Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2021: Updates Under Consideration for Incorporating Additional Geographically Disaggregated Data for the Production Segment

1 Introduction

This memo discusses updates under consideration for the 2023 *Inventory of U.S. Greenhouse Gas Emissions and Sinks* (GHGI) to develop national emission estimates for certain emissions sources by quantifying emissions for those sources at the basin level and aggregating those estimates to the national level. This memo also supports the public review version of the 2023 GHGI; EPA applied the updates under consideration presented in this memo for pneumatic controllers (section 2), storage tanks (section 3), equipment leaks and chemical injection pumps (section 4), and liquids unloading (section 5) in the public review version of the 2023 GHGI.

In the 2022 GHGI, EPA estimated emissions from most of the emission sources in Natural Gas and Petroleum Systems at the national-level using emission factors (EFs), activity factors (AFs), and activity data at the national-level. For example, for liquids unloading, EPA used Greenhouse Gas Reporting Program (GHGRP) subpart W data to develop average national AFs (e.g., fraction of wells conducting liquids unloading) and average national EFs (e.g., annual emissions per well that conducts liquids unloading with a plunger lift). These average factors were then applied to the national well population to estimate national emissions.

EPA used a basin-specific aggregation approach for two emission sources (i.e., associated gas venting and flaring and miscellaneous onshore production flaring).[1] For these emission sources, it was determined that national-level EFs and AFs would not reflect differences in associated gas venting and flaring among geographic regions and that over- or under-representation in GHGRP data by geographic regions where associated gas is vented or flared more or less frequently may disproportionately contribute to national-level factors. For associated gas venting and flaring (Petroleum Systems) and miscellaneous production flaring (both Petroleum and Natural Gas Systems), EPA calculated basin-specific activity and emission factors for basins that, in any year from 2011 forward, contributed at least 10 percent of total source emissions (on a CO_2 equivalents basis) in the GHGRP data. For associated gas venting and flaring, EPA calculated basin-specific factors for four basins: Williston, Permian, Gulf Coast, and Anadarko. For miscellaneous production flaring, EPA calculated basin-specific factors for three basins: Williston, Permian, and Gulf Coast. For these emission sources, data from all other basins were aggregated, and EPA calculated AFs and EFs for the other basins as a single group.

In recent years, EPA has developed additional GHG Inventory products that break out emissions from the national-level into gridded and state-level estimates.

- Gridded Inventory.[2] In an effort to improve the ability to compare the national-level Inventory with measurement results that may be at other spatial and temporal scales, a team at Harvard University along with EPA and other coauthors developed a gridded inventory of U.S. anthropogenic methane emissions with 0.1 degree x 0.1 degree spatial resolution, monthly temporal resolution, and detailed scale-dependent error characterization. The gridded methane inventory is designed to be consistent with the U.S. EPA's *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2014* estimates for the

[1] EPA 2018. Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2016: Revisions to CO_2 Emissions Estimation Methodologies. Available online at: <https://www.epa.gov/ghgemissions/natural-gas-and-petroleum-systems-ghg-inventory-additional-information-1990-2016-ghg>.

[2] U.S. EPA. Gridded 2012 Methane Emissions. https://www.epa.gov/ghgemissions/gridded-2012-methane-emissions

year 2012, which presents national totals. An updated version of the gridded inventory is being developed and will improve efforts to compare results of the GHG Inventory with atmospheric studies.

- State Inventory.[3] In 2022, EPA released its first annual publication of state greenhouse gas (GHG) data consistent with the GHGI, meaning state GHG totals when summed, will equal national totals in the GHGI. For Petroleum and Natural Gas Systems, the methods used to develop state-level estimates generally rely on relative differences in basic activity levels (e.g., petroleum production), and do not reflect differences between states due to differences in practices, technologies, or formation types.

Both the gridded and the state versions of the GHGI generally rely on national-level average activity and emission factors, along with location-specific information on activity drivers such as well counts or production. The update under consideration discussed in this memo seeks to improve the ability of the gridded and state inventories to reflect variation due to differences in formation types, technologies and practices, regulations, or voluntary initiatives, and not only the differences in key activity levels that are reflected in the current gridded and state inventories.

This memo discusses considerations for developing emissions estimates for the national GHGI using basin-specific data that are currently aggregated and averaged to develop national-level estimates. In this memo, EPA evaluates options to incorporate additional basin-level data from GHGRP subpart W in the GHGI. GHGRP subpart W data are used in the GHGI to calculate numerous EFs and AFs for emission sources across the industry segments in Natural Gas and Petroleum Systems.

The incorporation of basin-specific data would improve future versions of both the gridded and state-level inventories. This would allow EPA to use the gridded inventory for improved comparisons of the GHGI with various atmospheric observation studies (since regions will better reflect the local differences in emissions rates as reported to GHGRP) and would allow the state-level inventory to reflect differences in state-level programs, formation type mixes, and varying technologies and practices.

For many GHGI emission sources, an approach to develop estimates using geographically disaggregated data may not be possible based on currently available data. For some emission sources in the GHGI, EF data come from research studies and are applied at the national level. For example, many of the EFs used to quantify emissions in the GHGI for the gathering and boosting, transmission and storage, distribution, and post-meter segments are from research studies and do not have a level of detail or total population comparable to GHGRP. For petroleum refineries, because there is no reporting threshold for GHGRP subpart Y, facility-level data are generally available for all refineries in the U.S., and these site-specific data are already used to develop the gridded and state-level GHG estimates.[4] Even in cases where geographically disaggregated data are available, such an approach may not always be preferable. In cases with limited variation between areas, such an approach would have limited impact on emissions estimates regionally or nationally. In cases with limited data in certain areas, disaggregated approaches might substantially increase the uncertainty of estimates and basin-specific calculations would not be an improvement over use of a national average.

For the updates under consideration, EPA focused on the onshore oil and gas production segment, where data are available from the GHGRP that could be used to reflect distinctions in emissions levels by region, and which could impact (to varying extents) total emissions in the GHGI. Specifically, EPA assessed the four highest emitting

---

[3] U.S. EPA. State GHG Emissions and Removals. https://www.epa.gov/ghgemissions/state-ghg-emissions-and-removals.

[4] Some refineries have ceased reporting under GHGRP. A GHGRP facility that has reported total non-biogenic GHG emissions below 15,000 metric tons of carbon dioxide equivalent (mt CO_2e) for three consecutive years or below 25,000 mt CO_2e for five consecutive years can discontinue reporting for all direct emitter subparts. In these cases, in the GHGI estimates for refineries, EPA has used previously reported data for a proxy for years without reports.

sources within the onshore production segment for potential basin-level approaches. EPA analyzed subpart W basin-level data for pneumatic controllers, storage tanks, well pad equipment (including equipment leaks and chemical injection pumps), and liquids unloading.

Key considerations for use of the GHGRP subpart W data for onshore production to develop subnational estimates are the variability of emissions and activity levels between basins and GHGRP coverage of total activity for each basin. EPA presented variability and coverage considerations in a previous memo and in webinar slides.[5]

Subpart W of the EPA's GHGRP collects annual activity and emissions data on numerous sources from Natural Gas and Petroleum Systems that meet a reporting threshold of 25,000 metric tons of CO_2 equivalent (CO_2e) emissions. Reporting requirements under subpart W began in reporting year (RY) 2011 for onshore production. Onshore production facilities in subpart W are defined as a unique combination of operator and basin of operation (i.e., all operator sites within a basin). The GHGRP subpart W data used in the analyses discussed in this memo were reported to the EPA as of August 12, 2022. Coverage of onshore production activities varies by basin.

