Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2014: Revisions Under Consideration for Natural Gas and Petroleum Systems Production Emissions

This memo discusses updates under consideration for the natural gas and petroleum systems production segments for the Inventory of U.S. Greenhouse Gas Emissions and Sinks (GHGI), including potential updates using Greenhouse Gas Reporting Program data for condensate tanks, oil tanks, stripper well venting, liquids unloading, and other sources, and use of the latest data from DrillingInfo for well counts. It also includes information on an update under consideration for episodic emissions from gathering and boosting stations.

The EPA's Greenhouse Gas Reporting Program (GHGRP), subpart W, collects annual operating and emissions data on sources including production storage tanks, associated gas venting and flaring, and equipment that may leak (e.g., separators, heaters, dehydrators, and compressors) from onshore natural gas and petroleum systems facilities who meet a reporting threshold of 25,000 metric tons of CO_2 equivalent (MT CO_2e) emissions. Onshore production facilities in subpart W are defined as a unique combination of operator and basin of operation. Facilities that meet the subpart W reporting threshold have been reporting since 2011; currently, five years of subpart W reporting data are publicly available, covering reporting year (RY) 2011 through RY2015.[1]

This memorandum provides an overview of the current (2016) GHGI approach to estimate emissions and activity from production tanks and oil well venting and flaring, and recommendations for revising the approach to use subpart W data (see sections 1 through 4). This memorandum also examines new GHGRP equipment count and well count data available for RY2015, along with the latest national well count data, and presents options under consideration for updates to these activity data in the GHGI (see sections 5 and 6). Then, this memorandum presents the current approach to estimate emissions and activity for liquids unloading and options to update these data (see section 7). The memo discusses an update under consideration for gathering and boosting stations (see section 8). Specific requests for stakeholder feedback are solicited in section 9.

1. Current GHGI Methodology for Production Tanks and Oil Well Venting and Flaring

The current GHGI methodology for tank emissions and oil well venting and flaring emissions is depicted in Figure 1 below. The current GHGI calculates tank emissions from oil production by applying an oil tank emission factor (EF) to 20% of stripper well production and 100% of non-stripper oil well production, and applies a well venting EF (e.g., casinghead gas emissions) to the remainder of stripper well production (80%). For gas production, the current GHGI estimates tank emissions by applying the condensate tank EF to condensate production in each region, and well venting or flaring emissions are not applicable. The specific methodologies for each are discussed in detail below.

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

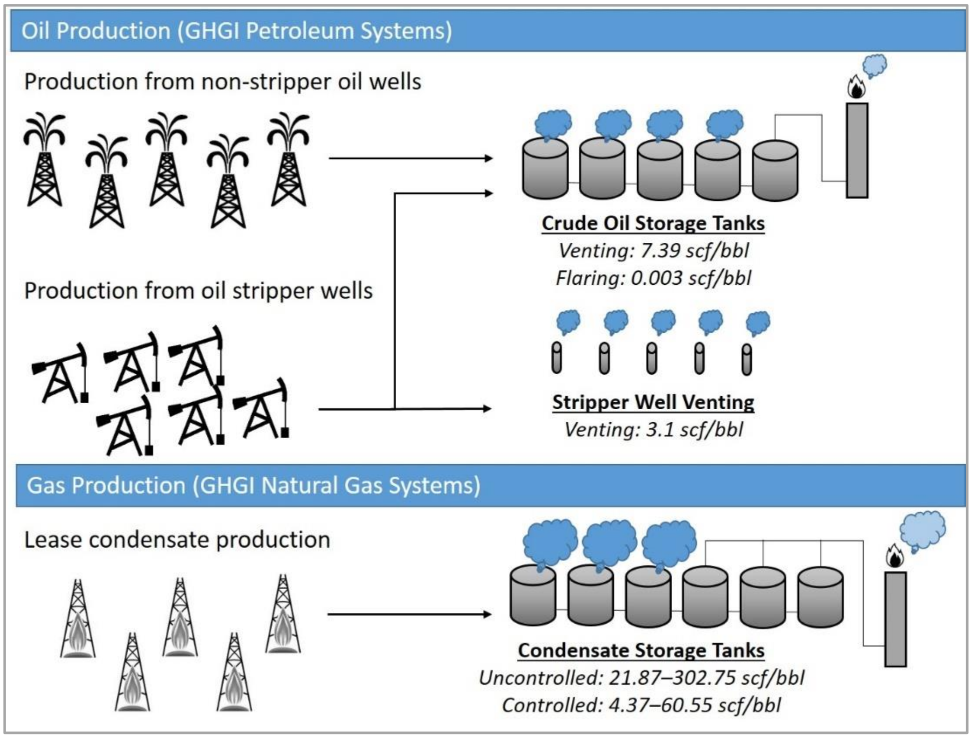

Figure 1. Current GHGI Calculation Methodology for Storage Tanks and Stripper Well Venting

The methane (CH_4) EFs for both condensate and oil tanks are based on throughput (units of standard cubic feet per barrel of production, scf/bbl). The current GHGI EFs were developed from default sample runs available through E&P Tank[2] (sometimes referred to as API TankCalc). These runs used data sampled from tanks in various regions in the United States with hydrocarbon gravities from 17 to 64˚ API and separator pressures and temperatures ranging from 4 to 870 psig and 40 to 180˚F, respectively. The EPA determined an uncontrolled methane emission rate and EF for each sample run.

