Inventory of U.S. Greenhouse Gas Emissions and Sinks: Updates Under Consideration to Use Revised Subpart W Emission Factors

This memo discusses updates under consideration for the *Inventory of U.S. Greenhouse Gas Emissions and Sinks* (GHGI) to incorporate revised Greenhouse Gas Reporting Program (GHGRP) subpart W emission factors (EFs).

The EPA recently revised subpart W and, as part of this revision, provided revised default EFs for certain emission sources and industry segments.[1] With the exception of certain methodologies that became optionally available to reporters on July 15, 2024, the majority of the revised subpart W requirements become effective January 1, 2025 and reporters will begin using them for reporting year (RY) 2025 data (available in 2026). However, some of the revised subpart W emission source calculation methodologies rely on default EFs that could be incorporated into the GHGI calculation methodologies before the reported subpart W data are available. EPA is considering incorporating the revised EFs into a future GHGI, potentially as early as the 2026 GHGI, because they are based on the best and most recent available data. EPA reviewed the revised EFs and identified potential opportunities to improve the GHGI, in areas where revised subpart W default EFs are available for the following emission sources and industry segments:

- Pneumatic controllers (see Section 1) for:
  - Onshore production
  - Gathering and boosting (G&B)
  - Transmission compression
  - Underground natural gas (NG) storage
- Equipment leaks for onshore production (see Section 2)
- Pipeline leaks for gathering pipelines and transmission pipelines (see Section 3)

EPA is also considering the following methodological changes:

- Equipment leaks for onshore production: incorporation of leak survey data (see Section 2)
- Use of material-specific onshore transmission pipeline miles (see Section 3)

EPA will consider stakeholder feedback on the updates under consideration for inclusion in a future GHGI.

1 Pneumatic Controllers

1.1 Current 2024 GHGI Methodology

1.1.1 Production

EPA estimates pneumatic controller emissions using activity factors (AFs) and EFs that are specific to low-bleed, intermittent-bleed, and high-bleed controllers. The current GHGI methodology is documented in the memo *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2021: Updates to Incorporate Additional Geographically Disaggregated Data for the Production Segment* (referred to as the 2023 Production Segment Data Disaggregation memo).[2]

EPA calculates year-specific AFs for each controller type (i.e., high-bleed, intermittent-bleed, and low-bleed) at the basin-level using subpart W data for 2011 forward. Two types of AFs are calculated: (1) the average number of controllers per well and (2) the fraction of controllers that are low-bleed, intermittent-bleed, and high-bleed controllers. The number of controllers per well can only be calculated beginning with RY2015, so RY2015 AFs are

[1] Additional information on the 2024 subpart W revisions, including the preamble and rule, are available here: https://www.epa.gov/ghgreporting/subpart-w-rulemaking-resources

[2] The 2023 Production Segment Data Disaggregation memo is available here: https://www.epa.gov/system/files/documents/2023-04/2023_ghgi_update_disaggregated_production_data.pdf

applied to 2011 through 2014. EPA also calculates the AFs separately for pneumatic controllers at gas wells and oil wells. For basins without subpart W data, national-level average AFs are applied.

For pneumatic controllers at gas wells, the average number of controllers per well and fraction of each controller type are available by National Energy Modeling System (NEMS) region for 1990 through 1992 from the 1996 GRI/EPA study.[3] The AFs for intermediate years in the time-series (i.e., 1993-2010) are calculated using linear interpolation between the 1992 and 2011 values at the basin-level.

For pneumatic controllers at oil wells, EPA estimated the total number of controllers per well and the fraction of each controller type for 1990 through 1993 based on the consensus of an Industry Review Panel. The AFs for intermediate years in the time-series (i.e., 1994-2010) are calculated using linear interpolation between the 1993 and 2011 values at the basin-level.

The annual AFs are multiplied by basin-level gas well and oil well counts from Enverus to calculate the number of controllers in each basin.

EPA also calculates year-specific basin-level CH_4 EFs (scfd/controller) using subpart W data for RY2011 forward. The basin-level EFs are calculated separately for gas wells and oil wells. For basins without subpart W data, EPA applies national average EFs calculated from subpart W data. The 2011 CH_4 EFs are then used for all prior years in the time series (i.e., 1990-2010). The CH_4 EFs for the entire time series are converted into CO_2 EFs using a basin-specific CO_2-to-CH_4 ratio.

1.1.2 Gathering and Boosting

The current GHGI calculates pneumatic controller emissions for gathering and boosting (G&B) stations using subpart W data. Year-specific EFs are calculated for each controller type (high-bleed, intermittent-bleed, and low-bleed) using subpart W data for years 2016 forward and the 2016 EF is applied to all prior years. To determine the number of each type of controller for 2016 forward, subpart W pneumatic controller counts are scaled up to the national level by assuming that 93 percent of all G&B stations report to subpart W. To determine the number of each type of controller for 1990 through 2015, the average number of controllers per G&B station are calculated from year 2016 data and are then multiplied by the G&B station counts for each year. The current GHGI methodology is documented in the memo *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2018: Updates to Natural Gas Gathering & Boosting Station Emissions*.[4]

1.1.3 Transmission

The current GHGI calculates pneumatic controller emissions for transmission compressor stations using data from subpart W and the 1996 GRI/EPA study. The current GHGI methodology is documented in the memoranda *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2014: Revisions to Natural Gas Transmission and Storage Emissions* and *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2016: Revisions to CO2 Emissions Estimation Methodologies*.[5] EPA calculates year-specific EFs for each controller type (high-bleed, intermittent-bleed, and low-bleed), the year-specific average number of pneumatic controllers per compressor station, and the year-specific fraction of each controller type using subpart W data for years 2011 forward. The EFs and AFs are multiplied by the transmission compressor station count for each year. For 1990 through 1992, the total number of pneumatic controllers and the average emissions per pneumatic controller are estimated

[3] GRI/EPA. Methane Emissions from the Natural Gas Industry. June 1996. EPA-600/R-96-080a. Each volume of the 1996 GRI/EPA study is available here: https://www.epa.gov/natural-gas-star-program/methane-emissions-natural-gas-industry

[4] The G&B memo is available here: https://www.epa.gov/sites/default/files/2020-04/documents/2020_ghgi_update_-_gb_stations_final.pdf

[5] The transmission memos are available here: https://www.epa.gov/sites/default/files/2016-08/documents/final_revision_ng_trans_storage_emissions_2016-04-14.pdf and https://www.epa.gov/sites/default/files/2018-04/documents/ghgemissions_co2_2018.pdf.

from the 1996 GRI/EPA study and EPA calculates station total pneumatic controller emissions (i.e., not broken down by controller type).

EPA uses linear interpolation to calculate emissions for 1993 through 2010. EPA calculates the total number of pneumatic controllers for year 2011, based on applying the subpart W RY2011 number of pneumatic controllers per compressor station, and then applies linear interpolation between the total pneumatic controller counts for 1992 and 2011 to determine the number of controllers for each intermediate year. Similarly, EPA calculates the overall average emissions per pneumatic controller for year 2011 and linearly interpolates from this value to the 1992 average emissions per pneumatic controller.

1.1.4 Underground NG Storage

The current GHGI calculates pneumatic controller emissions for underground natural gas (NG) storage stations using data from subpart W and the 1996 GRI/EPA study. The methodology is identical to that used for transmission compressor station pneumatic controller emissions but relies on underground NG storage data (see the memos cited in Section 1.1.3 for details on the current GHGI methodology). EPA calculates year-specific EFs for each controller type (high-bleed, intermittent-bleed, and low-bleed), the year-specific average number of pneumatic controllers per underground NG storage station, and the year-specific fraction of each controller type using subpart W data for years 2011 forward. The EFs and AFs are multiplied by the annual underground NG storage station counts. For 1990 through 1992, the total number of pneumatic controllers and the average emissions per pneumatic controller are estimated from the 1996 GRI/EPA study and EPA calculates station total pneumatic controller emissions (not broken down by controller type).

The current GHGI uses linear interpolation to calculate emissions for 1993 through 2010. EPA calculates the total number of pneumatic controllers for year 2011, based on applying the subpart W RY2011 number of pneumatic controllers per underground NG storage station, and then applies linear interpolation between the total pneumatic controller counts for 1992 and 2011 to determine the number of controllers for each intermediate year. Similarly, EPA calculates the overall average emissions per pneumatic controller for year 2011 and linearly interpolates from this value to the 1992 average emissions per pneumatic controller.

1.2 Available Data

The subpart W revisions included revised population EFs for pneumatic controllers in the production, gathering and boosting, transmission, and underground NG storage industry segments. The pneumatic controller EFs are specific to bleed type (i.e., low-bleed, high-bleed, and intermittent-bleed). EPA is considering incorporating the revised population EFs into the GHGI emission calculation methodologies for each industry segment.

1.3 Analysis of Available Data

1.3.1 Production

EPA is considering incorporating the revised subpart W population EFs into the emissions calculations for pneumatic controllers in the onshore production segment. EPA is not considering other updates to the calculation methodology, and basin-specific EFs and AFs would still be calculated. Table 1-1 compares the current and revised subpart W population EFs for low-bleed, high-bleed, and intermittent-bleed pneumatic controllers along with a ratio of the two EFs and the data sources that underly the EFs. The revised low-bleed pneumatic controller EF is significantly higher than the current EF, while the revised high-bleed and intermittent-bleed EFs are both lower than the current subpart W EFs.

Table 1-1. Comparison of Pneumatic Controllers Whole Gas Emission Factors in the Production Segment for the Current Subpart W and Revised Subpart W Requirements

Bleed Type	Subpart W EFs (scf/hr/controller)		Bleed Type EF Ratio (Revised/Current)
	Current EF[a]	Revised EF[b]	
Low-Bleed	1.39	6.8	4.89
High-Bleed	37.3	21	0.56
Intermittent-Bleed	13.5	8.8	0.65

a. The current EFs are from the 1996 GRI/EPA study.
b. The revised EFs were developed using data from the following sources: 1996 GRI/EPA study, Prasino Group 2013, Allen et al. 2015, Luck et al. 2019, Tupper 2019 (API study). See Section 1.4 for citations for each source.

The subpart W pneumatic controller calculation methodology using population EFs has no other substantive revisions, and reporters account for their specific methane content and operating hours when calculating emissions. As such, multiplying the reported subpart W pneumatic controller emissions by the ratios in Table 1-1 would reflect the use of the revised EFs and maintain the facility-specific characteristics for methane content and operating hours. By applying these ratios directly to the data reported, it would also subsequently affect the basin- and year- specific EFs that are calculated using the reported emissions for each bleed type. Because CO_2 emissions are calculated by multiplying CH_4 emissions by a basin-specific CO_2-to-CH_4 ratio, the revised population EFs would be incorporated into the CO_2 emissions as well. Table 1-2 and Table 1-3 present the EFs calculated after applying the ratio for each bleed type for pneumatic controllers at gas wells and oil wells, for the basins with the highest number of pneumatic controllers in the production segment in RY2023.