EPA is considering a variety of approaches to take coverage into consideration when evaluating and potentially implementing basin-specific calculations, such as: including basin-specific data for all basins regardless of coverage (all basins approach), selecting a coverage threshold and aggregating basin data from basins with lower coverage and developing a combined AF/EF for those basins (threshold basins approach), combining data from neighboring basins, retaining the national level approach, or developing another approach to rely on a larger (combined) dataset for emissions in those areas. EPA used basin-specific data for all basins that reported under subpart W for the updates under consideration and the public review version of the 2023 GHGI. In the Appendix, results are provided for a threshold basins approach that used 50 percent as a coverage threshold for basin-specific calculations. This coverage threshold was selected only for demonstration purposes. EPA is seeking stakeholder feedback on approaches for incorporating additional basin-level data including the use of a coverage threshold, and in case of its use, an appropriate coverage threshold level. Other approaches to address coverage could also be considered, such as a threshold based on the number of reported wells or number of reporters in each basin. Coverage data are also needed to determine how to scale emissions and/or activity from reported totals to basin totals.

GHGRP has proposed revisions to subpart W, some of which could impact sources discussed in this memo. The general analyses and approaches discussed in this memo would likely be applicable to both current and future GHGRP data.

2 Pneumatic Controllers

2.1 2022 GHGI (Published April 2022)

In the 2022 GHGI, EPA estimated pneumatic controller emissions using AFs and EFs that are specific to low-bleed, intermittent-bleed, and high-bleed controllers. EPA calculated year-specific, national-level AFs using subpart W data for recent years. The AFs were updated annually, and EPA calculated two types of AFs: (1) the average number of controllers per well and (2) the fraction of controllers that are low-bleed, intermittent-bleed, and high-bleed controllers. For the average number of controllers per well AF, EPA calculated year-specific values for 2015 forward and applied the RY2015 AF to 2011 through 2014. For the fraction of each controller type, EPA

[5] Memos and webinar slides supporting the updates under consideration for the 2023 GHGI are available here: https://www.epa.gov/ghgemissions/stakeholder-process-natural-gas-and-petroleum-systems-1990-2021-inventory

calculated year-specific AFs for 2011 forward. EPA also calculated the AFs separately for pneumatic controllers at gas wells and oil wells.

For pneumatic controllers at gas wells, the average number of controllers per well was presented by NEMS region for 1990 through 1992 (based on the 1996 GRI/EPA study); the values were linearly interpolated between 1992 and the subpart W-based AF for 2011. EPA applied the fraction of each controller type developed from the 1996 GRI/EPA study for 1990 through 1992. EPA then linearly interpolated from the 1992 to the 2011 fraction of each controller type value.

For pneumatic controllers at oil wells, EPA estimated the total number of controllers for 1990 through 1993 based on the consensus of an Industry Review Panel. Then EPA linearly interpolated the total number of controllers from 1993 through 2011. For the fraction of each controller type from 1990 through 1993, EPA applied values based on the consensus of an Industry Review Panel and then linearly interpolated from 1993 through 2011.

EPA calculated EFs for the three different types of controllers using RY2014 subpart W data from controllers at oil and gas wells combined. The same EFs were applied to all years.

2.2 Update Under Consideration in PR Draft of 2023 GHGI for Basin-Level EFs and AFs

For the update under consideration, EPA calculated year-specific AFs for each controller type (high-bleed, intermittent-bleed, and low-bleed) at the basin-level using subpart W data. The AFs were calculated separately for gas wells and oil wells. Subpart W data includes basin-level well counts, pneumatic controller counts by type of controller, and emissions. Using these data, EPA estimated basin-level AFs (average number of controllers/well and fraction of controllers, by type) for 2011 through 2021 for gas wells and for oil wells. For basins without subpart W data, EPA applied national-level average AFs. Table 1 shows the average number of pneumatic controllers per well for select basins calculated using subpart W RY2021 data and compares to the 2022 GHGI estimate. Similarly, Table 2 compares the pneumatic controller type fractions for select basins using subpart W RY2021 data to the 2022 GHGI estimate. The basins shown in Tables 1 and 2 are the highest emitting basins and collectively contributed 52% of national emissions in 2021 from oil and gas wells.

Table 1. Average Pneumatic Controllers Per Well for Select Basins (RY2021 Subpart W)

Basin Name	Basin Number	Controllers/Well (Gas)	Controllers/Well (Oil)
2022 GHGI[a]		*1.9*	*1.4*
Anadarko	360	1.3	2.8
Appalachian	160	0.4	5.0
Appalachian (Eastern Overthrust)	160A	1.1	2.0
Gulf Coast	220	1.7	2.8
Permian	430	1.2	1.1

a. The 2022 GHGI equals the average of all subpart W data for RY2020.

Table 2. Pneumatic Controller Type Fractions for Select Basins (RY2021 Subpart W)

Basin Name	Basin Number	Bleed Type Fractions (Gas)			Bleed Type Fractions (Oil)		
		Low	Intermittent	High	Low	Intermittent	High
2022 GHGI[a]		*0.26*	*0.73*	*0.01*	*0.29*	*0.70*	*0.01*
Anadarko	360	0.21	0.70	0.09	0.27	0.68	0.05
Appalachian	160	0.08	0.92	0	0.09	0.91	0
Appalachian (Eastern Overthrust)	160A	0.16	0.83	0.001	0.26	0.74	0
Gulf Coast	220	0.31	0.69	0.01	0.21	0.79	0.002
Permian	430	0.17	0.81	0.02	0.48	0.51	0.01

a. The 2022 GHGI equals the average of all subpart W data for RY2020.

Note: The bleed type fractions don't add up to 1, in some instances, due to rounding.

As part of this update under consideration, EPA also calculated year-specific basin-level CH_4 EFs (scfd/controller) using subpart W data for RY2011 through RY2021. The basin-level EFs were calculated separately for gas wells and oil wells. For basins without subpart W data, EPA applied national average EFs. The CH_4 EFs for select basins are shown in Table 3. The basins shown in Table 3 match those in Tables 1 and 2 and are the highest emitting basins in 2021 for pneumatic controller emissions from oil and gas wells.

Table 3. Pneumatic Controller EFs for Select Basins (RY2021 Subpart W)

Basin Name	Basin Number	Gas Well CH_4 EF (scfd/controller)			Oil Well CH_4 EF (scfd/controller)		
		Low	Intermittent	High	Low	Intermittent	High
2022 GHGI[a]		*25.2*	*187.8*	*689.7*	*21.1*	*177.3*	*628.6*
Anadarko	360	22.6	213.1	569.5	23.6	221.2	688.1
Appalachian	160	26.8	252.3	NA	27.2	259.3	NA
Appalachian (Eastern Overthrust)	160A	27.8	170.6	536.4	27.0	218.1	NA
Gulf Coast	220	20.6	191.3	645.9	22.4	197.2	623.3
Permian	430	20.9	201.8	599.2	22.9	221.4	578.3

a. The 2022 GHGI equals the average of all subpart W data for RY2020.

2.3 Time Series Considerations

In the update under consideration, EPA retained the 2022 GHGI AFs for 1990 through 1992 (for gas wells) and the 2022 GHGI assumptions regarding activity data for 1990 through 1993 (for oil wells) for all basins (i.e., the same AFs and assumptions were applied to all basins) and applied linear interpolation between the 1992 (or 1993) and 2011 AFs at the basin level. EPA applied emission factors developed using subpart W data for RY2011 for the time series years without subpart W data (i.e., 1990-2010).