The EPA calculated the uncontrolled EF for condensate tanks by averaging the uncontrolled EFs from tank sample runs that have hydrocarbon throughput with API gravity equal to or above 45. From this data, the EPA then calculated a controlled condensate tank EF assuming 80% control efficiency. Separately, measurement data were available for malfunctioning dump valve emissions in the midcontinent and southwest NEMS regions; these data showed that measured tank emissions were much higher than expected (e.g., when comparing to software emissions estimates) and the difference was attributed to malfunctioning dump valves. For those regions, the condensate tank uncontrolled and controlled EFs were adjusted to include the emissions from malfunctioning dump valves. The malfunctioning dump valve factor was not applied to other NEMS regions.

Similarly, the EPA calculated an uncontrolled EF for oil tanks by averaging the uncontrolled EFs from tank sample runs that have hydrocarbon throughput with API gravity below 45. As was the case for condensate tanks, limited regional data were available on malfunctioning dump valve emissions for oil tanks. Petroleum emissions are not calculated at a regional level, and the emissions from malfunctioning dump valves were incorporated into the oil tank EF for the United States. The EPA did not calculate a separate EF for controlled oil tanks for the GHGI. However, the current GHGI does account for combustion emissions from flares based on calculated oil tank emissions. Flared emissions from oil tanks are calculated by multiplying the oil tank emissions by 2.2%, and then multiplying this volume by a CH_4

[2] API. April, 2000. API PUBL 4697: Production Tank Emissions Model (E&P Tank).

EF of 20 scf per mcf of flared emissions. The flared emissions contribution is less than 0.05% of oil tank emissions. Table 7 and Table 8 present the current GHGI EFs for oil and condensate tanks.

The 2016 GHGI estimates emissions for stripper well venting by applying a well venting EF to 80% of the stripper well oil production, which is calculated based on the counts of stripper wells. The EPA developed the stripper well venting EF with the following assumptions: the gas-to-oil ratio (GOR) equaled five scf of gas per barrel of crude oil, a stripper well produces an average of 2.1 barrels per day, and that 61.2% of the gas is CH_4.[3] This translated to CH_4 emissions of 2,345 scfy per stripper well or 3.1 scf/bbl.

The associated activity data (throughput) for each emission source is unique to the source category: for condensate tanks, the activity data are condensate production as reported by the Department of Energy's Energy Information Administration (EIA), and for oil tanks and stripper well venting, the activity data are based on crude oil production as reported by EIA, and stripper well counts and average stripper well production from the Interstate Oil and Gas Compact Commission. The condensate production is subdivided to account for condensate stored in controlled versus uncontrolled tanks; the current GHGI methodology assumes that 50% of condensate throughput goes to controlled tanks and 50% goes to uncontrolled tanks. Crude oil production is subdivided into production from non-stripper and stripper wells. The oil tank activity data includes total crude oil production from all non-stripper wells and 20% of the crude oil production from stripper wells, and the stripper well venting activity data includes the remaining 80% of stripper well crude oil production.

The GHGI methodology described above accounts for the majority of emissions from condensate and oil tanks in the production segment, whether located at well pad sites or natural gas gathering and boosting (G&B) stations. The flashing loss component of a condensate tank EF developed by the modeling described above is usually significant (compared to working and breathing losses), and drives the order of magnitude of the EF. As such, it is important to note that flashing losses mainly occur during the first transfer of pressurized field condensate to atmospheric conditions, which may happen at a well pad or G&B station. As discussed in EPA's memorandum "Inventory of U.S. GHG Emissions and Sinks 1990-2014: Revision to Gathering and Boosting Station Emissions" (April 2016), revisions implemented in the 2016 GHGI based on the 2015 Marchese et al. study introduced potential minor double counting of some emissions from upstream tanks in natural gas systems since the new G&B facility-level EF includes flashing losses from condensate tanks that receive pressurized field condensate, and such losses were already accounted for by the nature of the existing GHGI methodology. These considerations would be addressed in the updates under consideration and are discussed in the requests for stakeholder feedback, in Section 8 below.

2. Available Subpart W Data for Production Tanks and Associated Gas

2.1 Production Tanks

Production storage tank data reported under subpart W are specific to onshore oil and gas production operations, defined as "all equipment on a single well-pad or associated with a single well-pad." Subpart W uses the term "production storage tanks" to refer to both condensate and oil tanks. However, certain data reported at the sub-basin level can be used to classify production type as gas or oil (further discussed below).

[3] ICF. October 1999. "Estimates of Methane Emissions from the U.S. Oil Industry."