Table 1-2. Comparison of Year 2022 Gas Well Pneumatic Controller CH_4 EFs in the Production Segment for Select Basins for the GHGI Update Under Consideration Versus the Current 2024 GHGI

Basin	Basin Number	2022 Low-Bleed EFs (scfd CH_4/controller)		2022 High-Bleed EFs (scfd CH_4/controller)		2022 Intermittent-Bleed EFs (scfd CH_4/controller)	
		2024 GHGI	GHGI Update Under Consideration	2024 GHGI	GHGI Update Under Consideration	2024 GHGI	GHGI Update Under Consideration
Appalachian (Eastern Overthrust Area)	160A	28	136	536	302	168	111
Anadarko	360	23	112	664	375	235	153
Green River Basin	535	27	137	674	379	122	113
San Juan	580	14	92	803	452	185	99
Piceance	595	22	110	0	0	135	116

Table 1-3. Comparison of Year 2022 Oil Well Pneumatic Controller CH_4 EFs in the Production Segment for Select Basins for the GHGI Update Under Consideration Versus the Current 2024 GHGI

Basin	Basin Number	2022 Low-Bleed EFs (scfd CH_4 /controller)		2022 High-Bleed EFs (scfd CH_4/controller)		2022 Intermittent-Bleed EFs (scfd CH_4/controller)	
		2024 GHGI	GHGI Update Under Consideration	2024 GHGI	GHGI Update Under Consideration	2024 GHGI	GHGI Update Under Consideration
Gulf Coast (LA, TX)	220	23	113	674	380	202	132
Williston	395	16	81	635	358	156	102
Permian	430	22	110	572	332	207	135
Denver	540	14	69	0	0	128	83
Uinta	575	25	123	0	0	152	146

In terms of the emissions impact from this update under consideration, since the emissions are calculated at the basin-level, the fraction of each pneumatic controller bleed type for each basin will determine whether emissions increase or decrease. For example, basins with a high fraction of low-bleed controllers will see an increase in emissions while basins with a high fraction of intermittent-bleed or high-bleed controllers will see a decrease in emissions. Section 1.6 and Appendix A present the calculated emissions for this update under consideration compared to the current GHGI.

1.3.2 Gathering and Boosting

EPA is considering incorporating the revised subpart W population EFs into the emissions calculations for pneumatic controllers in the G&B segment. EPA is not considering updates to the G&B pneumatic controller activity data methodology. Table 1-4 compares the current and revised subpart W population EFs for low-bleed, high-bleed, and intermittent-bleed pneumatic controllers along with a ratio of the two EFs. The revised low-bleed pneumatic controller EF is significantly higher than the current EF, while the revised high-bleed and intermittent-bleed EFs are both lower than the current subpart W EFs.

Table 1-4. Comparison of Pneumatic Controllers Whole Gas EFs in the G&B Segments for the Current Subpart W and Revised Subpart W Requirements

Controller Bleed Type	Subpart W EFs (scf/hr/controller)		Bleed Type EF Ratio (Revised / Current)
	Current EF[a]	Revised EF[b]	
Low-Bleed	1.39	6.8	4.89
High-Bleed	37.3	21	0.56
Intermittent-Bleed	13.5	8.8	0.65

a. The current EFs are from the 1996 GRI/EPA study.
b. The revised EFs were developed using data from the following sources: 1996 GRI/EPA study, Prasino Group 2013, Allen et al. 2015, Luck et al. 2019, Tupper 2019 (API study). See Section 1.4 for citations for each source.

As discussed in Section 1.3.1, the subpart W pneumatic controller calculation methodology using population EFs was not otherwise substantively revised. As such, multiplying the reported subpart W pneumatic controller emissions by the ratios in Table 1-4 would reflect the use of the revised EFs and maintain the facility-specific characteristics for methane content and operating hours. By applying these ratios directly to the data reported, it would subsequently affect the year-specific EFs that are calculated using the reported emissions for each bleed type. Table 1-5 presents the EFs calculated after applying the ratio for each bleed type for 2022.

Table 1-5. Comparison of Pneumatic Controllers CH_4 EFs (mt/controller) in the G&B Segment for GHGI Update Under Consideration Versus the Current 2024 GHGI, Year 2022

Controller Bleed Type	2024 GHGI	GHGI Update Under Consideration
Low-Bleed	0.18	0.88
High-Bleed	4.85	2.70
Intermittent-Bleed	1.63	1.08

1.3.3 Transmission

EPA is considering incorporating the revised subpart W population EFs into the emissions calculations for pneumatic controllers in the transmission segment. EPA is not considering updates to the AFs calculated using subpart W. Table 1-6 compares the current and revised subpart W population EFs for low-bleed, high-bleed, and intermittent-bleed pneumatic controllers along with a ratio of the two EFs (the same EFs are used for the transmission and underground NG storage segments). The revised low-bleed and high-bleed pneumatic controller EFs are higher while the intermittent-bleed EF did not change.

Table 1-6. Comparison of Pneumatic Controllers Whole Gas EFs in the Transmission & Storage Segments for the Current Subpart W and Revised Subpart W Requirements

Controller Bleed Type	Subpart W EFs (scf/hr/controller)		Bleed Type EF Ratio (Revised / Current)
	Current EF[a]	Revised EF[b]	
Low-Bleed	1.37	6.8	4.96
High-Bleed	18.2	30	1.65
Intermittent-Bleed	2.3	2.3	1

a. The current EFs are from the 1996 GRI/EPA study.
b. The revised low-bleed EF was developed using data from the following sources: 1996 GRI/EPA study, Prasino Group 2013, Allen et al. 2015, Luck et al. 2019, Tupper 2019 (API study). The revised high-bleed EF is from Zimmerle et al. 2015. See Section 1.4 for citations for each source.

As discussed in Section 1.3.1, the subpart W pneumatic controller calculation methodology using population EFs was not otherwise substantively revised. As such, multiplying the reported subpart W pneumatic controller emissions by the ratios in Table 1-6 would reflect the use of the revised EFs and maintain the facility-specific characteristics for methane concentration and operating hours. In the update under consideration, for 2011 forward, the CH_4 emissions reported to subpart W would be multiplied by the ratio of the revised population EF to the current population EF, specific to each bleed type. By applying these ratios directly to the data reported, it would subsequently affect the year- specific EFs that are calculated using the reported emissions for each bleed type. Table 1-7 presents the EFs calculated after applying the ratio for each bleed type from 2021 through 2023.

Table 1-7. Comparison of Pneumatic Controllers CH_4 EFs in the Transmission Segment for the Update Under Consideration Versus the Current 2024 GHGI

Controller Bleed Type	2022 Calculated EFs (scf CH_4/yr/controller)	
	2024 GHGI	GHGI Update Under Consideration
Low-Bleed	11,508	57,120
High-Bleed	147,418	242,997
Intermittent-Bleed	19,500	19,500

Currently, pneumatic controller emissions in the transmission segment are not divided into high-bleed, low-bleed, and intermittent-bleed for years 1990 through 2010; rather, EPA calculates emissions for total pneumatic controllers. EPA is considering calculating emissions specific to bleed type from 1990 through 2010, which would require developing AFs that represent the fraction of total controllers that are attributed to each bleed type, as well as EFs for each bleed type. In the 1996 GRI/EPA study, the total pneumatic controller EF calculation assumes that 32 percent of pneumatic controllers are continuous bleed controllers and 68 percent are turbine controllers or displacement controllers (types of intermittent-bleed controllers). EPA is considering applying these AFs so that from 1990-1992, 32 percent of pneumatic controllers are high-bleed, 68 percent are intermittent-bleed, and 0 percent are low-bleed. The AFs from 1993 through 2011 would be linearly interpolated between 1992 and 2011 values. In addition, the total pneumatic controller EF calculation in the 1996 GRI/EPA study can be disaggregated to calculate separate EFs for high-bleed and intermittent-bleed pneumatic controllers. EPA is considering applying the EF for continuous bleed controllers in the 1996 GRI/EPA study as the high-bleed EF for 1990-1992. EPA is then considering combining the data for turbine controllers and displacement controllers from the 1996 GRI/EPA study to calculate a weighted EF for intermittent-bleed controllers, based on the proportion of the turbine controller AF and displacement controller AF in the total intermittent-bleed controller AF, which is the sum of the two values. Table 1-8 presents the EFs and AFs from the GRI/EPA study and their correlation with the high-bleed and intermittent-bleed EFs and AFs for 1990-1992.

Table 1-8. Comparison of High-Bleed and Intermittent-Bleed Pneumatic Controllers EFs and AFs in 1996 GRI/EPA Study and Calculated EFs and AFs for the Update Under Consideration

Controller Type	1990-1992	
	AF (fraction of total controllers)	EF (scf whole gas/yr/controller)
High-Bleed (GHGI Update Under Consideration)	**0.32**	**497,584**
Continuous-Bleed Controllers (GRI/EPA)	0.32	497,584
Intermittent-Bleed (GHGI Update Under Consideration)	**0.68**	**20,209**
Turbine Controllers (GRI/EPA)	0.16	67,599
Displacement Controllers (GRI/EPA)	0.52	5,627

1.3.4 Underground NG Storage

EPA is considering incorporating the revised subpart W population EFs into the emissions calculations for the underground NG storage segment of pneumatic controllers. EPA is not considering updates to the AFs calculated using subpart W. Table 1-6 above compares the current and revised subpart W population EFs for low-bleed, high-bleed, and intermittent-bleed pneumatic controllers along with a ratio of the two EFs, as both the transmission and storage segments use the same population EFs. The revised low-bleed and high-bleed pneumatic controller EFs are higher while the intermittent-bleed EF did not change.

As discussed in Section 1.3, the subpart W pneumatic controller calculation methodology using population EFs was not otherwise substantively revised. As such, multiplying the reported subpart W pneumatic controller emissions by the ratios in Table 1-6 would reflect the use of the revised EFs and maintain the facility-specific characteristics for methane concentration and operating hours. In the update under consideration, for 2011 forward, the CH_4 emissions reported to subpart W would be multiplied by the ratio of the revised population EF to the current population EF, specific to each bleed type. By applying these ratios directly to the data reported, it would subsequently affect the year-specific EFs that are calculated using the reported emissions for each bleed type. Table 1-9 presents the EFs calculated after applying the ratio for each bleed type from 2021 through 2023.

Table 1-9. Comparison of Pneumatic Controllers CH_4 EFs in the Storage Segment for the GHGI Update Under Consideration Versus the Current 2024 GHGI

Controller Bleed Type	2022 Calculated EFs (scf CH_4/yr/controller)	
	2024 GHGI	GHGI Update Under Consideration
Low-Bleed	11,424	56,702
High-Bleed	148,910	245,455
Intermittent-Bleed	19,597	19,597

Currently, pneumatic controller emissions in the storage segment are not divided into high-bleed, low-bleed, and intermittent-bleed from 1990 through 2010; rather, EPA calculates emissions for total pneumatic controllers. EPA is considering calculating emissions specific to bleed type from 1990 through 2010, which would require developing AFs that represent the fraction of total controllers that are attributed to each bleed type, as well as EFs for each bleed type. In the 1996 GRI/EPA study, the 1992 total pneumatic controller EF calculation assumes that 32 percent of pneumatic controllers are continuous bleed controllers and 68 percent are turbine controllers or displacement controllers (types of intermittent-bleed controllers). EPA is considering applying these AFs for 1990-1992 such that, 32 percent of pneumatic controllers are high-bleed, 68 percent are intermittent-bleed, and 0 percent are low-bleed. The AFs from 1993 through 2011 would be calculated using linear interpolated between the 1992 and 2011 values. In addition, the total pneumatic controller EF calculation in the 1996 GRI/EPA study can be disaggregated to calculate separate EFs for high-bleed and intermittent-bleed pneumatic controllers. EPA is considering applying the EF for continuous bleed controllers in the 1996 GRI/EPA study as the high-bleed EF for 1990-1992. EPA is then considering combining the data for turbine controllers and displacement controllers from the 1996 GRI/EPA study to calculate a weighted EF for intermittent-bleed controllers, based on the proportion of the turbine controller AF and displacement controller AF in the total intermittent-bleed controller AF, which is the sum of the two values. Table 1-8 presents the EFs and AFs from the GRI/EPA study and their correlation with the high-bleed and intermittent-bleed EFs and AFs that EPA is considering using for the update under consideration for 1990-1992.