2.4 National Emissions for Update Under Consideration in PR Draft of 2023 GHGI

EPA calculated national time series estimates by applying the basin-level AF and EF methodologies presented in sections 2.2 and 2.3. Tables 4 and 5 present a summary of national CH_4 estimates from pneumatic controllers for select time series years for gas wells and for oil wells. Details on the emissions, EFs, AFs, activity data, data sources, and methodologies for each year from 1990 to 2021 are available in spreadsheet file annexes.[6] Appendix A.1 presents national time series emissions for the pneumatic controllers threshold basins approach.

Table 4. National CH_4 Estimates for Gas Well Pneumatic Controllers (Metric Tons)

Source	1990	2005	2017	2018	2019	2020	2021
2022 GHGI	*510,354*	*1,041,503*	*1,104,896*	*1,072,874*	*1,024,678*	*950,718*	*N/A*
Update under consideration							
Low-Bleed Controllers	0	22,745	32,360	33,805	31,475	27,364	25,609
Intermittent-Bleed Controllers	230,504	569,592	873,015	835,249	874,372	744,622	692,097
High-Bleed Controllers	350,535	483,375	108,533	87,071	53,233	42,332	42,828
Total	**581,039**	**1,075,712**	**1,013,908**	**956,125**	**959,080**	**814,318**	**760,534**

Table 5. National CH_4 Estimates for Oil Well Pneumatic Controllers (Metric Tons)

Source	1990	2005	2017	2018	2019	2020	2021
2022 GHGI	*736,447*	*708,680*	*835,129*	*727,365*	*732,092*	*853,562*	*N/A*
Update under consideration							
Low-Bleed Controllers	51,170	63,773	20,104	31,779	50,456	36,752	46,360
Intermittent-Bleed Controllers	0	276,145	1,252,028	1,155,041	762,647	1,006,263	920,518
High-Bleed Controllers	708,800	493,011	89,472	73,438	73,278	87,884	48,202
Total	759,970	832,929	1,361,605	1,260,259	886,382	1,130,899	1,015,080

3 Storage Tanks

3.1 2022 GHGI (Published April 2022)

In the 2022 GHGI, EPA estimated CH_4 and CO_2 emissions for production storage tanks using AFs and EFs that were specific to condensate tanks (i.e., tanks that store liquids produced from gas wells) and oil tanks (i.e., tanks that store liquids produced from oil wells) and each control category. The six control categories are large tanks with flares, large tanks with vapor recovery units (VRUs), large tanks without control, small tanks with flares, small tanks without flares, and malfunctioning separator dump valves.

EPA calculated two types of AFs: (1) production fraction sent to tanks and (2) throughput fraction for each control category. EPA calculated the production fraction sent to tanks separately for condensate and oil using subpart W data for RY2015 and applied the resulting value to all years. EPA calculated year-specific throughput fractions for each condensate and oil tank control category using subpart W data for RY2015 forward. The RY2015 fraction of throughput in each control category was applied to years 2011 to 2015. To estimate the control category throughput fractions for years without GHGRP data (i.e., 1990-2010), EPA applied different assumptions to condensate and oil tank activity in 1990. For large condensate tanks in 1990, EPA assumed 50% of condensate

[6] The basin-level annex spreadsheets are available here: https://www.epa.gov/ghgemissions/stakeholder-process-natural-gas-and-petroleum-systems-1990-2021-inventory

was sent to tanks without controls, 50% was sent to tanks with flares, and 0% was sent to tanks with VRUs. For small condensate tanks in 1990, EPA assumed all throughput was sent to tanks without flares. For large and small condensate tanks for 1992-2010, EPA used linear interpolation between 1990 to 2011 values for each control category. For oil tanks in 1990, EPA assumed all throughput was sent to tanks in the uncontrolled categories and then used linear interpolation between 1990 and 2011 for each control category.

EPA calculated year-specific EFs for each production tank control category using subpart W data for RY2015 forward. The EFs calculated for RY2015 were then applied to 1990 through 2014.

3.2 Update Under Consideration in PR Draft of 2023 GHGI for Basin-Level EFs and AFs

For the update under consideration, EPA calculated year-specific AFs for each condensate and oil tank control category at the basin-level using subpart W data for 2015 through 2021. For basins without subpart W data, EPA applied national average AFs. For the production fraction sent to tanks at the basin-level, EPA calculated the fraction of total liquids production (condensate plus oil production) sent to tanks using subpart W data for RY2015 forward, and applied the same production fraction to both condensate and oil tanks. This differs from the 2022 GHGI, which calculated the condensate production fraction and oil production fraction sent to tanks separately. The basin-level methodology for throughput fractions is similar to the national-level methodology, although the fractions are in relation to total liquids sent to tanks and not specific to condensate production sent to tanks and oil production sent to tanks. For example, EPA calculated the throughput fraction for large oil tanks with flares at the basin-level as the volume of oil stored in this control category divided by the total liquids production sent to tanks. Conversely, the 2022 GHGI methodology for this example equals the volume of oil stored in this control category divided by the total oil production sent to tanks. EPA calculated the basin-level AFs using total liquids production as the reference point because total condensate production and oil production are not available at the basin-level in subpart W. Table 6 and Table 7 present the RY2021 AFs for oil tanks and condensate tanks for select basins. The basins shown are the highest CO_2 emitting basins in year 2021.

Table 6. Oil Tank AFs for Select Basins (RY2021 Subpart W)

Basin Name	Basin Number	Production Fraction Sent to Tanks	Large Tanks With Flares	Large Tanks With VRUs	Large Tanks Without Controls	Small Tanks With Flares	Small Tanks Without Flares
2022 GHGI[a]		*63%*	*65%*	*21%*	*10%*	*1%*	*3%*
Anadarko	360	88%	58%	3%	9%	1%	6%
Gulf Coast	220	41%	66%	5%	5%	2%	4%
Permian	430	48%	40%	25%	17%	0%	1%
Powder River	515	74%	90%	5%	3%	1%	0%
Williston	395	95%	95%	2%	2%	1%	0%

a. The 2022 GHGI equals the average of all subpart W data for RY2020. The AFs are also unique to oil production.

Table 7. Condensate Tank AFs for Select Basins (RY2021 Subpart W)

Basin Name	Basin Number	Production Fraction Sent to Tanks	Large Tanks With Flares	Large Tanks With VRUs	Large Tanks Without Controls	Small Tanks With Flares	Small Tanks Without Flares
2022 GHGI[a]		*79%*	*66%*	*10%*	*5%*	*8%*	*11%*
Anadarko	360	88%	12%	1%	4%	0%	5%
Gulf Coast	220	41%	11%	3%	2%	1%	1%
Permian	430	48%	7%	4%	5%	0%	0%

Basin Name	Basin Number	Production Fraction Sent to Tanks	Large Tanks With Flares	Large Tanks With VRUs	Large Tanks Without Controls	Small Tanks With Flares	Small Tanks Without Flares
Powder River	515	74%	0%	0%	0%	0%	0%
Williston	395	95%	0%	0%	0%	0%	0%

a. The 2022 GHGI equals the average of all subpart W data for RY2020. The AFs are also unique to condensate production.

The basin-level methodology for storage tank EFs is identical to the national-level methodology. EPA calculated year-specific EFs for each production tank control category at the basin-level using subpart W data for RY2015 forward. For basins without subpart W data, EPA applied a national average EF. Table 8 through Table 11 present the RY2021 EFs for oil tanks and condensate tanks for select basins and compare to the 2022 GHGI. The basins shown are the highest CO_2 emitting basins in year 2021.