Production storage tank emission calculation and reporting requirements differ for tanks storing hydrocarbon liquids from separators or wells with throughput greater than or equal to 10 barrels per day (bbl/day) (herein referred to as *large tanks*) versus those tanks storing hydrocarbon liquids from separators or wells with throughput less than 10 bbl/day (herein referred to as *small tanks*). The RY2015 subpart W data includes new data elements that were not reported in prior years (RY2011–2014). In particular, the total number of tanks not on well pads (but associated with a single well-pad) were included in the reported tank counts starting in RY2015. Note that emissions from all tanks, including tanks that are not on well pads but are associated with a single well pad, were reported for all years (RY2011-2015). Table 1 and Table 2 below summarize the relevant information available for large and small production storage tanks for each reporting year and indicate whether the data are reported at a basin-level or sub-basin level.

Table 1. Available Subpart W Data for Large Production Storage Tanks

Reporting Year(s)	Throughput (bbl/yr)	Tank Count				CH_4 Emissions			
		Total	Vent to Atmosphere	Flare Control	Vapor Recovery Control	Venting Tanks	Tanks with Flaring	Tanks with Vapor Recovery	Malfunctioning Dump Valves (d)
2011–2014	Yes (a)	No (b)	No (b)	No (c)	No (c)	Yes	Yes	No	Yes
2015	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Reporting Basis	Sub-Basin	Sub-Basin	Sub-Basin	Sub-Basin	Sub-Basin	Sub-Basin	Sub-Basin	Sub-Basin	Sub-Basin

a. RY2014 reporting included data elements for RY2011-2013 that were previously deferred from reporting.
b. The total count was reported for tanks on well pads, but not for tanks off well pads.
c. For tanks not on well pads, a combined count of tanks that use a flare or vapor recovery were reported, but the counts were not reported separately.
d. The total number of separators with malfunctioning dump valves is reported, but counts of tanks or wells associated with the separators is not reported.

Table 2. Available Subpart W Data for Small Production Storage Tanks

Reporting Year(s)	Throughput (bbl/yr)	Tank Count				CH_4 Emissions			
		Total	Vent to Atmosphere	Flare Control	Vapor Recovery Control	Venting Tanks	Tanks with Flaring	Tanks with Vapor Recovery	Malfunctioning Dump Valves
2011–2014	Yes	No (a)	No	No	No	Yes	Yes	No	No
2015	Yes	Yes	No (b)	Yes	No (b)	No (b)	Yes	No (b)	No
Reporting Basis	Basin	Sub-Basin	Sub-Basin	Sub-Basin	Sub-Basin	Sub-Basin	Sub-Basin	Sub-Basin	N/A

a. The total count was reported for tanks on well pads, but not for tanks off well pads.
b. The count of tanks that did not control emissions with flares is reported; this value comprises tanks that vent directly to the atmosphere *or* use a vapor recovery system.

N/A – Not applicable

Subpart W provides separate methodologies for reporters to calculate emissions from large and small tanks. Emissions from large tanks in subpart W are calculated by applying one of two calculation methodologies for RY2015. Reporters may use a software program, such as AspenTech HYSYS or API E&P Tank, to calculate emissions or may assume that all CH_4 in the liquid and gas is emitted from the tank (based on applying certain assumptions for gas and liquid composition). Emissions from small tanks in subpart W are calculated by multiplying a population EF by the number of separators or wells. The small tank population EF was developed using GHGI condensate and oil tank EFs, coupled with an average throughput of 2.2 bbl/day (based on GHGI stripper well data). The subpart W calculation methodologies are summarized in Appendix A.

Section 3 presents analyses regarding how subpart W data might be used to revise the current GHGI methodology for condensate and oil tanks and related sources for the 2017 GHGI. As discussed above, RY2015 provides a level of granularity and several data elements that are not available in previous RYs. The revisions under consideration for the 2017 GHGI may be developed using RY2015 data and applied to previous years as appropriate.

2.2 Associated Gas

Associated gas venting or flaring is defined in subpart W as "the venting or flaring of natural gas which originates at wellheads that also produce hydrocarbon liquids and occurs either in a discrete gaseous phase at the wellhead or is released from the liquid hydrocarbon phase by separation. This does not include venting or flaring resulting from activities that are reported elsewhere, including tank venting, well completions, and well workovers." This generally refers to venting of gas from oil wells, when, for example, a pipeline is not available to collect the gas for sales. Facilities calculate associated gas emissions by determining the gas-to-oil ratio (GOR) for a well, and assuming that all gas is released based on the liquid throughput. Facilities may also subtract the volume of associated gas that is sent to sales from their estimate. Facilities report the number of wells that vent or flare associated gas, along with the emissions from each activity. The data reported for RY2011-2015 are similar, except that data are reported in more granularity for RY2015. Basin-level data are reported for RY2011-RY2014, while sub-basin level data are reported starting in RY2015. Differences in the reporting-level do not affect the analyses presented below, because data are currently evaluated at a national level. The subpart W calculation methodologies are summarized in Appendix A.

The data collected under subpart W associated gas venting and flaring is most comparable to the current GHGI methodology for "stripper well venting." A stripper well according to GHGI data sources is defined as producing less than 10 barrels per day of oil, which is the same as the subpart W throughput threshold definition for small tanks. However, associated gas data reported under subpart W may include venting or flaring from non-stripper wells and/or stripper wells.