1.4 Time Series Considerations

1.4.1 Production

EPA is considering applying revised population EFs for the basin- and year-specific EFs from 2011 through 2023 (i.e., the EFs calculated from subpart W with application of the ratios in Table 1-1), but EPA is not considering incorporating them across the entire time series. The revised population EFs are based on various studies, including the 1996 GRI/EPA study, the 2015 Allen et al. study[6], the 2013 Prasino Group study[7], the 2019 Luck et al.[8] study, and the 2019 API study[9]. The more recent studies (2013-2019) may not be representative of conditions in the early 1990s, due to changes in pneumatic controller design, operation, and their lifespan (i.e, pneumatic controllers in the early 1990s would not be in operation today). Therefore, for 1990-1992, EPA is considering retaining the current GHGI EFs calculated from unadjusted RY2011 subpart W emissions (i.e., use the current subpart W EFs, based on the 1996 GRI/EPA study). 2011 is the first year the applicable subpart W pneumatic controllers data are available for the onshore production segment. From 1993 through 2010, the EFs would be

[6] Allen, D.T., et al., 2015. ''Methane Emissions from Process Equipment at Natural Gas Production Sites in the United States: Pneumatic Controllers.'' *Environmental Science & Technology*. 49, 633–640. dx.doi.org/10.1021/es5040156.

[7] The Prasino Group (2013). ''Determining Emissions Factors for Pneumatic Devices in British Columbia—Final Field Sampling Report.'' November 15. Also, ''Final Report—For Determining Bleed Rates for Pneumatic Devices in British Columbia.'' December 18.

[8] Luck, B., *et al.,* 2019. ''Multiday Measurements of Pneumatic Controller Emissions Reveal the Frequency of Abnormal Emissions Behavior at Natural Gas Gathering Stations.'' *Environmental Science & Technology Letters 6* (6), 348–352.

[9] Tupper, P. 2019. ''API Field Measurement Study: Pneumatic Controllers'' presented at the EPA Stakeholder Workshop on Oil and Gas in Pittsburgh, Pennsylvania, on November 7, 2019.

interpolated between 1992 basin-specific EFs, which would incorporate the current population EFs, and 2011 basin-specific EFs, which would incorporate the revised population EFs. In summary, the methodology under consideration would use EFs based on the 1996 GRI/EPA study data for 1990 through 1992, incorporate the more recent emissions studies for 2011 through 2023, and interpolate for intermediate years.

1.4.2 Gathering and Boosting

EPA is considering applying revised population EFs for the year-specific EFs from 2016 through 2023 (i.e., the EFs calculated from subpart W with application of the ratios in Table 1-4), but EPA is not considering incorporating them across the entire time series. The revised population EFs are based on various studies, including the 1996 GRI/EPA study, the 2015 Allen et al. study[6], the 2013 Prasino Group study[7], the 2019 Luck et al. study[8], and the 2019 API study[9]. The more recent studies (2013-2019) may not be representative of conditions in the early 1990s, due to changes in pneumatic controller design, operation, and their lifespan (i.e, pneumatic controllers in the early 1990's would not be in operation today). Therefore, for 1990-1992, EPA is considering retaining the current GHGI EFs calculated from unadjusted RY2016 subpart W emissions (i.e., use the current subpart W EFs, based on the 1996 GRI/EPA study). 2016 is the first year the applicable subpart W pneumatic controllers data are available for the G&B segment. From 1993 through 2015, the EFs would be interpolated between the 1992 EFs, which would incorporate the current population EFs, and the 2016 EFs, which would incorporate the revised population EFs. In summary, the methodology under consideration would use EFs based on the 1996 GRI/EPA study data for 1990 through 1992, incorporate the more recent emissions studies for 2016 through 2023, and interpolate for intermediate years.

1.4.3 Transmission

EPA is considering applying revised population EFs for the year-specific EFs from 2011 through 2023 (i.e., the EFs calculated from subpart W with application of the ratios in Table 1-6), but EPA is not considering incorporating them across the entire time series. The revised low-bleed population EFs are based on various studies, including the 1996 GRI/EPA study, the 2015 Allen et al. study[6], the 2013 Prasino Group study[7], the 2019 Luck et al. study[8], and the 2019 API study[9], and the revised high-bleed population EFs are based on the 2015 Zimmerle et al. study[10]. The more recent studies (2013-2019) may not be representative of conditions in the early 1990s, due to changes in pneumatic controller design, operation, and their lifespan (i.e, pneumatic controllers in the early 1990's would not be in operation today). Therefore, for 1990-1992, as discussed in Section 3.1.3 EPA is considering updating the methodology so that the 1996 GRI/EPA study data is disaggregated to calculate EFs specific to high-bleed and intermittent-bleed pneumatic controllers, as well as the fraction of total controllers that are high-bleed or intermittent-bleed controllers. 2011 is the first year the applicable subpart W pneumatic controllers data are available for the transmission segment. From 1993 through 2010, the EFs and AFs for high-bleed and intermittent-bleed controllers would be interpolated between the 1992 EFs and the 2016 EFs, which would incorporate the revised population EFs. For low-bleed pneumatic controllers, EPA is considering applying the 2011 EF, calculated using subpart W data, to all prior years in the time series.

1.4.4 Underground NG Storage

EPA is considering applying revised population EFs for the year-specific EFs from 2011 through 2023 (i.e., the EFs calculated from subpart W with application of the ratios in Table 1-6), but EPA is not considering incorporating them across the entire time series. The revised low-bleed population EFs are based on various studies, including the 1996 GRI/EPA study, the 2015 Allen et al. study[6], the 2013 Prasino Group study[7], the 2019 Luck et al. study[8], and the 2019 API study[9], and the revised high-bleed population EFs are based on the 2015 Zimmerle et al. study[10]. The more recent studies (2013-2019) may not be representative of conditions in the early 1990s.

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[10] Zimmerle, D. J., Williams, L. L., Vaughn, T. L., Quinn, C., Subramanian, R., Duggan, G. P., Willson, B. Opsomer, J. D., Marchese, A. J., Martinez, D. M., & Robinson, A. L. 2015. Methane emissions from the natural gas transmission and storage system in the United States. *Environ. Sci. Technol*. 2015, *49*(15), 9374–8383. Including Supplemental Information and Excel "CDFMaster" spreadsheet of data. *https://doi.org/10.1021/acs.est.5b01669*.

Therefore, for 1990-1992, as discussed in Section 3.1.3 EPA is considering updating the methodology so that the 1996 GRI/EPA study data is disaggregated to calculate EFs specific to high-bleed and intermittent-bleed pneumatic controllers, as well as the fraction of total controllers that are high-bleed or intermittent-bleed controllers. 2011 is the first year the applicable subpart W pneumatic controllers data are available for the transmission segment. From 1993 through 2010, the EFs and AFs for high-bleed and intermittent-bleed controllers would be interpolated between the 1992 EFs and the 2016 EFs, which would incorporate the revised population EFs. For low-bleed pneumatic controllers, EPA is considering applying the 2011 EF, calculated using subpart W data, to all prior years in the time series.

1.5 Summary of Updates Under Consideration

The following is a summary of updates under consideration for pneumatic controller emission estimates:

- **Production**: For 2011-2023, apply a ratio of the revised and current subpart W CH_4 EFs to reported emissions, resulting in adjusted basin- and year-specific EFs. For 1990-1992, use basin-specific 2011 EFs that incorporate only the current subpart W EFs, and interpolate EFs from 1993 to 2010.
- **Gathering and Boosting:** For 2016-2023, apply a ratio of the revised and current subpart W CH_4 EFs to reported emissions, resulting in adjusted year-specific EFs. For 1990-1992, use 2016 EFs that incorporate only current subpart W EFs, and interpolate EFs from 1993 to 2015.
- **Transmission:** For 2011-2023, apply a ratio of the revised and current subpart W CH_4 EFs to reported emissions, resulting in adjusted year-specific EFs. Disaggregate the total pneumatic controller EF from the 1996 GRI/EPA study to determine high-bleed and intermittent-bleed EFs for 1990-1992. Apply the fraction of total controllers that are high-bleed, intermittent-bleed, and low-bleed from the 1996 GRI/EPA study for 1990-1992. Interpolate high-bleed and intermittent-bleed EFs and all AFs from 1992-2010. Set 1990-2010 low-bleed EFs equal to the 2011 low-bleed EF.
- **Underground NG Storage:** For 2011-2023, apply a ratio of the revised and current subpart W CH_4 EFs to reported emissions, resulting in adjusted year-specific EFs. Disaggregate the total pneumatic controller EF from the 1996 GRI/EPA study to determine high-bleed and intermittent-bleed EFs for 1990-1992. Apply the fraction of total controllers that are high-bleed, intermittent-bleed, and low-bleed from the 1996 GRI/EPA study total pneumatic controller EF for 1990-1992. Interpolate high-bleed and intermittent-bleed EFs and all AFs from 1992-2010. Set 1990-2010 low-bleed EFs equal to the 2011 low-bleed EF.

1.6 National Emissions for Updates under Consideration

Table 1-10 presents the national 2022 CH_4 emission estimates for each of the pneumatic controller bleed types in the production, gathering and boosting, transmission, and underground NG storage segments in the 2024 GHGI and updates under consideration. The estimates under consideration for production pneumatic controllers at gas wells in 2022 are lower than the 2024 GHGI by 12 percent, while the estimates under consideration for production pneumatic controllers at oil wells are lower than the 2024 GHGI by 17 percent. The estimates under consideration for gathering and boosting in 2022 are lower than the 2024 GHGI by 23 percent. The estimates under consideration for transmission pneumatic controllers in 2022 are greater than the 2024 GHGI by 26 percent, and the estimates under consideration for the underground NG storage are greater than the 2024 GHGI by 55 percent. Together, the updates under consideration result in approximately 14 percent lower pneumatic controller CH_4 emissions than the 2024 GHGI, for year 2022.

Table 1-10. Comparison of Pneumatic Controller CH4 Emissions (mt) in the 2024 GHGI and Updates Under Consideration

Pneumatic Controller Segment	2022 CH_4 Emissions (2024 GHGI)	2022 CH_4 Emissions (Updates Under Consideration)
Production – Gas Wells	**643,721**	**568,754**
Low-Bleed	29,877	132,626
High-Bleed	30,700	17,299
Intermittent-Bleed	583,144	418,829
Production – Oil Wells	**693,551**	**575,203**
Low-Bleed	35,439	171,732
High-Bleed	23,712	13,611
Intermittent-Bleed	634,400	389,860
Gathering and Boosting	**171,000**	**132,332**
Low-Bleed	6,572	31,805
High-Bleed	18,854	9,712
Intermittent-Bleed	145,574	90,815
Transmission	**31,170**	**39,212**
Low-Bleed	663	3,292
High-Bleed	8,350	13,763
Intermittent-Bleed	22,157	22,157
Underground NG Storage	**15,265**	**23,652**
Low-Bleed	627	3,112
High-Bleed	9,103	15,006
Intermittent-Bleed	5,534	5,534

2 Production Wellpad Equipment Leaks

2.1 Current 2024 GHGI Methodology

EPA calculates leak emissions from certain wellpad equipment. Leak emissions in the current GHGI are calculated at gas wellpads for gas wellheads, separators, heaters, dehydrators, meters/piping, and compressors; and at oil wellpads for oil wellheads, separators, heater-treaters, and headers. Oil well equipment is categorized as being in either light crude or heavy crude service. The current GHGI does not calculate storage tank leak emissions. The current GHGI methodology is documented in the 2023 Production Segment Data Disaggregation memo.