Table 8. Oil Tank CH_4 EFs (scf CH_4/bbl) for Select Basins (RY2021 Subpart W)

Basin Name	Basin Number	Large Tanks With Flares	Large Tanks With VRUs	Large Tanks Without Controls	Small Tanks With Flares	Small Tanks Without Flares
2022 GHGI[a]		*0.15*	*0.12*	*5.0*	*0.08*	*2.4*
Anadarko	360	0.22	0.01	7.6	0.06	3.4
Gulf Coast	220	0.15	0.26	9.7	0.09	1.4
Permian	430	0.15	0.08	1.9	0.11	3.2
Powder River	515	0.25	<0.01	14.3	0.16	2.7
Williston	395	0.12	0.06	3.4	0.05	2.0

a. The 2022 GHGI equals the average of all subpart W data for RY2020.

Table 9. Oil Tank CO_2 EFs (scf CO_2/bbl) for Select Basins (RY2021 Subpart W)

Basin Name	Basin Number	Large Tanks With Flares	Large Tanks With VRUs	Large Tanks Without Controls	Small Tanks With Flares	Small Tanks Without Flares
2022 GHGI[a]		*85*	*0.03*	*0.3*	*12*	*1.4*
Anadarko	360	72	<0.01	0.3	13	5.8
Gulf Coast	220	77	0.01	0.7	8	2.3
Permian	430	49	0.08	0.6	14	5.1
Powder River	515	93	<0.01	0.8	9	4.0
Williston	395	150	<0.01	0.1	12	3.1

a. The 2022 GHGI equals the average of all subpart W data for RY2020.

Table 10. Condensate Tank CH_4 EFs (scf CH_4/bbl) for Select Basins (RY2021 Subpart W)

Basin Name	Basin Number	Large Tanks With Flares	Large Tanks With VRUs	Large Tanks Without Controls	Small Tanks With Flares	Small Tanks Without Flares
2022 GHGI[a]		*0.1*	*0.2*	*14*	*0.2*	*27*
Anadarko	360	0.3	0.01	5	0.3	29
Gulf Coast	220	0.2	1.2	7	0.3	33
Permian	430	0.2	0.3	4	0.1	27
Powder River	515	0.2	<0.01	25	0.2	6
Williston	395	<0.01	<0.01	<0.01	0.04	2

a. The 2022 GHGI equals the average of all subpart W data for RY2020.

Table 11. Condensate Tank CO_2 EFs (scf CO_2/bbl) for Select Basins (RY2021 Subpart W)

Basin Name	Basin Number	Large Tanks With Flares	Large Tanks With VRUs	Large Tanks Without Controls	Small Tanks With Flares	Small Tanks Without Flares
2022 GHGI[a]		*68*	*<0.01*	*0.5*	*15*	*5*
Anadarko	360	95	<0.01	0.3	37	6
Gulf Coast	220	104	<0.01	0.4	12	6
Permian	430	264	<0.01	0.4	11	9
Powder River	515	61	<0.01	1.3	9	4
Williston	395	264	<0.01	<0.01	6	1

a. The 2022 GHGI equals the average of all subpart W data for RY2020.

3.3 Time Series Considerations

For the update under consideration, EPA used subpart W AFs and EFs for 2015 through 2021. For the production fraction sent to tanks, EPA applied the RY2015 AF to 1990 through 2014. For the throughput fraction for each control category, EPA maintained the 2022 GHGI AF assumptions for 1990 and linearly interpolated from the 1990 to 2015 AFs. EPA applied the EFs calculated for RY2015 were used for 1990 through 2014.

3.4 National Emissions for Update Under Consideration in PR Draft of 2023 GHGI

EPA estimated national estimates by applying the basin-level AF and EF methodologies presented in sections 3.2 and 3.3. Table 12 through Table 15 present a summary of national CH_4 and CO_2 estimates from oil and condensate storage tanks for select time series years and compare to the 2022 GHGI. Details on the emissions, EFs, AFs, activity data, data sources, and methodologies for each year from 1990 to 2021 are available in spreadsheet file annexes.[7] Appendix A.2 presents national time series emissions for the storage tanks threshold basins approach.

Table 12. National Oil Tank CH_4 Emissions (Metric Tons)

Source	1990	2005	2017	2018	2019	2020	2021
2022 GHGI	*218,419*	*60,186*	*61,098*	*57,412*	*35,266*	*29,613*	*N/A*
Update Under Consideration							
Large Tanks w/Flares	0	993	5,142	6,330	4,226	3,715	3,108
Large Tanks w/VRU	0	721	9,334	2,410	2,320	1,026	513
Large Tanks w/o Control	105,668	40,150	42,112	42,679	26,491	21,294	12,290
Small Tanks w/Flares	0	15	45	16	23	29	68
Small Tanks w/o Flares	7,438	3,448	2,991	3,326	2,755	2,709	3,598
Malfunctioning Separator Dump Valves	2,397	1,472	4,247	785	428	338	320
Total	**115,503**	**46,799**	**63,871**	**55,546**	**36,243**	**29,112**	**19,896**

Table 13. National Oil Tank CO_2 Emissions (Metric Tons)

Source	1990	2005	2017	2018	2019	2020	2021
2022 GHGI	*114,701*	*2,505,440*	*4,312,648*	*6,189,224*	*6,682,129*	*6,537,103*	*N/A*
Update Under Consideration							

[7] The basin-level annex spreadsheets are available here: https://www.epa.gov/ghgemissions/stakeholder-process-natural-gas-and-petroleum-systems-1990-2021-inventory

Source	1990	2005	2017	2018	2019	2020	2021
Large Tanks w/Flares	0	716,264	3,771,444	5,348,119	5,973,929	5,212,454	5,381,419
Large Tanks w/VRU	0	3,011	3,542	3,509	5,719	2,008	1,245
Large Tanks w/o Control	23,733	7,675	4,811	4,422	4,871	5,841	5,426
Small Tanks w/Flares	0	2,632	11,232	6,850	8,578	10,208	9,201
Small Tanks w/o Flares	11,736	5,435	4,352	5,109	4,318	4,462	4,863
Malfunctioning Separator Dump Valves	11,539	12,910	32,278	30,403	26,096	20,254	36,508
Total	**47,008**	**747,928**	**3,827,658**	**5,398,412**	**6,023,510**	**5,255,229**	**5,438,663**

Table 14. National Condensate Tank CH_4 Emissions (Metric Tons)

Source	1990	2005	2017	2018	2019	2020	2021
2022 GHGI	*16,421*	*11,331*	*21,493*	*24,435*	*21,194*	*17,294*	*N/A*
Update Under Consideration							
Large Tanks w/Flares	505	336	1,016	1,273	789	600	606
Large Tanks w/VRU	0	27	205	143	905	525	371
Large Tanks w/o Control	16,161	6,867	6,622	15,416	2,446	4,284	4,916
Small Tanks w/Flares	0	51	249	237	208	201	168
Small Tanks w/o Flares	89,757	31,176	40,152	43,448	63,168	47,749	37,959
Malfunctioning Separator Dump Valves	7	4	648	40	80	254	197
Total	**106,429**	**38,461**	**48,892**	**60,556**	**67,595**	**53,613**	**44,217**

Table 15. National Condensate Tank CO_2 Emissions (Metric Tons)

Source	1990	2005	2017	2018	2019	2020	2021
2022 GHGI	*298,202*	*380,108*	*1,131,470*	*844,112*	*634,177*	*573,973*	*N/A*
Update Under Consideration							
Large Tanks w/Flares	578,973	421,656	1,804,309	1,356,381	840,013	795,330	825,379
Large Tanks w/VRU	0	2,365	298	46	886	849	649
Large Tanks w/o Control	2,019	747	855	36,514	662	580	1,367
Small Tanks w/Flares	0	13,434	71,617	87,043	81,718	40,631	27,855
Small Tanks w/o Flares	47,128	17,500	23,266	26,491	33,134	23,526	17,784
Malfunctioning Separator Dump Valves	32	19	1,640	405	46	621	7
Total	**628,152**	**455,720**	**1,901,984**	**1,506,880**	**956,460**	**861,538**	**873,041**

4 Well Pad Equipment Leaks and Chemical Injection Pumps

4.1 2022 GHGI (Published April 2022)

EPA calculated leak emissions from certain well pad emission sources and venting emissions from chemical injection pumps. EPA calculated leak emissions at gas wells for separators, heaters, dehydrators, meters/piping, and compressors and calculated leak emissions at oil wells for separators, heater-treaters, and headers.