3. Revisions Under Consideration for Tanks

This section discusses two general options for calculating emission factors (EFs) and activity data (AD) for the GHGI using subpart W data. To estimate GHGI emissions using subpart W data, activity factors (AFs) can be developed and coupled with either national throughput or national wellhead count data to generate national level AD, then combined with associated EFs. For the throughput basis option discussed in Section 3.1, national condensate and oil production data (e.g., obtained from EIA) would be coupled with subpart W-based AFs (percent of total throughput for each tank category), then combined with subpart W-based category-specific EFs (scf/bbl). This approach is similar to the current GHGI methodology which is on a throughput basis. For the tank basis option discussed in Section 3.2, the national gas and oil well counts (determined using DrillingInfo) would be coupled with subpart W-based AFs (number of tanks per wellhead for each tank category), then combined with subpart W-based category-specific EFs (scf/tank). These options are discussed in greater detail in the following subsections.

3.1 Throughput Basis Option

3.1.1 Activity Factor Development

To estimate national emissions, AD must be developed for each of the large and small tank categories. The EPA conducted the following steps to calculate activity factors:

<u>Step 1</u>: Apportion the tanks data between gas and oil production using the subpart W formation type that is part of the sub-basin ID. Data reported in sub-basins with *high permeability gas*, *shale gas*, *coal seam,* or *other tight reservoir rock* formation types were assigned to gas production. Data reported in sub-basins with the *oil* formation type were assigned to oil production.
<u>Step 2</u>: For each reporting facility/sub-basin combination, apportion the reported throughput data by tank category (tanks that use a flare, a vapor recovery unit (VRU), or are uncontrolled). Note this step assumes that throughput for each facility is equivalent for each tank within a sub-basin (for large tanks) or basin (for small tanks), as throughput is only reported as a sub-basin total for large tanks or a basin total for small tanks.
<u>Step 3</u>: Sum the reported subpart W throughput data for each tank category and divide by the total reported subpart W tank throughput to calculate the percent of the total tank throughput that would be used as AD for each tank category.

Table 3 and Table 4 present the reported RY2015 subpart W and 2016 GHGI year 2014 throughput for each tank category, for condensate and oil tanks, respectively. Table 5 provides the resulting percent of total tank throughput that is applicable to each tank category based on RY2015 subpart W data and 2016 GHGI year 2014 estimates.

Table 3. Subpart W RY2015 and 2016 GHGI Year 2014 Condensate Tank Throughput (MMbbl) by Tank Category

<table>
<tr><th rowspan="2">Tank Category</th><th colspan="4">Condensate Tank Throughput</th></tr>
<tr><th>Subpart W - Large Tanks (a)</th><th>Subpart W - Small Tanks (a)</th><th>Subpart W - Total</th><th>GHGI</th></tr>
<tr><td>All Tanks</td><td>182 (100%)</td><td>54 (100%)</td><td>236 (100%)</td><td>277 (100%)</td></tr>
<tr><td>Tanks with Flaring</td><td>126 (69%)</td><td>18 (33%)</td><td rowspan="2">168 (71%)</td><td rowspan="2">139 (50%)</td></tr>
<tr><td>Tanks with VRU</td><td>24 (13%)</td><td>n/a</td></tr>
<tr><td>Tanks without Controls</td><td>32 (18%)</td><td>n/a</td><td rowspan="2">68 (29%)</td><td rowspan="2">139 (50%)</td></tr>
<tr><td>Tanks without Flares</td><td>n/a</td><td>36 (67%)</td></tr>
</table>

a. Based on RY2015 subpart W data.
n/a – Not applicable.

Table 4. Subpart W RY2015 and 2016 GHGI Year 2014 Oil Tank Throughput (MMbbl) by Tank Category

<table>
<tr><th rowspan="2">Tank Category</th><th colspan="4">Oil Tank Throughput</th></tr>
<tr><th>Subpart W - Large Tanks (a)</th><th>Subpart W - Small Tanks (a)</th><th>Subpart W - Total</th><th>GHGI</th></tr>
<tr><td>All Tanks</td><td>1,249 (100%)</td><td>92 (100%)</td><td>1,340 (100%)</td><td rowspan="5">2,998 (100%)</td></tr>
<tr><td>Tanks with Flaring</td><td>743 (59%)</td><td>25 (28%)</td><td rowspan="2">1,039 (78%)</td></tr>
<tr><td>Tanks with VRU</td><td>270 (22%)</td><td>n/a</td></tr>
<tr><td>Tanks without Controls</td><td>235 (19%)</td><td>n/a</td><td rowspan="2">301 (22%)</td></tr>
<tr><td>Tanks without Flares</td><td>n/a</td><td>66 (72%)</td></tr>
</table>

a. Based on RY2015 subpart W data.

n/a – Not applicable.