EPA calculates basin- and year-specific AFs using subpart W data for RY2015 forward. Each AF is on a per-well basis (e.g., number of separators per gas well). The subpart W equipment counts are reported under the equipment leaks section and are categorized as in gas service (which EPA uses for gas wellpad equipment) or crude service (which EPA uses for oil wellpad equipment). For basins without subpart W data, EPA applies national-level average AFs calculated using subpart W data.

Early year (1990 through 1992) AFs for equipment on gas wellpads are from the 1996 GRI/EPA study; these are national-level AFs that are applied to all basins. The AFs applied to gas wellpad equipment are unique to the NEMS region in which the wellpad resides. To calculate AFs for intermediate years of the time-series (i.e., 1993-2014), EPA applies linear interpolation between the 1992 and 2015 AFs. Early year (1990 through 1993) AFs for equipment on oil wellpads are from a 1999 Radian report; these are national-level AFs that are applied to all basins.[11] EPA then applies linear interpolation between the 1993 and 2015 AFs. The AFs are multiplied by Enverus gas well and oil well counts, as applicable, to calculate the relevant activity data.

The EFs used in the current GHGI are derived from different sources for gas and oil wellpads. At gas wellpads, EPA applies either an Eastern U.S. or Western U.S. EF from the 1996 GRI/EPA study for all years. The determination of Eastern U.S. or Western U.S. is based on the NEMS region where the wells are located, with the Northeast and Midcontinent regions classified as Eastern U.S. and all others classified as Western U.S. The EFs used for equipment at oil wellpads are based on values from a 1996 API workbook. Distinct EFs are used for wellheads, separators, and headers at heavy crude oil wells versus light crude oil wells. The same EFs are applied to all years of the time series.

2.2 Available Data

The subpart W revisions included revised EFs for onshore production equipment leaks and rod packing emissions for onshore production reciprocating compressors. Revised equipment leak EFs are available for both population EFs and leaker survey EFs. The equipment leak population EFs are available by service type (i.e., gas service, oil service) and for specific equipment (i.e., wellheads, separators, meters/piping, compressors, dehydrators, heater-treaters, heaters, storage tanks) and the leaker survey EFs are based on the leak survey detection method (e.g., Method 21 at a leak definition of 500 ppm, optical gas imaging), service type (i.e., gas service, oil service), and component type (i.e., valve, flange, connector (other), pressure relief valve, pump seal, open-ended line, other component type). A single EF is also available for rod packing emissions from reciprocating compressors in the onshore production industry segment. EPA is considering incorporating the revised population EFs and the leaker survey emissions into the GHGI emission calculation methodologies.

2.3 Analysis of Available Data

EPA is considering incorporating the revised subpart W population EFs and leaker survey emissions into the emissions calculation methodology for production wellpad equipment leaks in a future GHGI. Section 2.3.1 presents the updates under consideration for the population EF methodology and Section 2.3.2 presents considerations for a new methodology developed to incorporate leaker survey emissions.

2.3.1 Population EF Methodology

The current GHGI EFs and the revised subpart W population EFs are both on a 'per equipment' basis. For oil wellpad equipment, EPA is considering applying the revised Subpart W population EFs for oil wellheads, heater-treaters, separators, meters/piping (as a replacement for the headers source), and storage tanks (a new leaks source). For gas wellpad equipment, EPA is considering applying the revised Subpart W population EFs for gas wellheads, heaters, separators, dehydrators, meters and piping, compressors, and storage tanks (a new leaks source).

There are unique considerations for certain wellpad equipment. For oil wellpad equipment, EPA is considering adjustments for meters/piping and not distinguishing between heavy crude and light crude wellpad equipment. The current GHGI calculates leak emissions for headers while the revised subpart W EFs include headers as part of the meters/piping source. Meters/piping accounts for header leak emissions plus other components and provides a more comprehensive accounting of leak emissions. As such, EPA is considering replacing headers with the meters/piping source for oil wellpad leak emissions and applying the revised subpart W population EF. Parallel to the EF update under consideration for meters/piping, EPA evaluated the activity data methodology for meters/piping. The current GHGI calculates the number of headers per oil well at the basin-level using subpart W data, and the national average equaled 0.24 headers per oil well for years 2015-2022. Conversely, subpart W requires reporters to use an AF of 1 meters/piping per wellpad. Since the number of oil wells per oil wellpad will not be available until RY2025, EPA is considering applying the gas wellpad AF for meters/piping to

[11] Radian International. Methane Emissions from the U.S. Petroleum Industry. 1999. EPA-600/R-99-010.

oil wellpad meters and piping. The gas wellpad AF ranges from about 0.84 to 1 meters/piping per gas well. In addition, a maximum of 1 meters/piping per well would also be applied to both gas wellpad and oil wellpad meters/piping emissions calculations, to align with the subpart W requirement to assume 1 meters/piping for each wellpad; this equates to assuming a minimum of 1 well per wellpad (i.e., there can be more but not less than 1 well per wellpad). The updates under consideration for oil wellpad equipment leaks would also remove the heavy crude and light crude distinction for separators and wellheads. The revised subpart W population EFs do not provide separate EFs for heavy crude and light crude equipment and so this distinction is not applicable for the update under consideration.

For gas wellpad equipment, EPA is considering adjusting the meters/piping AF, combining two subpart W compressor EFs together to more seamlessly account for both leak and rod packing emissions, and removing East and West distinctions. As discussed above, EPA is considering applying a maximum of 1 meters/piping per well, when calculating the basin-level AF to remove irregularities in the reported data. For compressors, the current GHGI compressor EF accounts for compressor leaks and reciprocating compressor rod packing emissions and EPA is considering maintaining that approach for the update under consideration. To do this, EPA combined the revised subpart W compressor leaks EF and the revised subpart W compressor rod packing EF. Additionally, the Subpart W EF update for gas wellpad equipment leak sources would remove the East and West determination currently applied to basins, because while the current GHGI EFs apply unique EFs based on whether a basin is in the eastern or western part of the country, the revised subpart W population EFs do not vary geographically and thus this distinction would not be applicable for the update under consideration.

For both oil and gas wellpad equipment leaks, EPA is also considering updates for operating hours and methane content. The current GHGI wellpad equipment leak EFs are calculated assuming 8,760 operating hours per year (i.e., continuous operation) and are on a CH_4 basis. To apply the revised subpart W population EFs, assumptions regarding both CH_4 content and operating hours must be made. The subpart W equipment leaks methodology requires that reporters use actual operating hours and CH_4 content to calculate leak emissions and these data elements are also reported. EPA reviewed these data and calculated an average of 8,100 operating hours per year which is applied for this update under consideration. For CH_4 content, the current GHGI default of 79 percent CH_4 was applied for the update consideration. EPA is continuing to evaluate the reported subpart W data for operating hours and CH_4 content and will consider further refinement to incorporate basin-level data for both; the storage tank leaks update under consideration does incorporate basin-level data and a summary of these results for RY2023 are presented in Section 3.2.2.

Table 2-1 and Table 2-2 compare the production wellpad equipment leaks EFs for the current GHGI and the update under consideration for oil wellhead equipment and gas wellhead equipment, respectively. Oil wellpad equipment leak EFs are from 3 to 20 times higher for the update under consideration compared to the current GHGI. Gas wellpad equipment leak EFs are about 1.5 to 4 times higher (relative to the West EFs) and about 2.5 to 188 times higher (relative to the East EFs) for the update under consideration compared to the current GHGI. Storage tank leaks are discussed later in this section since a new methodology was required for the update under consideration.

Table 2-1. EF Comparison for Oil Wellpad Equipment

<table>
<tr><th>Equipment</th><th>Current GHGI EFs[a]</th><th>EFs for GHGI Update Under Consideration[b]</th><th>EF Units</th></tr>
<tr><td>Heater-Treaters</td><td>19</td><td>56</td><td>scfd CH_4/heater</td></tr>
<tr><td>Separators (light crude)</td><td>14</td><td rowspan="2">84</td><td>scfd CH_4/separator</td></tr>
<tr><td>Separators (heavy crude)</td><td>0.15</td><td>scfd CH_4/separator</td></tr>
<tr><td>Wellheads (light crude)</td><td>16.6</td><td rowspan="2">73</td><td>scfd CH_4/well</td></tr>
<tr><td>Wellheads (heavy crude)</td><td>0.13</td><td>scfd CH_4/well</td></tr>
<tr><td>Headers (light crude)</td><td>11</td><td>n/a</td><td>scfd CH_4/header</td></tr>
</table>

Equipment	Current GHGI EFs[a]	EFs for GHGI Update Under Consideration[b]	EF Units
Headers (heavy crude)	0.08	n/a	scfd CH_4/header
Meters/Piping	n/a	217	scfd CH_4/meter-piping

a. The current GHGI EFs are from a 1996 API workbook.
b. Equals the revised subpart W EFs (which are whole gas EFs on an hourly basis) with adjustments for operating hours (8,100 operating hours per year) and a CH_4 content of 79 percent. The revised subpart W EFs are from the 2021 Rutherford study; see Section 2.4.1 for the citation.

Table 2-2. EF Comparison for Gas Wellhead Equipment

Equipment	Current GHGI EFs[a]		EFs for GHGI Update Under Consideration[b]	EF Units
	East EFs	West EFs		
Heaters	14.21	57.72	92	scfd/heater
Separators	0.90	122.02	169	scfd/separator
Dehydrators	21.75	91.13	142	scfd/dehydrator
Meters/Piping	9.01	52.90	124	scfd CH_4/meter-piping
Compressor Leaks	267.75	267.75	242	scfd/compressor
Compressor Rod Packing			434	scfd/compressor
Wellhead	7.11	36.44	156	scfd/well

a. The current GHGI EFs are from the 1996 GRI/EPA study.
b. Equals the revised subpart W EFs (which are whole gas EFs on an hourly basis) with adjustments for operating hours (8,100 operating hours per year) and a CH_4 content of 79 percent. The revised subpart W EFs are from the 2021 Rutherford study; see Section 2.4.1 for the citation.