The AFs applied to gas wells are unique to the National Energy Modeling System (NEMS) region in which the well resides. From 2015 forward, EPA applied national level AFs (e.g., average number of separators per gas well) calculated using RY2015 subpart W data for separators, heaters, dehydrators, meters/piping, compressors, and chemical injection pumps. Early year (1990 through 1992) AFs at gas wells are from a 1996 GRI/EPA study. EPA applied linear interpolation between the 1992 and 2015 AFs.

For oil wells, EPA calculated AFs for separators, heater-treaters, and headers for 1990 through 1993 based on a 1999 Radian report.[8] EPA also used the 1999 Radian report to calculate the fraction of oil wells that are light crude and heavy crude and the fraction of separators and headers at light crude versus heavy crude wells. The chemical injection pumps AF for 1990 through 1993 is based on an estimate from the 1999 Radian report and an industry assumption that 25% of pumps use methane.[9] EPA calculated AFs for all equipment on oil wells using RY2015 subpart W data and applied these AFs for 2011 through 2021. Linear interpolation is applied between 1993 and 2011.

The EFs used in the 2022 GHGI are derived from several different sources. At gas wells, EPA calculated the chemical injection pumps EF using RY2014 subpart W data and applied it for years 2011 forward. EPA used a different EF from the 1996 GRI/EPA study[10] for 1990 through 1993. Linear interpolation between the two values was used for 1994 through 2010. For all other well pad equipment at gas wells, EPA applied either an east or west EF from the 1996 GRI/EPA study for all years. The east or west determination was based on the NEMS region the wells fall in, with the northeast and midcontinent region classified as east and all others classified as west.

For chemical injection pumps at oil wells, EPA calculated the EF using RY2014 subpart W data and applied it to all years of the time series. The EFs used for all other equipment at oil wells are based on values from a 1996 API workbook. Distinct EFs are used for wellheads, separators, and headers at heavy crude oil wells and at light crude oil wells. The same value EFs are applied to all years of the time series.

4.2 Update Under Consideration in PR Draft of 2023 GHGI for Basin-Level AFs

For the update under consideration, EPA calculated year-specific AFs and EFs for each emission source at the basin-level using subpart W data for RY2015 through RY2021.

For gas wells, the AF methodology at the basin-level is identical to the national-level methodology. EPA summed equipment counts and pump counts for each basin with subpart W data (e.g., number of separators) and divided by the number of gas wells in that basin. Note that different well counts are used to estimate the equipment AFs and chemical injection pump AFs. For the equipment AFs (i.e., separators, heaters, dehydrators, meters/piping, compressors), EPA used the wellhead counts reported under the subpart W equipment leaks reporting section

[8] Radian International. Methane Emissions from the U.S. Petroleum Industry. 1999. EPA-600/R-99-010.
[9] Ron Rayman from Dresser Texsteam-25% pumps use methane (1 million CIPs, 80-85% for Pet E&P, 25% on methane)
[10] GRI/EPA. Methane Emissions from the Natural Gas Industry. 1996. EPA-600/R-96-080a.

to ensure consistency in the equipment leaks data.[11] For chemical injection pump AFs, EPA used the well counts reported under the subpart W facility overview section. EPA applied national average AFs to basins without subpart W data.

For oil wells, the AF methodology at the basin-level is similar to the national-level methodology, but EPA evaluated additional data to distinguish between separators and headers at light crude and heavy crude oil wells. For chemical injection pumps and heater-treaters, EPA applied basin-specific AFs calculated in the same way as the 2022 GHGI, using year-specific subpart W data specific to each basin.

For separators and headers at oil wells, EPA evaluated basin-level data to allocate equipment to heavy crude and light crude oil wells. First, EPA analyzed subpart W data to identify basins reporting heavy crude (i.e., an API gravity of less than 20, as reported under subpart W Facility Overview information) at any time in RY2015 through RY2021. Nineteen basins reported heavy crude data during this timeframe: Anadarko, Arctic Coastal Plains Province, Arkla, Coastal, East Texas, Fort Worth Syncline, Gulf Coast, Los Angeles, Michigan, Mid-Gulf Coast, Paradox, Permian, Powder River, San Joaquin, Santa Maria, Sedgwick, Strawn, Williston, and Wind River. Of these, the San Joaquin Basin accounted for the majority of the heavy crude data; 83 percent of wells reported in a heavy crude subbasin were in the San Joaquin basin. EPA developed three groups of basins for oil well data: (1) the San Joaquin basin (where 32 to 87 percent of wells are heavy crude wells for RY2015 through 2021), (2) the other 18 basins that have heavy crude wells (where 1 to 4 percent of wells are heavy crude wells for RY2015 through 2021), and (3) the remaining basins which have only light crude wells. Next, EPA assessed the equipment leaks data for the basins with heavy crude and light crude wells, and focused on facilities that only reported heavy crude wells and that only reported light crude wells. EPA calculated separator and header AFs for these two subsets of populations; facilities with only light crude wells had noticeably higher AFs than facilities with only heavy crude wells. For example, facilities with only light crude wells averaged 0.5 separators per well and facilities with only heavy crude wells averaged 0.05 separators per well. Considering separators for facilities with both light and heavy crude wells, the average number of separators per well in these basins was between those values but skewed towards the higher separator AF for facilities with only light crude wells. This meant that most oil well separators were for light crude wells. The subpart W data analysis for oil well headers led to a similar result. EPA calculated the percentage of separators at heavy crude wells for RY2015 through RY2021 to vary between 0.3% and 5.1% and the percentage of headers at heavy crude wells for RY2015 through RY2021 to vary between 3% and 15%; these percentages were calculated and applied uniquely for each year. To calculate the basin-level AFs for separators and headers for basins with light crude and heavy crude wells, EPA applied the percentage of separators and headers at heavy crude wells to the reported equipment counts in the numerator and the percentage of wells that were heavy crude wells to the denominator. For basins that did not report heavy crude, EPA used all equipment counts and well counts to calculate the AFs for separators and headers in each basin.

EPA did not change emission factors for the update under consideration. In addition, EPA did not change the methodology used to develop CO_2 emissions estimates for the update under consideration. However, EPA is considering applying the same basin-level AF methodology that is used to estimate CH_4 emissions to calculate CO_2 emissions for the final methodology.

Table 16 presents the updated activity factors for natural gas wellhead equipment and Table 17 presents the updated activity factors for oil wellhead equipment, compared to the 2022 GHGI activity factors based on

[11] Facilities have the option to calculate equipment leak emissions in subpart W using population counts or leak survey data. Equipment counts and wellhead counts are reported under the equipment leaks section only if the population count methodology is applied. As a result, the reported counts are a subset of the reporting population.