Table 5. Overall Condensate and Oil Tank Throughput Allocation

Tank Category	Condensate Tank Throughput				Oil Tank Throughput			
	Subpart W - Large Tanks (a)	Subpart W - Small Tanks (a)	Subpart W – Total (a)	2016 GHGI	Subpart W - Large Tanks (a)	Subpart W - Small Tanks (a)	Subpart W – Total (a)	2016 GHGI
All Tanks	77%	23%	100%	100%	93%	7%	100%	100%
Tanks with Flaring	53%	8%	71%	50%	55%	2%	78%	
Tanks with VRU	10%	n/a			20%	n/a		
Tanks without Controls	14%	n/a	29% (b)	50%	18%	n/a	22%	
Tanks without Flares	n/a	15%			n/a	5%		
Malfunctioning Dump Valves	(c)	n/a	(c)	n/a	(c)	n/a	(c)	

a. Based on RY2015 subpart W data.
b. While the small tank category "tanks without flares" may include small tanks that use a VRU, for comparison to the GHGI, this table assumes that this reported category of tanks is uncontrolled.
c. The total throughput for large condensate tanks (i.e., 77% of throughput) and large oil tanks (i.e., 93% of throughput) is applicable to malfunctioning dump valves due to the malfunctioning dump valve EF methodology which applies an average per-tank EF to all large tanks (see the following Large Tank EF Development section).

n/a – Not applicable.

Subpart W facilities report their total condensate and oil production in the "Facility Overview" reporting section. In addition to condensate and oil production stored in tanks, this may include the production that is not stored in tanks or is stored in tanks that are not applicable to onshore production. Condensate and oil production are also not reported separately. The EPA assessed available data to determine the total condensate and oil production from subpart W reporters that is appropriate for scaling to the national level. We first applied the percent of condensate and oil production based on the subpart W tank throughput data to the total subpart W production. However, the condensate production exceeded the total condensate production from the 2016 GHGI, and therefore, this may overestimate condensate production. Therefore, we set the total subpart W condensate production equal to the total condensate production from the GHGI and calculated the total subpart W oil production (see the column Modified Subpart W Total Production). The EPA then calculated the percent of the total subpart W production that is applicable to tanks by dividing the subpart W tank throughput by the modified subpart W total production data. Table 6 presents the condensate and oil production data from subpart W and the GHGI, along with the calculated percent of production that is applicable to tanks. Note that year 2014 data from the GHGI are used in this analysis; if the throughput-basis option is included in the 2017 GHGI, year 2015 data would be applied in this analysis (2015 data are not yet available).

Table 6. Subpart W RY2015 and 2016 GHGI Year 2014 Condensate and Oil Production (MMbbl)

Parameter	Subpart W Tank Throughput	Subpart W Total Production	2016 GHGI (Year 2014)	Modified Subpart W Total Production	% of Total Subpart W Throughput Applicable to Tanks
Total	1,576	2,437	3,275	2,437	--
Condensate Production	236 (15%)	366 (15%) (a)	277 (8%)	277 (11%) (b)	85%
Oil Production	1,340 (85%)	2,072 (85%) (a)	2,998 (92%)	2,160 (89%) (c)	62%

a. Condensate and oil production were calculated by applying the subpart W tank throughput percentages to the subpart W total production.
b. Condensate production is set equal to the 2016 GHGI condensate production.
c. Equals total production minus condensate production.

Under the throughput basis option, the EPA would develop national AD by applying the throughput allocation data in Table 5 to the relevant condensate tank and oil tank throughput. The relevant throughput would equal the condensate and oil production reported by EIA multiplied by the appropriate percentage in the last column of Table 6.

The data that would be used in the tanks update under consideration is from subpart W onshore production data, representing activities at well pad production sites and not G&B stations. This creates a unique challenge for the throughput basis option, because the national throughput must be specific to well pad production sites versus G&B stations as tank emissions from G&B stations are already included in the G&B station emission factors. Please see the request for stakeholder feedback on this issue. As discussed in Section 1 and EPA's memorandum "Inventory of U.S. GHG Emissions and Sinks 1990-2014: Revision to Gathering and Boosting Station Emissions" (April 2016), the current GHGI methodology for G&B stations accounts for CH_4 losses from liquids that are routed directly to gathering segment tanks (i.e., such condensate or oil volume does not result in significant well pad losses in the form of tank emissions).

3.1.2 Large Tank EF Development

Using the subpart W large production storage tank data, as assigned to gas or oil production per Section 3.1.1 above, the EPA then conducted the following steps to calculate EFs:

Step 1: For each reporting facility/sub-basin combination, apportion the reported throughput data by tank category (tanks that use a flare, a vapor recovery unit (VRU), or are uncontrolled). Note this step assumes that throughput is equivalent for each tank within a sub-basin for a facility, as throughput is only reported as a sub-basin total.
Step 2: Calculate EFs specific to gas and oil production by dividing the summed reported emissions by summed throughput for each tank category.
Step 3: Calculate a separate malfunctioning dump valve EF by summing dump valve emissions and dividing by the summed throughput. Note that the dump valve EF represents emissions from all large tanks, regardless of reported tank category.

Table 7 shows the resulting EFs compared to the current GHGI EFs. Subpart W data allows the EPA to calculate more granular EFs than are used in the current GHGI. The current GHGI also does not distinguish between large and small tanks.