Additionally, EPA is considering a new methodology to incorporate the new subpart W population EFs for production storage tanks and estimate production storage tank leak emissions, which are not currently accounted for in the GHGI. For 2015 forward, EPA would pair the new subpart W EFs under consideration with year-specific AFs calculated at the basin level using subpart W data (i.e., tanks per liquids production). For basins without subpart W data, EPA would apply the national average AF. For the tanks per liquids production AF, EPA calculated the ratio of total tank counts to total liquids production (condensate plus oil production) for each basin. To determine the total tank counts, EPA reviewed subpart W data reported for each of the three tanks calculation methods. For atmospheric storage tanks whose emissions reported to subpart W were calculated using Calculation Method 1 or 2 (as defined in subpart W), EPA summed direct, sub basin-level condensate and oil tank counts from subpart W data to the basin level. For purposes of the GHGI, EPA classifies oil tanks as those reported under the "oil" formation type and condensate tanks as those reported under all other formation types. For atmospheric storage tanks whose emissions reported to subpart W were calculated using Calculation Method 3 (defined in subpart W), the total tank counts are reported at the basin-level while the sub-basin level tank counts are reported by control category (i.e., tanks with and without flaring). Because a tank can be both controlled by a flare and uncontrolled for portions of the year, the sub-basin level counts exceed the basin-level counts. As such, rather than using the sub-basin level counts directly, EPA calculated the fraction of storage tanks that are condensate and oil tanks based on the counts reported under each control category (i.e., tanks with and without flaring) and applied those fractions to the total atmospheric storage tank count at the basin level.

To pair the AFs (tanks per liquids production) with the new subpart W EFs (scf whole gas/hour/tank), EPA developed methods to estimate CH_4 content and annual tank operating hours to apply to the subpart W EFs. To estimate CH_4 content, EPA calculated the average CH_4 mole fraction reported by facilities to subpart W at the basin level. To estimate annual tank operating hours, EPA calculated the average operational time reported to subpart W for onshore production equipment leaks at the basin level. Table 2-3 and Table 2-4 present the RY2023 AFs, CH_4 content, annual operating hours, and calculated EFs for oil tanks and condensate tanks for select basins. The basins shown are those with the highest number of oil and gas wells in year 2023.

Table 2-3. Oil Tank AFs and EFs for Select Basins (RY2023 Subpart W)

Basin Name	Basin Number	Tanks per Liquids Production (tanks/mbbl)	CH_4 Content	Annual Operating Hours	EFs for GHGI Update Under Consideration (scf CH_4/tank/yr)[a]
Appalachian	160	0	0.78	0	0
Appalachian (Eastern Overthrust)	160A	0.0003	0.75	7,300	10,450
Gulf Coast	220	0.04	0.77	8,248	12,115
Anadarko	360	0.2	0.79	7,726	11,654
Williston	395	0.1	0.55	7,657	7,978
Permian	430	0.02	0.66	8,253	10,335
National Average		0.04	0.70	8,021	10,699

a. Equals the new subpart W storage tank leak EFs (which are whole gas EFs on an hourly basis) with adjustments for operating hours and CH_4 content. The new subpart W EFs are from the 2021 Rutherford study.

Table 2-4. Condensate Tank AFs and EFs for Select Basins (RY2023 Subpart W)

Basin Name	Basin Number	Tanks per Liquids Production (tanks/mbbl)	CH_4 Content	Annual Operating Hours	EFs for GHGI Update Under Consideration (scf CH_4/tank/yr)[a]
Appalachian	160	0	0.84	0	0
Appalachian (Eastern Overthrust)	160A	0.04	0.91	6,795	11,314
Gulf Coast	220	0.02	0.80	8,136	11,966
Anadarko	360	0.1	0.82	7,416	11,088
Williston	395	0.0003	0.55	7,657	9,059
Permian	430	0.004	0.76	8,007	11,164
National Average		0.01	0.84	7,754	11,978

a. Equals the new subpart W storage tank leak EFs (which are whole gas EFs on an hourly basis) with adjustments for operating hours and CH_4 content. The new subpart W EFs are from the 2021 Rutherford study.

To calculate emissions for the update under consideration, EPA would couple the storage tank AFs and EFs with liquids production data (obtained from Enverus). Refer to Section 4 for the resulting emission estimates under consideration for incorporation into a future GHGI.

The population EF methodology would apply to the wellpad equipment that is not applicable to the leaker survey methodology (i.e., if 30 percent of wells perform leaker surveys for a particular basin and year, the population EF methodology would apply to 70 percent of all wells and related equipment).

2.3.2 Leaker Survey Methodology

As part of this update under consideration, EPA is also considering incorporating subpart W leak detection survey emissions (the term “leaker survey” is used in this memo) by applying basin- and year-specific leaker survey AFs and EFs. Subpart W facilities have had the option since RY2017 to conduct leaker surveys using Method 21 at a leak definition of 500 ppm, Method 21 at a leak definition of 10,000 ppm, optical gas imaging, infrared, or acoustic leak detection methods. For this update under consideration, the leaker survey AF for each basin equals the percentage of wells that conducted leaker surveys, and the leaker survey EF equals the average leaker survey emissions per well.

To determine the leaker survey AF for each basin, EPA first determined how many wells (and their associated equipment) had leaker surveys conducted for each facility. EPA subtracted the sum of well counts reported under the subpart W equipment leaks section (i.e., the well counts and equipment whose subpart W emissions were calculated using the subpart W population EF methodology) from the sum of well counts reported under the subpart W facility overview section (i.e., the total well counts for a facility), with two exceptions. There were two scenarios where EPA set the equipment leak well counts equal to the facility overview well counts for a facility: (1) when the equipment leaks well counts exceeded the facility overview well counts and (2) when the equipment leaks well counts were less than the facility overview well counts but a leaker survey was not conducted for the facility. With the number of wells that had leaker surveys determined for each facility, EPA then summed these values for each basin and divided by the total wells reported under the subpart W facility overview section for each basin. Table 2-5 displays the percentage of wells with leaker surveys for RY2017-RY2023, for the basins with the highest number of oil and gas wells and for all basins combined. In each of these basins, leaker surveys became much more common over time. EPA assumed these percentages are applicable for all wellpad equipment; therefore, if 20 percent of wells had leaker surveys in a basin then 20 percent of all other wellpad equipment (e.g., separators, heater-treaters, meters and piping, storage tanks) also had leaker surveys. As part of this, EPA assumed that facilities that reported leaker survey emissions included leaking components on storage tanks.

Table 2-5. Percentage of Wells That Had Leaker Surveys for RY2017-RY2023, for Select Basins

Basin	Basin Number	2017	2018	2019	2020	2021	2022	2023
Appalachian	160	0%	1%	1%	1%	13%	100%	100%
Appalachian (Eastern Overthrust)	160A	5%	10%	20%	17%	24%	73%	78%
Gulf Coast	220	13%	16%	20%	19%	25%	29%	49%
Anadarko	360	4%	7%	9%	8%	23%	16%	43%
Williston	395	16%	28%	37%	40%	48%	34%	39%
Permian	430	5%	6%	9%	8%	18%	20%	27%
National Average		7%	11%	17%	18%	26%	41%	52%

To calculate the leaker survey EFs for each basin, EPA adjusted the leaker survey emissions reported under subpart W using the revised subpart W leaker EFs and a new k factor, which adjusts emissions for undetected leaks and varies depending on the leak detection survey method. Table 2-6 compares the current and revised subpart W leaker survey EFs for components in gas service, the k factor applicable to the leak detection survey method, and the calculated overall EF ratio for each component and leak detection survey method combination. As shown by the overall EF Ratio, the leaker survey emissions for components in gas service are between 2 to 8 times higher after adjusting for the revised EF and the k factor.

Table 2-6. Comparison of Whole Gas Leaker Survey EFs in the Production Segment for the Current Subpart W and Revised Subpart W Requirements for Components in Gas Service

Leak Detection Survey Method	Equipment Components	Subpart W EFs (scf whole gas/hr/ component)		Revised Subpart W Rule - k factor	Overall EF Ratio[c]
		Current EF[a]	Revised EF[b]		
Method 21 with 500 ppm Leak Definition	Valve	3.5	5.5	1.27	2.0
	Flange	2.2	4	1.27	2.3
	Connector (other)	0.8	2.8	1.27	4.4
	Open-Ended Line	1.9	3.6	1.27	2.4
	Pressure Relief Valve	2.8	4.5	1.27	2.0

Leak Detection Survey Method	Equipment Components	Subpart W EFs (scf whole gas/hr/ component)		Revised Subpart W Rule - k factor	Overall EF Ratio[c]
		Current EF[a]	Revised EF[b]		
	Pump Seal	1.4	8.3	1.27	7.5
	Other	2.8	5.3	1.27	2.4
Method 21 with 10,000 ppm Leak Definition	Valve	4.9	9.6	1.55	3.0
	Flange	4.1	6.9	1.55	2.6
	Connector (other)	1.3	4.9	1.55	5.8
	Open-Ended Line	2.8	6.3	1.55	3.5
	Pressure Relief Valve	4.5	7.8	1.55	2.7
	Pump Seal	3.7	14	1.55	5.9
	Other	4.5	9.1	1.55	3.1
Other - Optical Gas Imaging, Infrared, or Acoustic Leak Detection	Valve	4.9	16	1.25	4.1
	Flange	4.1	11	1.25	3.4
	Connector (other)	1.3	7.9	1.25	7.6
	Open-Ended Line	2.8	10	1.25	4.5
	Pressure Relief Valve	4.5	13	1.25	3.6
	Pump Seal	3.7	23	1.25	7.8
	Other	4.5	15	1.25	4.2

a. The current EFs are from the 1996 GRI/EPA study.
b. The revised EFs are from Pacsi et al. 2019 and Zimmerle et al. 2020.[12,13]
c. Overall EF Ratio = (Revised EF × ‘k factor’) / Current EF

The subpart W reporters account for their specific methane content and operating hours when calculating leaker survey emissions. As such, EPA multiplied the reported subpart W component-level leaker survey emissions by the overall EF ratios in Table 2-6 to reflect the use of the revised EFs and k factors and maintain the facility-specific characteristics. Some facilities perform leaker surveys using multiple detection methods. If a facility reported they used both Method 21 leak definitions (i.e., 500 ppm and 10,000 ppm), EPA applied the EF ratio for the lower leak definition of 500 ppm. If a facility reported they used a combination of Method 21 and other methods, EPA applied the average of the applicable EF ratios. EPA also applied this approach to components in heavy crude and light crude service to adjust leaker survey emissions.

Once the subpart W leaker survey emissions were adjusted for each facility, EPA calculated leaker survey EFs by summing the emissions for each basin and dividing by the number of wells subject to leaker surveys in each basin. Table 2-7 presents the leaker survey EFs calculated for RY2017-RY2023, for the basins with the highest number of oil and gas wells.

Table 2-7. Leaker Survey EFs for Selected Basins (mt/leaker survey well)

Basin	Basin Number	2017	2018	2019	2020	2021	2022	2023
Appalachian	160	0.57	1.53	2.16	1.65	0.16	0.23	0.33
Appalachian (Eastern Overthrust)	160A	0.68	0.64	0.47	0.86	0.47	0.26	0.31
Gulf Coast	220	0.19	0.09	0.21	0.12	0.16	0.21	0.29

[12] Pacsi, A.P., et al., 2019. “Equipment leak detection and quantification at 67 oil and gas sites in the Western United States.” *Elem Sci Anth*, 7: 29. Available at https://doi.org/10.1525/elementa.368.
[13] Zimmerle, D., et al., 2020. “Methane Emissions from Gathering Compressor stations in the U.S.’’ *Environmental Science & Technology*, 54(12), 7552–7561. Available at https://doi.org/10.1021/acs.est.0c00516.