RY2015. The basins presented are the top five emitters for equipment leaks and chemical injection pump emissions in RY2021.

Table 16. Gas Well Pad Equipment Leak and Chemical Injection Pump AFs (RY2021 Subpart W)

Basin Name	Basin Number	Compressors AF	Dehydrators AF	Heaters AF	Meters/ Piping AF	Separators AF	Chemical Injection Pumps AF
2022 GHGI[a]		*0.08*	*0.03*	*0.13*	*0.8*	*0.7*	*0.2*
East Texas	260	0.04	0.01	0.03	1.1	0.6	0.3
Gulf Coast	220	0.06	0.02	0.05	1.2	0.7	0.2
Permian	430	0.2	<0.01	0.04	1.3	0.8	0.04
Powder River	515	0.8	0	0	30	0.5	<0.01
San Juan	580	0.2	<0.01	0.96	1.0	0.96	0.02

a. The 2022 GHGI equals the average of all subpart W data for RY2015.

Table 17. Oil Well Pad Equipment Leak and Chemical Injection Pump AFs (RY2021 Subpart W)

Basin Name	Basin Number	Headers AF (Light Crude)	Heater-Treaters AF	Separators AF (Light Crude)	Chemical Injection Pumps AF
2022 GHGI		*0.2*	*0.2*	*0.4*	*0.1*
East Texas	260	0.3	0.2	0.6	0.5
Gulf Coast	220	0.3	0.3	0.9	0.4
Permian	430	0.2	0.2	0.4	0.01
Powder River	515	0.4	1.3	0.9	<0.01
San Juan	580	0.01	0.01	1.0	0.02

a. The 2022 GHGI equals the average of all subpart W data for RY2015.

4.3 Time Series Considerations

In the update under consideration, EPA retained the 2022 GHGI AFs for 1990 through 1992 for all gas well emission sources and basins (e.g., the same national-level AFs were applied to all basins) and applied linear interpolation between the 1992 and 2015 factors at the basin level.

EPA retained the 2022 GHGI oil well equipment AF assumptions for 1990 through 1993 and applied these at the basin-level. EPA also adjusted the default percentage of heavy crude wells from the Radian report to a value specific to the subset of 19 basins with heavy crude wells and applied that factor to years 1990 to 1993. Specifically, 7.05% of oil wells are heavy crude at the national level and EPA back-calculated that 13.5% of oil wells were crude wells in the 19 basins with heavy crude wells. Linear interpolation was used between the 1993 and 2015 AFs at the basin level.

4.4 National Emissions for Update Under Consideration in PR Draft of 2023 GHGI

Based on applying the basin-level AF methodologies presented in section 4.2 and 4.3, Table 18 and Table 19 present a summary of national CH_4 emissions estimates for gas and oil well pad equipment for select time series years and compare to the 2022 GHGI. Details on the emissions, EFs, AFs, activity data, data sources, and methodologies for each year from 1990 to 2021 are available in spreadsheet file annexes.[12] Appendix A.3 presents national time series emissions for the well pad equipment leaks and chemical injection pump threshold basins approach.

[12] The basin-level annex spreadsheets are available here: https://www.epa.gov/ghgemissions/stakeholder-process-natural-gas-and-petroleum-systems-1990-2021-inventory

Table 18. Gas Well Pad Equipment Leaks and Chemical Injection Pump Emissions (MT CH4)

Source	1990	2005	2017	2018	2019	2020	2021
2022 GHGI (leaks and pumps)	*66,003*	*327,970*	*91,883*	*389,876*	*384,333*	*376,575*	*N/A*
Update Under Consideration							
Chemical Injection Pumps	25,345	183,832	113,726	120,984	108,546	84,002	76,315
Compressors	29,585	64,877	73,000	72,026	64,471	60,157	73,963
Dehydrators	12,722	12,796	4,485	5,552	3,739	3,133	4,128
Heaters	12,116	20,307	20,068	80,312	16,421	19,223	17,694
Meters/Piping	42,205	72,148	78,403	81,139	85,625	154,544	135,476
Separators	40,745	92,060	129,978	124,339	128,675	132,409	112,425
Total	**162,992**	**446,020**	**419,661**	**484,351**	**407,476**	**453,468**	**420,001**

Table 19. Oil Well Pad Equipment Leaks and Chemical Injection Pump Emissions (MT CH4)

Source	1990	2005	2017	2018	2019	2020	2021
2022 GHGI (leaks and pumps)	*128,631*	*153,932*	*181,178*	*179,080*	*177,578*	*171,205*	*N/A*
Update Under Consideration							
Chemical Injection Pumps	47,401	105,458	121,469	138,866	387,416	116,080	115,678
Headers	3,323	12,434	12,754	13,217	15,595	8,075	8,444
Heater/Treaters	11,119	20,741	16,245	17,492	22,706	18,734	21,307
Separators	10,970	17,514	30,021	42,001	38,510	29,356	27,107
Wellheads	56,524	51,563	60,557	59,195	60,877	58,632	60,029
Total	**129,337**	**207,709**	**241,047**	**270,770**	**525,104**	**230,877**	**232,565**

5 Liquids Unloading

5.1 2022 GHGI (Published April 2022)

In the 2022 GHGI, EPA estimated emissions from natural gas well liquids unloading with and without plunger lifts. EPA used national-level AFs and EFs calculated using subpart W data (RY2011-RY2020) to estimate CH_4 and CO_2 emissions from liquids unloading.

The AFs consisted of national-level fraction of all gas wells requiring liquids unloading, and fractions of liquids unloading events with and without plunger lifts. These AFs were year-specific for 2011 through 2020. For 1990, EPA used AFs developed from API/ANGA data (56.3% of all gas wells required liquids unloading and 100% of liquids unloading was conducted without plunger lifts).[13] AFs for the remaining time series years without GHGRP data (i.e., 1991-2010) were developed using linear interpolation between the 1990 values from API/ANGA and the 2011 values that were developed using subpart W data.

EPA also estimated national-level CH_4 and CO_2 EFs (scfd/venting well) using year-specific subpart W data for 2011 through 2020. These EFs were calculated separately for liquids unloading with and without plunger lifts.

[13] API/ANGA 2012. Characterizing Pivotal Sources of Methane Emissions from Natural Gas Production – Summary and Analysis of API and ANGA Survey Responses. Final Report. American Petroleum Institute and America's Natural Gas Alliance. September 2012.

Emission factors developed using subpart W data for RY2011 were used for the time series years without GHGRP data (i.e., 1990-2010).

EPA then applied the AFs and EFs to the national-level gas well counts from Enverus to estimate national-level emissions of CH_4 and CO_2 from liquids unloading.

5.2 Update Under Consideration in PR Draft of 2023 GHGI for Basin-Level EFs and AFs

For the update under consideration, EPA calculated year-specific AFs at the basin-level using subpart W data. EPA used the same methodology as the national methodology in the 2022 GHGI to estimate basin-level AFs for this update. Subpart W data includes basin-level counts for gas wells, gas wells that conducted liquids unloading with plunger lifts, and gas wells that conducted liquids unloading without plunger lift in the reporting year. Using these basin-level data, EPA estimated the fraction of all gas wells conducting liquids unloading, and fractions of liquids unloading with and without plunger lifts. Year-specific basin-level AFs were calculated for RY2011 through RY2021. For basins without subpart W data, EPA applied national average AFs. Table 18 presents liquids unloading AFs for select basins for 2021. The basins shown in the table are the highest emitting basins and collectively contributed almost 80% of national emissions in 2021.