Table 7. Throughput-based CH_4 EFs (scf/bbl) for Large Tanks, By Tank Category

<table>
<tr><th rowspan="2">Tank Category</th><th colspan="2">Condensate Tank EF</th><th colspan="2">Oil Tank EF</th></tr>
<tr><th>Subpart W (a)</th><th>2016 GHGI (b)</th><th>Subpart W (a)</th><th>2016 GHGI (b)</th></tr>
<tr><td>Tanks with Flaring</td><td>0.28</td><td rowspan="2">4.4 or 60.6 (c)</td><td>0.35</td><td rowspan="5">7.39</td></tr>
<tr><td>Tanks with VRU</td><td>0.21</td><td>0.47</td></tr>
<tr><td>Tanks without Controls</td><td>8.7</td><td>21.9 or 302.8 (c)</td><td>7.9</td></tr>
<tr><td>Malfunctioning Dump Valves</td><td>0.016</td><td>(c)</td><td>0.15</td></tr>
<tr><td>Average for all Large Tanks</td><td>1.8 (e)</td><td>56.3 (d)</td><td>2.0 (e)</td></tr>
</table>

a. Based on RY2015 subpart W data.
b. EFs are applied to all tanks without differentiating by size.
c. The lower EF is applied to the North East, Rocky Mountain, West Coast, and Gulf Coast NEMS regions. The higher EF, which includes malfunctioning dump valve emissions, is applicable to the midcontinent and south west NEMS regions.
d. Calculated as total emissions divided by throughput for year 2014.
e. The subpart W average EF for “all tanks” equals the sum of total large tank emissions divided by the total number of reported large tanks.

n/a – Not applicable.

3.1.3 Small Tank EF Development

Data for small production storage tanks reported under subpart W has certain limitations, compared to large tanks (as shown in Table 2):

1. Throughput data are reported at a basin level instead of the sub-basin level.
2. Emissions are reported for only two categories: tanks with flares and without flares. Therefore, the data for tanks without flares includes emissions from both uncontrolled tanks and tanks equipped with a VRU. However, some activity data are available on VRUs, and based on analysis of the data set, very few small tanks report controlling emissions with a VRU.

The EPA calculated EFs as the data allowed using the following steps:

Step 1: Assign the sub-basin level emissions and tank count data to either oil or gas production using the same method discussed in section 3.1.1 above.
Step 2: For each reporting facility, apportion the reported throughput data by tank category (tanks that do or do not use a flare). Note this step assumes that throughput is equivalent for each tank at a facility, as throughput is only reported as a basin total.
Step 3: Calculate EFs specific to gas and oil production by dividing the summed reported emissions by throughput for each tank category.

Table 8 shows the resulting EFs compared to the current GHGI EFs.

Table 8. Throughput-based CH_4 EFs (scf/bbl) for Small Tanks, By Tank Category

<table>
<tr><th rowspan="2">Tank Category</th><th colspan="2">Condensate Tank EF</th><th colspan="2">Oil Tank EF</th></tr>
<tr><th>Subpart W (a)</th><th>2016 GHGI (b)</th><th>Subpart W (a)</th><th>2016 GHGI (b)</th></tr>
<tr><td>Tanks with Flaring</td><td>0.34</td><td>4.4 or 60.6 (c)</td><td>0.09</td><td rowspan="3">7.39</td></tr>
<tr><td>Tanks without Flares</td><td>24.8</td><td>21.9 or 302.8 (c)</td><td>2.3</td></tr>
<tr><td>Average for all Small Tanks</td><td>16.6 (e)</td><td>56.3 (d)</td><td>1.7 (e)</td></tr>
</table>

a. Based on RY2015 subpart W data.
b. EFs are applied to all tanks without differentiating by size.
c. The lower EF is applied to the North East, Rocky Mountain, West Coast, and Gulf Coast NEMS regions. The higher EF is applicable to the Midcontinent and South West NEMS regions.
d. Calculated as total emissions divided by throughput for year 2014.
e. The subpart W average EF for “all tanks” equals the sum of total small tank emissions divided by the total reported condensate or oil throughput for small tanks.

n/a – Not applicable.

3.1.4 Time Series Considerations

There are differences between the subpart W and current GHGI EFs and AFs presented in Table 5, Table 7, and Table 8. Of note, controlled subpart W condensate tanks (using a flare or VRU) and uncontrolled subpart W condensate tanks have lower EFs compared to the current GHGI assumption for the natural gas production segment (considering both large and small tanks). The GHGI controlled EF was calculated by applying 80% control efficiency, whereas the subpart W data reflects a much higher control efficiency of approximately 97%. A greater fraction of the condensate throughput is also stored in controlled tanks based on subpart W data compared to the current GHGI data.

The current GHGI EF for oil tanks is similar to the subpart W EFs for large uncontrolled oil tanks and small oil tanks without flares. However, the subpart W EFs for controlled large and small oil tanks are lower than the current GHGI EF and these tanks compose a large percent of the population.

The emissions profile and the number of large tanks with controls is changing over the subpart W time series, as presented in Table 9. The fraction of the condensate and oil throughput that is stored in uncontrolled tanks is higher according to the current GHGI, as compared to subpart W data. Regulations developed since the current GHGI AF and EF data were developed contribute to this increase in controls. For example, a NESHAP for Oil and Natural Gas Production was promulgated in 1999 and an NSPS was promulgated in 2012 that require control of emissions from certain tanks.