Basin	Basin Number	2017	2018	2019	2020	2021	2022	2023
Anadarko	360	1.25	0.94	0.69	0.97	0.41	0.79	0.44
Williston	395	0.19	0.37	0.24	0.33	0.34	0.41	0.26
Permian	430	0.62	1.25	0.41	0.47	0.22	0.23	0.23
National Average		0.21	0.34	0.25	0.17	0.14	0.11	0.12

2.4 Time Series Considerations

2.4.1 Population EF Methodology

For production wellpad equipment, EPA is considering incorporating the revised subpart W population EFs into the emissions calculations across the time series. The revised subpart W EFs were developed using the 2021 Rutherford study, which includes a larger sample size and incorporated infrequent but large leaks via bootstrapping.[14] Specifically, the EFs in Table 2-1 and Table 2-2 were applied for each year of the time series for the update under consideration. These EFs were calculated using the average of multiple years of subpart W operating hours data (8,100 hours per year) and the current GHGI CH_4 default content of 79 percent. For storage tank leaks, year 2015 EFs were applied to 1990-2014 and year-specific EFs (based on year-specific data for operating hours and CH_4 content) were applied for 2015-2023. EPA is also considering applying the storage tank leaks EF methodology to the other wellpad equipment EFs for the final version of the 2025 GHGI (i.e., making year-specific adjustments for operating hours and CH_4 content to the subpart W EFs for 2015-2023 and applying year 2015 EFs to 1990-2014). The current GHGI uses EFs from the 1996 GRI/EPA study (for equipment on gas wellpads) and a 1996 API workbook (for equipment on oil wellpads) for all years of the time series, and EPA did not retain these EFs for the updates under consideration. The revised subpart W population EFs are expected to be more representative of leaks and include more data points and reflect periodically occurring higher emitting leaks.

The methodology to calculate the AFs for wellpad equipment (e.g., separators per well) is mostly unchanged for the updates under consideration except for meters/piping (discussed in more detail below), the removal of heavy crude and light crude categories, and the incorporation of a new methodology for storage tank leaks. The separator and wellhead EFs in Table 2-1 and Table 2-2 for the update under consideration do not distinguish between heavy crude and light crude equipment on oil wellpads, and instead all separators and wellheads are treated the same. Therefore, the AFs were simplified across the time series to remove unique AFs for heavy crude separators (i.e., 0.33 separators per heavy crude well) and light crude separators (i.e., 0.228 separators per light crude well) and all basins now use 0.235 separators per well for 1990-1993 and linearly interpolate to the 2015 AFs. The storage tanks AF (i.e., number of tanks per liquids production) methodology mirrors the storage tank leaks EF methodology; year 2015 AFs were applied to 1990-2014 and year-specific AFs were applied for 2015-2023.

There are multiple considerations for meters/piping on oil and gas wellpads. For oil wellpad equipment, as discussed in Section 3.2.1 above, the revised Subpart W EFs account for emissions from meters/piping instead of emissions from just headers, as seen in the current GHGI. Since meters/piping includes header leak emissions, EPA is considering replacing the headers source with meters/piping and applying the EF in Table 2-1 to all years of the time series. EPA is also considering the application of the meters/piping gas wellpad AFs to oil wellpad meters/piping across the time series. In the current GHGI, the gas wellpad meters/piping AFs for 1990-1992 are from the 1996 GRI/EPA study and are unique to the NEMS region a basin is in (i.e., Northeast, Midcontinent, Rocky Mountain, Southwest, West Coast, and Gulf Coast). However, because the update under consideration uses subpart W-based EFs across the time series, the meters/piping AFs need to align with that basis. Subpart W requires reporters to use an AF of 1 meters/piping per wellpad. Assuming there is at least 1 well per wellpad,

[14] Rutherford, J.S., Sherwin, E.D., Ravikumar, A.P. *et al*. "Closing the methane gap in US oil and natural gas production emissions inventories". *Nat Commun* 12, 4715 (2021). https://doi.org/10.1038/s41467-021-25017-4.

this equates to a maximum AF of 1 meters/piping per well based on the subpart W requirements. Five of the six NEMS regions have AFs greater than 1 in the 1996 GRI/EPA study (ranging from 1.2 to 1.6). After applying a maximum of 1 to the 1990-1992 AFs, only the Northeast region meters/piping AF is less than 1 for 1990-1992. Consistent with the current GHGI methodology, the meters/piping AFs between 1992 and 2015 are developed through linear interpolation.

For the update under consideration, the population EF methodology is applicable to all wellpad equipment for 1990-2016. For 2017-2023, the population EF methodology would only apply to the wellpad equipment that is not applicable to the leaker survey methodology (i.e., if 30 percent of wells perform leaker surveys for a particular basin and year, the population EF methodology would apply to 70 percent of all wells and related equipment).

2.4.2 Leaker Survey Methodology

For the update under consideration, EPA is considering incorporating the use of subpart W leaker survey emissions into the GHGI methodology. However, this methodology would only apply for years 2017-2023. Year 2017 is the first year that subpart W allowed facilities to conduct leaker surveys and is thus the first year where data are directly available to calculate leaker survey AFs and EFs. In addition, relatively few wells were subject to leaker surveys in 2017 (5 percent, see Table 2-5), indicating few leaker surveys would have been conducted in prior years. EPA would apply the AFs (see Table 2-5) and EFs (Table 3-14) to calculate leaker survey emissions for each basin for 2017-2023. EPA would apply a leaker survey percentage AF of 0 from 1990-2016.

2.5 Summary of Updates Under Consideration

For each basin and year, the following is a summary of the calculation methodology EPA would apply for the update under consideration for the years with subpart W data (i.e., 2015 forward).

The wellpad equipment population is split into the percent subject to the population EF methodology (i.e., 100 percent minus the percent subject to the leaker survey methodology) and the percent that is subject to the leaker survey methodology (see Table 2-5). Once this is done, unique steps are applied for each.

Population EF Methodology Summary

For the wellpad equipment subject to the population EF methodology, EPA would apply the following calculation for oil wellpads and gas wellpads for each piece of equipment in Table 2-1 and Table 2-2, by basin and by year:

$$E_{EL} = W_{OG} \times \%_{PopEF} \times AF_E \times EF_E$$

Where:

E_{EL}	=	Equipment leak emissions;
W_{OG}	=	Total oil or gas wells (from Enverus);
$\%_{PopEF}$	=	% subject to population EF method (100% minus leaker survey % - see Table 2-5);
AF_E	=	Equipment count per well, for each equipment “E” (not impacted by update; except meters/piping); and
EF_E	=	Emissions per equipment count, for each equipment “E” (see Table 2-1 and Table 2-2).

For the storage tanks subject to the population EF methodology, EPA would apply the following calculation for oil tanks and condensate tanks for each basin and each year:

$$E_{STL} = P_{TL} \times \%_{PopEF} \times EF_T$$

Where:

E_{STL}	=	Storage tank leak emissions;
P_{TL}	=	Total liquids production;
$\%_{PopEF}$	=	% subject to population EF method (100% minus leaker survey %, see Table 2-5);

EF_T = Emissions per throughput (see Table 2-3 and Table 2-4).

Leaker Survey Methodology Summary

For the wellpad equipment subject to the leaker survey methodology, EPA would apply the following calculation for each basin and year:

$$E_{LS} = W_{OG} \times \%_{LS} \times EF_{LS}$$

Where:

E_{LS} = Leaker survey emissions;
W_{OG} = Total oil or gas wells (from Enverus);
$\%_{LS}$ = % subject to leaker survey method (AFs as presented in Table 2-5); and
EF_{LS} = Average leaker survey emissions per well subject to leaker surveys (see Table 2-7).

2.6 National Emissions for Updates under Consideration

Table 2-8 presents the national 2022 CH_4 emission estimates for each production wellpad equipment leak source in the 2024 GHGI and updates under consideration. The 2022 estimates under consideration are lower than the 2024 GHGI for gas wellpad heaters, dehydrators, and compressors, but greater than the 2024 GHGI for gas wellheads, separators, and meters/piping, along with new estimates for storage tanks and leaker surveys. For oil wellpad equipment leaks, the 2022 estimates under consideration are greater for all leak sources. Together, the updates under consideration result in approximately 196 percent greater CH_4 emissions for all production wellpad equipment leaks, for year 2022.

Table 2-8. Comparison of Production Wellpad Equipment Leak CH_4 Emissions (mt) in the 2024 GHGI and Updates Under Consideration

Leak Source	2022 CH_4 Emissions (2024 GHGI)	2022 CH_4 Emissions (Updates Under Consideration)
Gas Wellpad Equipment Leaks		
Wellheads	46,495	217,648
Heaters	18,476	16,002
Separators	94,591	140,823
Dehydrators	3,105	2,836
Meters/Piping	75,719	159,415
Compressors	193,389	109,088
Storage Tanks	NE	22,765
Leaker Survey	NE	53,126
Total Gas Wellpad Equipment Leaks	431,775	721,703
Oil Wellpad Equipment Leaks		
Wellheads	57,273	186,994
Heater-Treaters	20,121	36,429
Separators	25,885	111,575
Meters/Piping	8,985[a]	473,365
Storage Tanks	NE	33,092
Leaker Survey	NE	45,312
Total Oil Wellpad Equipment Leaks	112,264	886,767
Total Wellpad Equipment Leaks	**544,039**	**1,608,470**

a. Equals header emissions.
NE = Emissions not estimated for this source.

3 Pipeline Leaks

3.1 Current 2024 GHGI Methodology

The current GHGI calculates gathering pipeline leak emissions using data from subpart W and the 1996 GRI/EPA study. Year-specific EFs are calculated using subpart W data for years 2016 forward and the 2016 EF is then applied to all prior years of the time-series. EPA assumes that subpart W gathering pipeline miles represent the national total, so subpart W miles are used "as is" for year 2016 forward. For years prior to 2016, EPA estimates gathering pipeline mileage as the total producing gas wells in a given year, multiplied by a factor of pipeline miles per well from the 1996 GRI/EPA study, plus an additional assumed 82,600 miles of gathering pipeline owned by transmission companies (per 1996 GRI/EPA). The gathering pipelines current GHGI methodology is documented in the memo *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2017: Updates to Natural Gas Gathering & Boosting Pipeline Emissions*.[15]

Transmission pipeline leak emissions are calculated in the current GHGI by applying an EF from the 1996 GRI/EPA study to all years of the time series. This EF is paired with transmission pipeline miles which are available for the entire time series from the Pipeline and Hazardous Materials Safety Administration (PHMSA).

3.2 Available Data

The subpart W revisions included revised population EFs for gathering pipeline leaks and new population EFs for transmission pipeline leaks. The pipeline leak EFs are specific to pipeline material (i.e., protected steel, unprotected steel, plastic, cast iron). Onshore transmission pipeline mileage data are also available from PHMSA, disaggregated by pipeline material, for potential pairing with the new material-specific EFs. EPA is considering incorporating the revised population EFs and PHMSA data into the GHGI emission calculation methodologies.

3.3 Analysis of Available Data

3.3.1 Gathering Pipelines

EPA is considering incorporating the revised subpart W population CH_4 EFs into the emissions calculations for gathering pipeline leaks. Table 3-1 compares the current and revised subpart W EFs for gathering pipelines of each material type (protected steel, unprotected steel, plastic/composite, and cast iron) along with a ratio of the two EFs. The revised protected steel EF is about two times higher while the revised EFs for the other pipeline materials are lower than the current subpart W EFs. The current subpart W EFs are based on leak rates and leak incidence (i.e., the frequency of leaks) data from the 1996 GRI/EPA study while the revised subpart W EFs are based on leak incidence data from the 1996 GRI/EPA study and leak rate data from a more recent pipeline leaks measurement study (Lamb et al. 2015[16]).