Table 20. Liquids Unloading AFs for Select Basins (RY2021 Subpart W)

Basin Name	Basin Number	Fraction of All Gas Wells Conducting Liquids Unloading	Fraction of Liquids Unloading with Plunger Lifts	Fraction of Liquids Unloading without Plunger Lifts
2022 GHGI[a]		*13%*	*67%*	*33%*
Appalachian (Eastern Overthrust)	160A	14%	30%	70%
Arkla	230	11%	24%	76%
East Texas	260	6%	31%	69%
Arkoma	345	48%	77%	23%
San Juan	580	25%	97%	3%

a. The 2022 GHGI equals the average of all subpart W data for RY2020.

EPA also calculated year-specific basin-level EFs for CH_4 and CO_2 using subpart W data. EPA calculated EFs separately for liquids unloading with and without plunger lifts for RY2011 through RY2021. Year-specific EFs were calculated using reported basin-level emissions and number of wells that conducted liquids unloading with and without plunger lifts. For basins without subpart W data, EPA applied national average EFs. Table 19 presents CH_4 and CO_2 EFs for select basins for 2021.

Table 21. Liquids Unloading EFs (scfy/venting well) for Select Basins (RY2021 Subpart W)

Basin Name	Basin Number	CH_4 EF – With Plunger Lifts	CH_4 EF – Without Plunger Lifts	CO_2 EF – With Plunger Lifts	CO_2 EF – Without Plunger Lifts
2022 GHGI[a]		*78,846*	*213,224*	*1,293*	*3,115*
Appalachian (Eastern Overthrust)	160A	54,308	171,114	90	287
Arkla	230	192,754	296,902	8,140	12,374
East Texas	260	21,568	1,486,005	884	53,648

Basin Name	Basin Number	CH_4 EF – With Plunger Lifts	CH_4 EF – Without Plunger Lifts	CO_2 EF – With Plunger Lifts	CO_2 EF – Without Plunger Lifts
Arkoma	345	60,100	76,996	1,436	1,642
San Juan	580	172,452	268,877	2,851	5,099

a. The 2022 GHGI equals the average of all subpart W data for RY2020.

5.3 Time Series Considerations

In the 2022 GHGI, EPA used AFs for 1990 from API/ANGA. AFs for the remaining time series years (i.e., 1991-2010) were developed using linear interpolation between the 1990 values and the 2011 values that were developed using subpart W data. Emission factors developed using subpart W data for RY2011 were used for the time series years without GHGRP data (i.e., 1990-2010).

In this update under consideration, EPA used AFs and EFs from the 1994 GRI study for 1990-1992.[14] The GRI study data indicates that 41.4 percent of all gas wells required liquids unloading and all liquids unloading was conducted without using plunger lifts (i.e., 100%). The GRI study also included CH_4 EF for liquids unloading without plunger lifts (49,570 scfy/venting well). The same GRI data were used for all basins for 1990-1992. Basin-level AFs for the remaining time series years (i.e., 1993-2010) were developed using linear interpolation between 1992 and 2011 values. Basin-level CH_4 EFs for liquids unloading without plunger lifts for the remaining time series years (1993-2010) were also developed using linear interpolation between 1992 and 2011 values. Basin-level CH_4 EFs for liquids unloading with plunger lifts and the CO_2 EFs (with and without plunger lifts) developed using RY2011 subpart W data were used as constant for time series years without subpart W data (i.e., 1990-2010).

5.4 National Emissions for Update Under Consideration in PR Draft of 2023 GHGI

Based on applying the basin-level AF methodologies presented in sections 5.2 and 5.3, Tables 20 and 21 present a summary of national CH_4 and CO_2 estimates from liquids unloading for select time series years. Details on the emissions, EFs, AFs, activity data, data sources, and methodologies for each year from 1990 to 2021 are available in spreadsheet file annexes.[15] Appendix A.4 presents national time series emissions for the liquids unloading threshold basins approach.

Table 22. National CH_4 Estimates from Liquids Unloading (Metric Tons)

Source	1990	2005	2017	2018	2019	2020	2021
2022 GHGI	*373,528*	*379,184*	*155,178*	*207,603*	*175,156*	*129,831*	*N/A*
Update under consideration							
Liquids Unloading With Plunger Lifts	0	144,856	68,633	99,159	85,536	60,280	39,456
Liquids Unloading Without Plunger Lifts	76,815	214,070	116,012	166,014	124,428	98,687	80,690
Total	**76,815**	**358,925**	**184,645**	**265,173**	**209,964**	**158,968**	**120,145**

Note: Totals may not add up due to rounding.

[14] GRI/EPA (1996) Methane Emissions from the Natural Gas Industry. Prepared by Harrison, M., T. Shires, J. Wessels, and R. Cowgill, eds., Radian International LLC for National Risk Management Research Laboratory, Air Pollution Prevention and Control Division, Research Triangle Park, NC. EPA-600/R-96-080a.

[15] The basin-level annex spreadsheets are available here: https://www.epa.gov/ghgemissions/stakeholder-process-natural-gas-and-petroleum-systems-1990-2021-inventory

Table 23. National CO_2 Estimates from Liquids Unloading (Metric Tons)

Source	1990	2005	2017	2018	2019	2020	2021
2022 GHGI	*83,155*	*67,087*	*7,487*	*9,181*	*8,284*	*5,491*	*N/A*
Update under consideration							
Liquids Unloading With Plunger Lifts	0	11,926	3,376	4,212	2,864	2,606	1,967
Liquids Unloading Without Plunger Lifts	44,810	40,806	5,390	7,227	7,270	3,562	3,733
Total	**44,810**	**52,733**	**8,767**	**11,439**	**10,134**	**6,168**	**5,700**

Note: Totals may not add up due to rounding.

6 Requests for Stakeholder Feedback

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

1. The potential benefits and potential disadvantages of updating the GHGI to use an approach that incorporates additional basin-level calculations.
2. Approaches for quantifying emissions for the full time series.
3. Use of basin-specific data for all basins, or application of a coverage threshold for use of basin-specific data for a basin versus a national or other average value.
4. Type and level of coverage threshold (e.g., percentage total activity covered by subpart W, a certain number of wells included in the data set), and the rationale for a threshold.
5. If a coverage threshold were to be applied, approaches for basins with coverage below a threshold (e.g., combining data for basins below the threshold to develop EFs/AFs for all basins below the threshold or using data from all basins to apply to basins below the threshold).
6. Approaches for basins that have subpart W data reported in certain years (e.g., RY2015-RY2017, RY2019, RY2021), but not all GHGRP years (e.g., no data in RY2018, RY2020). For example, using a basin's data from surrounding years, applying average data (based on multiple basins) to those years, or assume the activity did not occur in that year.
7. Data sources in addition to GHGRP that EPA should consider for disaggregating emissions data to a basin-level.
8. Additional emission sources and industry segments for which EPA should consider basin-/state-level approaches.

Appendix A – Threshold Basins Approach

EPA calculated emissions using a threshold basins approach for each emission source, to compare to the emissions for the all basins approach presented in the main body of the memo. The threshold basins approach uses a threshold of 50 percent coverage, for demonstration purposes. For example, if 50 percent of all wells within a basin were reported to subpart W, EPA applied basin-specific AFs and/or EFs to the basin. If a basin did not have at least 50 percent coverage, and for basins that did not have data available in subpart W, EPA applied average factors calculated from the subset of basins that did not meet the coverage threshold. For pneumatic controllers, well pad equipment leaks and chemical injection pumps, and liquids unloading, EPA calculated the coverage using well counts (i.e., compared the wells reported to subpart W in a basin to the total well population in that basin). Liquids unloading well coverage considered only gas wells. For storage tanks, EPA calculated basin coverage using liquids production (i.e., compared the liquids production reported to subpart W in a basin to the total liquids produced in that basin).