Table 9. Subpart W Large Tank Reported Emissions and Controls Information for RY2011-RY2015

RY	Flaring CH_4 (mt CO_2e)	Venting CH_4 (mt CO_2e) (a)	# Large Tanks (b)	% of Large Tanks w/Controls
2011	93,530	1,547,441	71,184	48%
2012	167,080	1,592,895	81,766	57%
2013	104,424	1,208,986	101,340	57%
2014	125,739	1,328,849	128,191	66%
2015	143,014	1,046,472	145,061	69%

a. Venting emissions include emissions from tanks that use a VRU.
b. Does not include the count of tanks off well pads that are uncontrolled for RY2011-RY2014 because these data are not reported.

The subpart W EFs and AFs are calculated on a category-specific basis that is more granular than the current GHGI structure and data are not available to use such a granular structure in earlier years of the time series. Therefore, the EPA might select a year to implement a transition between the two sets of EFs and AFs; alternatively, the EPA might use the subpart W EFs across the entire time series and establish new assumptions for AFs within each tank category for early years. The EPA is also considering an option that maintains the current GHGI methodology to estimate tank emissions for 1992, and then assumes a linear correlation between the 1992 and 2015 tank emissions for each year between. The EPA may also apply the year-specific % of controlled tanks from subpart W for 2011-2015 (as reported for tanks on well pads), and moving forward. The EPA requests stakeholder feedback on these options in section 8. In future GHGIs, for years 2015 and forward, the EPA would be able to develop year-specific EFs and AFs using subpart W data. Subpart W tanks data for future reporting years will also contain a similar level of detail as RY2015, and as such, changes in the use of controls on tanks over time could be reflected in the GHGI.

3.2 Tank Basis Option

3.2.1 Activity Factor Development

To use tank-based emission factors (scf/tank) in the GHGI, the EPA must develop national level tank counts. To assess this option, similar to the approach used in the 2016 GHGI for other production segment emission sources, the EPA developed AFs in units of tanks per wellhead using subpart W equipment leak data. Subpart W reporting requirements for wellhead counts changed for RY2015 compared to previous years, and wellhead counts are now reported by all reporters, and by production type (gas or oil). In prior reporting years, facilities reported total wellhead counts not differentiated by production type, and they were only reported for one of multiple methodology options. The EPA's activity factor methodology involved analysis and assumptions to allocate wellhead counts between GHGI source categories.

The EPA summed the wellhead count data to obtain total gas wellheads (307,737) and oil wellheads (219,433) for all subpart W reporters in RY2015; in addition to wells with tanks, this may include wells that do not have tanks or that have tanks that are not applicable to onshore production (e.g., the tanks are located at gathering and boosting sites). The EPA then divided the number of tanks in each category by the total gas or oil wellhead values to calculate the number of condensate or oil tanks per gas or oil wellhead. Table 10 and Table 11 provide the reported subpart W tank counts for each category. Table 12 summarizes the calculated AFs (number of tanks per wellhead).

Table 10. RY2015 Subpart W Condensate Tank Counts, By Tank Category

<table>
<tr><th rowspan="2">Tank Category</th><th colspan="3">Condensate Tanks</th></tr>
<tr><th>Subpart W - Large Tanks</th><th>Subpart W - Small Tanks</th><th>Subpart W - Total</th></tr>
<tr><td>All Tanks</td><td>27,094 (100%)</td><td>97,120 (100%)</td><td>124,214 (100%)</td></tr>
<tr><td>Tanks with Flaring</td><td>15,862 (59%)</td><td>15,715 (16%)</td><td rowspan="2">34,395 (28%)</td></tr>
<tr><td>Tanks with VRU</td><td>2,818 (10%)</td><td>n/a</td></tr>
<tr><td>Tanks without Controls</td><td>8,414 (31%)</td><td>n/a</td><td rowspan="2">89,819 (72%)</td></tr>
<tr><td>Tanks without Flares</td><td>n/a</td><td>81,405 (84%)</td></tr>
</table>

n/a – Not applicable.

Table 11. RY2015 Subpart W Oil Tank Counts, By Tank Category

Tank Category	Oil Tanks		
	Subpart W - Large Tanks	Subpart W - Small Tanks	Subpart W - Total
All Tanks	117,683 (100%)	46,535 (100%)	164,218 (100%)
Tanks with Flaring	69,590 (59%)	11,325 (24%)	92,693 (56%)
Tanks with VRU	11,778 (10%)	n/a	
Tanks without Controls	36,315 (31%)	n/a	71,525 (44%)
Tanks without Flares	n/a	35,210 (76%)	

n/a – Not applicable.

Table 12. Number of Tanks Per Wellhead, By Tank Category (a)

Tank Category	Condensate Tanks		Oil Tanks	
	Subpart W - Large Tanks	Subpart W - Small Tanks	Subpart W - Large Tanks	Subpart W - Small Tanks
Tanks with Flaring	0.052	0.051	0.32	0.052
Tanks with VRU	0.0092	n/a	0.054	n/a
Tanks without Controls	0.027	n/a	0.17	n/a
Tanks without Flares	n/a	0.26	n/a	0.16
All Tanks	0.088	0.316	0.54	0.21
	0.404		0.75	

a. Based on RY2015 subpart W data.
n/a – Not applicable.