Table 3-1. Comparison of Gathering Pipeline Whole Gas Emission Factors for the Current Subpart W and Revised Subpart W Requirements

Pipeline Material	Subpart W EFs (scf/hr/mile pipeline)		Pipeline EF Ratio (Revised / Current)
	Current EF	Revised EF	
Protected Steel	0.47	0.93	1.98
Unprotected Steel	16.59	8.2	0.49
Plastic/Composite	2.5	0.28	0.11
Cast Iron	27.6	8.4	0.30

[15] The gathering pipelines methodology memo is available here: https://www.epa.gov/sites/default/files/2019-04/documents/2019_ghgi_update_-_gb_segment_2019-04-09.pdf

[16] Lamb et al. 2015. "Direct Measurements Show Decreasing Methane Emissions from Natural Gas Local Distribution Systems in the United States.'' *Environmental Science & Technology*. 2015, 49, 5161–5169.

The subpart W gathering pipeline leak calculation methodology has no other substantive revisions, and reporters account for their specific methane concentration and operating hours when calculating emissions. As such, multiplying the reported subpart W gathering pipeline leaks emissions by the ratios in Table 3-1 would reflect the use of the revised EFs and maintain the facility-specific characteristics. In the update under consideration, for 2016 forward, the CH_4 emissions reported to subpart W would be multiplied by the ratio of the revised population EF to the current population EF, specific to each pipeline material type. Applying this EF ratio to the subpart W data would then impact the resulting calculated EFs based on reported emissions and pipeline miles. Table 3-2 presents the emissions and gathering pipeline miles reported to subpart W for RY2022, as well as the adjusted emissions after applying the material-specific ratios, and the calculated EFs based on each approach.

Table 3-2. Comparison of Gathering Pipeline Leak CH_4 Emissions and Calculated EFs (Reported to Subpart W and Adjusted)

Pipeline Material	Reported CH_4 Emissions and Calculated Overall EF (2022)	Adjusted CH_4 Emissions and Calculated Overall EF (2022)
Protected Steel (mt)	18,065	35,745
Unprotected Steel (mt)	51,794	25,600
Plastic/Composite (mt)	25,374	2,842
Cast Iron (mt)	910	277
Total Gathering Pipeline Leaks (mt)	96,142	64,464
Gathering Pipeline Miles	387,920	387,920
Gathering Pipeline Leaks EF (mt/mi)	0.25	0.17

Table 3-2 shows that the overall adjusted gathering pipeline leak EFs under consideration are lower than the overall EFs calculated directly from the subpart W data for 2022. Section 4 further discusses the resulting emission estimates calculated based on the adjusted EFs.

3.3.2 Transmission Pipelines

EPA is considering incorporating the new subpart W population CH_4 EFs into the emissions calculations for transmission pipeline leaks. Table 3-3 presents the current EF used to estimate emissions in the GHGI, which is from the 1996 EPA/GRI study and applies to total transmission pipeline miles, and the revised subpart W EFs, which are specific to pipeline material. The revised subpart W EFs are based on leak incidence data from the 1996 GRI/EPA study and leak rate data from Lamb et al. 2015.

Table 3-3 Current and Revised CH4 EFs for Transmission Pipeline Leaks

Pipeline Material	Current CH_4 EF (1996 GRI/EPA) (scf/hr/mi pipeline)	Revised CH_4 EF (Subpart W) (scf/hr/mi pipeline)
Total Transmission Pipeline	0.065	-
Protected Steel	-	0.041
Unprotected Steel	-	0.74
Plastic	-	0.061
Cast Iron	-	27

To incorporate this update under consideration, EPA would pair the new subpart W EFs with pipeline mileage from PHMSA by material type. The PHMSA pipeline mileage data includes the following materials: steel cathode unprotected bare, steel cathode protected coated, steel cathode unprotected bare, steel cathode unprotected coated, cast iron, wrought iron, plastic, composite, and other. To account for most of the pipeline mileage available in the PHMSA dataset, EPA is considering grouping the material types as shown in Table 3-4. Pipeline mileage in the “other” material category would not be accounted for in emission estimates since there is not a corresponding subpart W EF. In addition, the PHMSA pipeline miles in Table 3-4 are for onshore transmission pipelines only, offshore transmission pipelines are not included. Conversely, the transmission pipeline miles currently used in the GHGI include offshore mileage. For the update under consideration, EPA is considering using only the onshore transmission pipelines miles to ensure the emissions for the transmission pipelines (and the related compressor stations) are reflective of only the onshore pipeline network, consistent with the intention of the transmission segment emissions in the GHGI.

Table 3-4. PHMSA Pipeline Miles by Material for 2020-2023

Pipeline Material (EF, Subpart W)	Pipeline Material (Pipeline Miles, PHMSA)	2020	2021	2022	2023
Protected Steel	Steel Cathode Protected Bare	3,098	3,276	3,292	3,026
	Steel Cathode Protected Coated	293,629	293,379	292,784	292,686
	Total Protected Steel	**296,652**	**296,726**	**296,655**	**296,076**
Unprotected Steel	Steel Cathode Unprotected Bare	406	414	317	339
	Steel Cathode Unprotected Coated	175	176	172	112
	Total Unprotected Steel	**683**	**582**	**590**	**489**
Plastic	Plastic	1,444	1,404	1,437	1,435
	Composite	30	28	27	28
	Total Plastic	**1,493**	**1,475**	**1,432**	**1,464**
Cast Iron	Cast Iron	0	0	0	0
	Wrought Iron	18	18	17	17
	Total Cast Iron	**20**	**18**	**18**	**17**
-	Other	70	55	55	54

3.4 Time Series Considerations

For gathering pipeline leaks, EPA is considering incorporating the year-specific, adjusted EFs for 2016 through 2023 (i.e., rely on the revised subpart W EFs which incorporate the more recent Lamb et al. 2015 pipeline leak rate data). However, for 1990 through 1992, EPA is considering retaining the current GHGI EFs calculated from unadjusted RY2016 subpart W emissions (i.e., use the current subpart W EFs, based only on the 1996 GRI/EPA study) and pipeline mileage data. EPA would apply linear interpolation to calculate EFs between 1992 and 2016. This methodology is consistent with the distribution mains methodology, which also uses EFs based only on the 1996 GRI/EPA study for 1990 through 1992 and then incorporates EFs that rely on the Lamb et al. 2015 leak rates for recent years of the time series; this methodological approach uses leak rates to represent the time period during which their measurements were conducted.[17]

For transmission pipelines, EPA is considering applying the revised subpart W, pipeline material-specific EFs to all years of the time series. Other material-specific EF options are not available for transmission pipeline leaks. EPA is also considering an update to the pipeline mileage available from PHMSA and would only use onshore transmission pipelines instead of also including offshore pipelines.

[17] The GHGI methodology for distribution mains is documented in this memo: https://www.epa.gov/sites/default/files/2016-08/documents/final_revision_ng_distribution_emissions_2016-04-14.pdf

3.5 Summary of Updates Under Consideration

The following is a summary of updates under consideration for pipeline leak emission estimates:

- **Gathering:** Apply a ratio of the revised and current subpart W CH_4 EFs to reported emissions and pipeline miles, resulting in adjusted EFs, for 2016 to 2023. Apply the unadjusted 2016 EF for 1990 to 1992 and linearly interpolate EFs from 1993 to 2015.
- **Transmission:** Use the new, pipeline material-specific subpart W CH_4 EFs for all years of the time series and only onshore transmission pipeline mileage from PHMSA.

3.6 National Emissions for Updates under Consideration

Table 3-5 presents the national 2022 CH_4 emission estimates for pipeline leaks in the 2024 GHGI and the updates under consideration. The estimates under consideration for both gathering and transmission pipeline leaks in 2022 are lower than the 2024 GHGI estimates. Together, the updates under consideration result in approximately 33 percent lower pipeline leak CH_4 emissions than the 2024 GHGI, for year 2022.

Table 3-5. Comparison of Pipeline Leak CH_4 Emissions (mt) in the 2024 GHGI and the Updates Under Consideration

Pipeline Segment	2022 CH_4 Emissions (2024 GHGI)	2022 CH_4 Emissions (Updates Under Consideration)
Gathering	96,302	64,395
Transmission	3,286	2,201
Total Pipeline Leaks	**99,588**	**67,405**

4 Overview of National Emissions for Sources with Updates under Consideration

The updates under consideration impact multiple emission sources and industry segments. The year 2022 emissions summary for each emission source with updates under consideration is presented in the following sections: Section 1.6 for pneumatic controllers, Section 2.6 for production wellpad equipment leaks, and Section 3.6 for pipeline leaks. Table 4-1 consolidates all the emission sources and presents an overall year 2022 emissions comparison for the sources with updates under consideration. There are many other emission sources that are included in the GHGI but are not included in this memo. Together, the updates under consideration result in approximately 37 percent higher CH_4 emissions than the 2024 GHGI, for year 2022. Appendix A presents detailed emissions for select years of the time series for the sources with updates under consideration.

Table 4-1. Comparison of CH_4 Emissions (kilotons, kt) Emissions for the 2025 GHGI Sources With Updates Under Consideration and the 2024 GHGI

Emission Source	2024 GHGI (Year 2022)	GHGI Updates Under Consideration (Year 2022)
Production Wellpad Equipment Leaks	544	1,609
Pneumatic Controllers		
Production	1,337	1,144
G&B	171	132
Transmission	31	39
Underground NG Storage	15	24
Gathering Pipeline Leaks	96	64
Transmission Pipeline Leaks	3	2
TOTAL for sources with updates under consideration	**2,198**	**3,015**

5 Requests for Stakeholder Feedback

EPA seeks stakeholder feedback on the updates under consideration discussed in this memo and the questions below.

Overarching

1. EPA requests feedback on the timing for implementation of these updates, noting that these revised emission factors reflect improved data over current factors in the GHGI, but also noting that additional data will become available from subpart W for some of these sources in future years.
2. Are there other recent studies that would be relevant to consider for future GHGI methodology updates?

Pneumatic Controllers

1. EPA requests feedback on the time series approach (for all segments) of using the current GHGI EFs for 1990-1992 (which are based on the current subpart W EFs that rely on the 1996 GRI/EPA study) and incorporating the revised subpart W EFs (which are based on emissions measurements from various studies) for 2011 forward.
2. Specific to transmission and underground NG storage, EPA requests feedback on the 1996 GRI/EPA study disaggregation analysis for 1990-1992, as summarized in Table 1-8.

Production Wellpad Equipment Leaks

1. EPA requests feedback on using the revised subpart W EFs for all years of the time series for the population EF methodology.
2. EPA requests feedback on setting a maximum of 1 meters/piping per well over the time series, which is based on the subpart W requirement to use 1 meters/piping per wellpad and assuming there is at least 1 well per wellpad.
3. EPA requests feedback on the new leaker survey methodology, including calculating the percentage of wells with leaker surveys (and assuming that percent is applicable to all wellpad equipment) and leaker survey EFs for each basin.
4. EPA requests feedback on whether the leaker survey methodology should apply only to the wells at subpart W facilities or to the entire U.S. well population.

