavy crude)	separator	Calculated using 1993 base year factor; scaled using annual domestic production and total producing oil wells	Annual count of separators from facilities using EL Methodology 1
Separators (light crude)	separator		
Heater-Treaters (light crude)	heater	Calculated using 1993 base year factor; scaled using annual domestic production and total producing oil wells	Annual count of heater/treaters from facilities using EL Methodology 1
Headers (heavy crude)	header	Calculated based on total producing oil wells and ratio of heavy crude production wells to total crude production wells	Annual count of headers from facilities using EL Methodology 1
Headers (light crude)	header		