A.1. Pneumatic Controllers Emissions for the Threshold Basins Approach

Table 24. Threshold Basins: National CH_4 Estimates for Gas Well Pneumatic Controllers (Metric Tons)

Source	1990	2005	2017	2018	2019	2020	2021
Low-Bleed Controllers	0	20,088	33,211	34,498	31,344	26,158	26,754
Intermittent-Bleed Controllers	229,604	538,225	859,570	809,737	823,424	706,139	649,275
High-Bleed Controllers	339,641	463,874	107,560	83,298	50,870	40,384	40,825
Total	**569,245**	**1,022,187**	**1,000,341**	**927,532**	**905,638**	**772,680**	**716,853**

Table 25. Threshold Basins: National CH4 Estimates for Oil Well Pneumatic Controllers (Metric Tons)

Source	1990	2005	2017	2018	2019	2020	2021
Low-Bleed Controllers	51,645	53,572	21,647	38,461	44,817	33,730	42,766
Intermittent-Bleed Controllers	0	288,272	1,082,074	936,242	777,591	998,060	911,025
High-Bleed Controllers	725,146	559,976	89,307	69,832	73,592	63,842	57,160
Total	**776,791**	**901,820**	**1,193,029**	**1,044,536**	**896,000**	**1,095,632**	**1,010,952**

A.2 Storage Tank Emissions for the Threshold Basins Approach

Table 26. Threshold Basins: National Oil Tank CH_4 Emissions (Metric Tons)

Source	1990	2005	2017	2018	2019	2020	2021
Large Tanks w/Flares	0	1,079	5,217	6,381	4,380	3,813	3,229
Large Tanks w/VRU	0	717	9,217	2,375	2,318	1,118	501
Large Tanks w/o Control	108,400	40,246	41,281	41,499	25,543	20,873	12,614
Small Tanks w/Flares	0	14	47	18	25	30	69
Small Tanks w/o Flares	6,923	2,916	3,072	3,321	3,224	2,849	2,856

Source	1990	2005	2017	2018	2019	2020	2021
Malfunctioning Separator Dump Valves	2,303	1,424	4,205	776	425	338	319
Total	**117,626**	**46,396**	**63,038**	**54,370**	**35,916**	**29,021**	**19,589**

Table 27. Threshold Basins: National Oil Tank CO_2 Emissions (Metric Tons)

Source	1990	2005	2017	2018	2019	2020	2021
Large Tanks w/Flares	0	734,118	3,798,040	5,351,552	6,057,795	5,346,816	5,488,113
Large Tanks w/VRU	0	2,371	3,395	3,402	5,618	1,975	1,198
Large Tanks w/o Control	19,784	6,697	4,976	4,490	5,033	6,204	5,464
Small Tanks w/Flares	0	1,582	11,363	7,146	8,872	10,314	9,538
Small Tanks w/o Flares	10,345	4,330	4,623	5,319	4,795	4,646	4,619
Malfunctioning Separator Dump Valves	9,548	11,909	31,858	30,109	25,886	20,101	36,308
Total	**39,676**	**761,007**	**3,854,255**	**5,402,017**	**6,108,000**	**5,390,057**	**5,545,241**

Table 28. Threshold Basins: National Condensate Tank CH_4 Emissions (Metric Tons)

Source	1990	2005	2017	2018	2019	2020	2021
Large Tanks w/Flares	524	354	1,171	1,495	1,016	674	643
Large Tanks w/VRU	0	44	203	142	910	544	373
Large Tanks w/o Control	27,298	10,072	8,855	15,941	2,845	4,557	5,118
Small Tanks w/Flares	0	53	232	235	216	231	174
Small Tanks w/o Flares	61,831	24,874	39,075	43,235	48,101	38,753	43,553
Malfunctioning Separator Dump Valves	6	4	673	45	80	253	196
Total	**89,660**	**35,401**	**50,209**	**61,093**	**53,168**	**45,011**	**50,057**

Table 29. Threshold Basins: National Condensate Tank CO_2 Emissions (Metric Tons)

Source	1990	2005	2017	2018	2019	2020	2021
Large Tanks w/Flares	650,047	462,327	1,864,639	1,427,348	917,975	838,739	879,817
Large Tanks w/VRU	0	4,034	267	46	881	845	645
Large Tanks w/o Control	2,694	953	1,294	38,487	690	621	1,439
Small Tanks w/Flares	0	15,507	66,238	87,712	83,683	46,241	27,763
Small Tanks w/o Flares	30,949	12,684	21,427	22,895	23,867	19,527	20,357
Malfunctioning Separator Dump Valves	56	29	1,630	427	46	623	7
Total	**683,746**	**495,534**	**1,955,494**	**1,576,915**	**1,027,142**	**906,596**	**930,027**

A.3 Well Pad Equipment Leaks and Chemical Injection Pump Emissions for the Threshold Basins Approach

Table 30. Threshold Basins: Gas Well Pad Equipment Leaks and Chemical Injection Pump Emissions (MT CH4)

Source	1990	2005	2017	2018	2019	2020	2021
Chemical Injection Pumps	24,729	63,095	144,536	109,919	99,083	77,992	70,182
Compressors	29,858	57,700	79,773	87,924	77,937	71,491	73,169
Dehydrators	11,794	12,418	5,217	6,035	3,906	3,352	4,679
Heaters	12,689	20,732	22,422	60,144	16,707	16,582	18,644
Meters/Piping	42,003	72,420	77,587	77,315	84,121	82,143	82,094
Separators	37,549	85,857	123,581	115,290	118,952	114,037	103,085
Total	**158,623**	**312,220**	**453,116**	**456,626**	**400,708**	**365,597**	**351,852**

Table 31. Threshold Basins: Oil Well Pad Equipment Leaks and Chemical Injection Pump Emissions (MT CH4)

Source	1990	2005	2017	2018	2019	2020	2021
Chemical Injection Pumps	47,517	116,404	116,284	153,794	158,533	113,964	109,976
Headers	3,867	15,586	11,726	11,228	14,981	7,198	7,321
Heater/Treaters	11,236	13,236	18,329	17,943	19,593	18,474	18,097
Separators	11,104	16,598	28,798	35,282	29,520	27,388	27,653
Wellheads	49,495	45,697	51,875	50,579	52,106	50,115	51,443
Total	**105,688**	**188,646**	**202,971**	**244,893**	**248,887**	**217,139**	**214,490**

A.4 Liquids Unloading Emissions for the Threshold Basins Approach

Table 32. National CH_4 Estimates from Liquids Unloading (Metric Tons)

Source	1990	2005	2017	2018	2019	2020	2021
Liquids Unloading With Plunger Lifts	0	155,258	68,463	101,050	88,975	61,618	41,122
Liquids Unloading Without Plunger Lifts	80,581	220,878	121,645	171,225	130,798	102,509	84,852
Total	**80,581**	**376,136**	**190,108**	**272,275**	**219,772**	**164,127**	**125,975**

Table 33. National CO_2 Estimates from Liquids Unloading (Metric Tons)

Source	1990	2005	2017	2018	2019	2020	2021
Liquids Unloading With Plunger Lifts	0	12,844	3,376	4,245	2,984	2,669	2,047
Liquids Unloading Without Plunger Lifts	46,774	44,358	5,652	7,477	7,596	3,748	3,978
Total	**46,774**	**57,202**	**9,027**	**11,723**	**10,580**	**6,417**	**6,025**