Pipeline Leaks

1. EPA requests feedback on the PHMSA pipeline categories that are applied for each of the EFs (see Table 3-4).
2. EPA requests feedback on the time series approach of using the current GHGI EFs for 1990-1992 (which are based on current subpart W EFs that rely on the 1996 GRI/EPA study) and incorporating the revised subpart W EFs (which are based on Lamb et al. 2015 leak rate data) for 2016 forward.

Appendix A – Time Series CH_4 Emissions for the Updates Under Consideration Compared to the Current 2024 GHGI

Table A-1. CH_4 Emissions (mt) for Select Years of the Time Series for the Updates Under Consideration

Source	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
Production Wellpad Equipment Leaks	**1,735,878**	**1,818,034**	**1,941,020**	**2,253,889**	**2,707,181**	**3,006,697**	**2,395,165**	**2,180,406**	**1,609,401**	**1,363,246**
Gas Wellpad Leaks	**672,160**	**785,950**	**921,906**	**1,196,599**	**1,521,581**	**1,576,279**	**1,239,469**	**1,131,292**	**721,796**	**575,199**
Wellheads	209,948	258,406	307,001	397,576	502,198	505,438	402,699	351,263	217,648	169,961
Heaters	29,302	33,454	37,643	46,855	54,510	52,815	31,911	28,812	16,002	9,901
Separators	134,074	171,659	211,172	279,046	366,429	384,241	271,526	269,456	140,823	91,779
Dehydrators	26,644	29,030	27,244	26,288	21,643	10,302	3,541	3,551	2,836	1,960
Meters/Piping	116,194	140,894	177,495	248,596	329,692	348,950	299,936	266,334	159,415	117,718
Compressors	76,518	93,698	118,172	162,954	209,222	217,060	135,027	143,478	109,088	84,845
Storage Tanks	79,479	58,809	43,178	35,284	37,888	57,472	57,600	31,563	22,859	18,731
Leaker Survey	0	0	0	0	0	0	37,230	36,837	53,126	80,303
Oil Wellpad Leaks	**1,063,717**	**1,032,085**	**1,019,115**	**1,057,290**	**1,185,600**	**1,430,418**	**1,155,695**	**1,049,113**	**887,605**	**788,047**
Wellheads	267,132	255,315	243,518	244,384	264,240	302,283	233,838	209,585	186,994	169,700
Separators	70,699	75,099	88,958	106,320	134,140	178,628	151,651	121,904	111,575	90,612
Heater-treaters	32,788	36,105	46,254	60,202	77,279	99,670	44,617	42,574	36,429	50,925
Meters/Piping	649,703	631,798	613,692	622,906	682,807	797,636	657,625	604,510	473,365	386,041
Storage Tanks	43,396	33,768	26,693	23,478	27,134	52,203	37,011	33,210	33,930	32,719
Leaker Survey	0	0	0	0	0	0	30,954	37,330	45,312	58,051
Pneumatic Controllers - Production	**1,358,454**	**1,410,524**	**1,479,627**	**1,613,328**	**1,813,205**	**1,703,463**	**1,487,245**	**1,432,335**	**1,143,958**	**976,353**
Pneumatic Controllers - Gas Wells	**596,763**	**665,832**	**727,251**	**860,570**	**987,359**	**820,954**	**627,157**	**615,566**	**568,754**	**473,118**
Low-Bleed	0	4,245	25,386	84,219	215,717	152,394	100,397	103,187	132,626	111,700
High-Bleed	362,528	385,269	368,347	342,133	247,680	58,268	23,803	23,339	17,299	6,773
Intermittent-Bleed	234,235	276,317	333,519	434,218	523,962	610,292	502,957	489,039	418,829	354,644
Pneumatic Controllers - Oil Wells	**761,692**	**744,692**	**752,375**	**752,758**	**825,846**	**882,510**	**860,088**	**816,770**	**575,203**	**503,235**
Low-Bleed	50,868	80,592	147,969	237,019	389,196	129,444	178,679	223,336	171,732	149,959
High-Bleed	710,824	629,071	492,916	334,744	176,759	38,448	48,938	25,585	13,611	8,137
Intermittent-Bleed	0	35,029	111,491	180,995	259,891	714,618	632,471	567,849	389,860	345,140
Pneumatic Controllers - G&B	**98,229**	**112,455**	**109,960**	**109,963**	**125,897**	**153,525**	**157,624**	**144,298**	**132,332**	**113,056**
Low-Bleed	2,713	4,764	7,605	10,904	16,742	26,314	33,814	31,904	31,805	27,268
High-Bleed	17,092	19,085	17,802	16,841	18,041	20,281	12,101	10,806	9,712	8,545
Intermittent-Bleed	78,424	88,607	84,553	82,218	91,115	106,930	111,709	101,588	90,815	77,242

Source	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023
Pneumatic Controllers - Transmission	**212,235**	**179,818**	**134,405**	**98,140**	**69,950**	**41,109**	**39,124**	**39,377**	**39,212**	**37,785**
Low-Bleed	0	765	1,877	2,786	3,490	3,841	3,865	3,736	3,292	3,208
High-Bleed	195,373	162,461	116,436	79,886	51,745	23,524	15,031	14,754	13,763	12,978
Intermittent-Bleed	16,861	16,592	16,091	15,468	14,715	13,745	20,228	20,887	22,157	21,599
Pneumatic Controllers - Underground NG Storage	**44,264**	**49,290**	**51,551**	**52,193**	**50,929**	**33,939**	**26,879**	**27,213**	**23,652**	**19,308**
Low-Bleed	0	253	737	1,299	1,941	1,992	2,567	2,735	3,112	2,191
High-Bleed	40,748	45,215	46,925	46,998	45,146	26,213	17,893	18,411	15,006	9,920
Intermittent-Bleed	3,517	3,823	3,889	3,896	3,842	5,734	6,418	6,067	5,534	7,197
Pipeline Leaks - G&B	**84,667**	**85,312**	**86,775**	**97,524**	**104,543**	**91,746**	**81,691**	**72,512**	**64,395**	**62,761**
Pipeline Leaks - Transmission	**2,441**	**2,483**	**2,500**	**2,513**	**2,549**	**2,379**	**2,223**	**2,223**	**2,201**	**2,192**
TOTAL - For Sources With Updates Under Consideration	**3,536,168**	**3,657,917**	**3,805,839**	**4,227,548**	**4,874,255**	**5,032,858**	**4,189,951**	**3,898,364**	**3,015,151**	**2,574,701**

Table A-2. CH_4 Emissions (mt) for Select Years of the Time Series for the 2024 GHGI

Source	1990	1995	2000	2005	2010	2015	2020	2021	2022
Production Wellpad Equipment Leaks	**241,573**	**269,974**	**303,257**	**377,448**	**442,369**	**511,314**	**528,231**	**496,544**	**544,039**
Gas Wellpad Leaks	**159,480**	**187,137**	**213,525**	**275,983**	**322,015**	**362,594**	**413,370**	**382,242**	**431,775**
Wellheads	19,329	23,529	28,150	39,905	50,752	50,326	48,044	46,947	46,495
Heaters	12,305	14,110	15,264	18,436	18,586	20,858	18,568	17,581	18,476
Separators	41,579	50,457	59,493	80,745	97,457	125,567	129,133	109,610	94,591
Dehydrator	12,904	13,478	12,098	11,381	7,630	5,673	3,070	4,078	3,105
Meters/piping	43,055	48,452	51,714	63,764	65,054	74,248	153,917	130,390	75,719
Compressors	30,307	37,112	46,806	61,753	82,536	85,922	60,637	73,636	193,389
Oil Wellpad Leaks	**82,094**	**82,836**	**89,732**	**101,464**	**120,354**	**148,720**	**114,862**	**114,302**	**112,264**
Wellheads (Heavy)	32	33	33	34	38	41	22	14	19
Wellheads (Light)	56,612	53,891	51,172	51,198	55,275	63,441	58,784	58,644	57,254
Separators (Heavy)	12	14	15	13	11	5	8	4	4
Separators (Light)	10,981	11,729	14,164	17,194	21,962	29,421	29,282	26,551	25,881
Heater-treaters	11,124	12,273	15,769	20,547	26,396	34,000	18,770	21,098	20,121
Headers (Heavy)	7	8	9	9	7	4	6	8	2
Headers (Light)	3,360	4,912	8,589	12,483	16,674	21,807	7,989	7,982	8,982
Pneumatic Controllers - Production	**1,350,257**	**1,465,542**	**1,646,644**	**1,879,139**	**2,070,506**	**2,261,929**	**1,937,079**	**1,750,454**	**1,337,272**
Pneumatic Controllers - Gas Wells	**589,332**	**700,269**	**840,934**	**1,067,997**	**1,241,624**	**1,070,889**	**817,727**	**747,391**	**643,721**
Low-Bleed	0	2,591	9,477	22,656	45,429	31,151	27,238	25,247	29,877
High-Bleed	355,671	406,903	443,829	480,272	419,827	103,494	42,269	41,435	30,700
Intermittent-Bleed	233,661	290,776	387,627	565,070	776,369	936,243	748,219	680,708	583,144

Source	1990	1995	2000	2005	2010	2015	2020	2021	2022
Pneumatic Controllers - Oil Wells	**760,925**	**765,273**	**805,710**	**811,142**	**828,882**	**1,191,040**	**1,119,352**	**1,003,063**	**693,551**
Low-Bleed	51,129	49,892	55,004	62,162	78,230	26,460	36,740	46,060	35,439
High-Bleed	709,796	675,139	605,834	481,760	309,855	68,291	86,363	44,611	23,712
Intermittent-Bleed	0	40,242	144,873	267,220	440,796	1,096,289	996,250	912,391	634,400
Pneumatic Controllers - G&B	**98,229**	**116,062**	**119,894**	**127,072**	**154,745**	**201,531**	**201,625**	**184,116**	**171,000**
Low-Bleed	2,713	3,205	3,311	3,509	4,274	5,566	6,965	6,564	6,572
High-Bleed	17,092	20,195	20,862	22,111	26,927	35,067	22,981	20,709	18,854
Intermittent-Bleed	78,424	92,661	95,721	101,451	123,545	160,898	171,679	156,842	145,574
Pneumatic Controllers - Transmission	**213,081**	**180,254**	**130,947**	**87,701**	**50,517**	**28,790**	**30,120**	**30,585**	**31,170**
Low-Bleed						774	779	753	663
High-Bleed						14,271	9,119	8,951	8,350
Intermittent-Bleed						13,745	20,222	20,882	22,157
Pneumatic Controllers - Underground NG Storage	**44,441**	**46,146**	**42,914**	**38,388**	**32,570**	**22,038**	**17,791**	**17,787**	**15,265**
Low-Bleed						401	517	551	627
High-Bleed						15,902	10,855	11,169	9,103
Intermittent-Bleed						5,734	6,418	6,067	5,534
Pipeline Leaks - G&B	**84,774**	**89,667**	**99,446**	**122,864**	**146,233**	**144,239**	**133,333**	**113,187**	**96,302**
Pipeline Leaks - Transmission	**3,189**	**3,244**	**3,266**	**3,282**	**3,330**	**3,290**	**3,295**	**3,294**	**3,286**
TOTAL - For Sources With Updates Under Consideration	**2,035,544**	**2,170,888**	**2,346,367**	**2,635,895**	**2,900,270**	**3,173,130**	**2,771,211**	**3,235,088**	**3,117,937**