The EPA analyzed emissions from malfunctioning dump valves in a different manner to develop an AF (and EF) specific to separators with malfunctioning dump valves. The number of tanks associated with the malfunctioning dump valves are not reported under subpart W, but the number of separators with malfunctioning dump valves are. Here, the AF (and EF) are on a per-separator basis instead of a per-tank basis. Note that malfunctioning dump valves are only reported under the subpart W methodology for large tanks, so this estimate would not take into account any malfunctioning dump valve emissions at small tanks. The total number of separators are reported with subpart W equipment leak data (counts specific to gas and oil production are reported by each facility). The EPA summed the RY2015 subpart W separator count data to obtain total separators at gas production sites (210,836) and total separators at oil production sites (87,260) for all reporters. Table 13 presents the RY2015 subpart W data for malfunctioning dump valves. The national total number of separators is already calculated in the GHGI, and under this option, that value will be multiplied by the percent of separators with malfunctioning dump valves to determine the total number of separators with malfunctioning dump valves for the GHGI.

Table 13. RY2015 Subpart W Malfunctioning Dump Valve Data

Separators with Malfunctioning Dump Valves	Condensate Production	Oil Production
Reported Count	137	1,243
Reported Percent of Total Separators	0.065%	1.4%

While data are not available to determine the fraction of tanks that have separators with malfunctioning dump valves, it is possible to develop an average emission factor for malfunctioning dump valves to be applied to large tanks or all tanks (see next section).

3.2.2 Emission Factor Development

The EPA calculated EFs on a per-tank basis (scf/tank) and on a per-separator basis for malfunctioning dump valves (scf/separator). The approach to calculating EFs is identical for large tanks and small tanks, with the following steps:

Step 1: Assign reported sub-basin-level tank counts, separators with malfunctioning dump valve counts, and emissions to gas or oil production using the methodology discussed in Section 3.1.1.
Step 2: Calculate EFs specific to each tank category (tanks with flaring, a VRU, and uncontrolled) by dividing the summed emissions by the summed tank count.
Step 3: Calculate a malfunctioning dump valve EF by summing all reported dump valve emissions and dividing by the total number of separators with malfunctioning dump valves.

Table 14 shows the resulting EFs for each tank category, and Table 15 presents the malfunctioning separator dump valve EF.

Table 14. Tank-based CH_4 EFs (scf/tank), By Tank Category (a)

Tank Category	Condensate Tanks		Oil Tanks	
	Subpart W EF - Large Tanks	Subpart W EF - Small Tanks	Subpart W EF - Large Tanks	Subpart W EF - Small Tanks
Tanks with Flaring	2,242	393	3,755	197
Tanks with VRU	1,774	n/a	10,854	n/a
Tanks without Controls	33,201	n/a	51,192	n/a
Tanks without Flares	n/a	10,951	n/a	4,236
Average for all Tanks (b)	11,915	9,242	20,739	3,253

a. Based on RY2015 subpart W data.
b. The average EF for "all tanks" equals the sum of total emissions divided by the total number of reported tanks (calculated separately for large and small tanks).

Table 15. Malfunctioning Dump Valve EF (scf/separator with malfunctioning dump valves)

Category	Condensate Production	Oil Production
Malfunctioning Dump Valves	21,175	154,874

The malfunctioning dump valve EF may also be calculated in the same units as the other tank-based EFs (scf/tank). Summing the malfunctioning dump valve emissions and dividing by the total number of large tanks results in an average (to be applied to all applicable tanks (e.g. large tanks or all tanks)) malfunctioning dump valve CH_4 EF of 107 scf/tank for condensate tanks and 1,636 scf/tank for oil tanks.

3.2.3 Time Series Considerations

The EPA is considering the following approach to estimate emissions over the time series. The EPA could use the subpart W RY2015 EFs for all prior years in the GHGI. For large condensate and oil tanks, the EPA could develop 1992 AFs by using the subpart W RY2015 AFs (number of tanks per wellhead) and applying the assumption that 50% of tanks are controlled, 50% of tanks are uncontrolled, and no tanks use VRU (similar to the current GHGI approach) while maintaining the subpart W dump valve AF. The subpart W AF for small condensate and small oil tanks would be maintained because most tanks are currently uncontrolled in the subpart W data set (i.e., do not have flares). The large tank AF for each year between 1992 and 2015 would be estimated with linear interpolation between the two years. These assumptions would then be used along with the total number of gas and oil wells for each year to estimate emissions. The EPA is also considering an option that maintains the current GHGI methodology to estimate tank emissions for 1992, and then assumes a linear correlation between the 1992 and 2015 tank emissions for each year between. The EPA may also apply the year-specific % of controlled tanks from subpart W (as reported for tanks on well pads) for 2011-2015, and moving forward. In future GHGIs, the EPA would be able to develop year-specific EFs and AFs using subpart W data.

3.3 Activity Factor Comparison

A consideration when evaluating the throughput- and tank-based options are the differences in activity factors. In particular, how the EPA uses the activity factors to scale up subpart W data to a national level for each option. Table 16 presents throughput and well count data for RY2015 subpart W, the revised 2015 well counts (as discussed in section 6), and 2014 throughput from the 2016 GHGI for the throughput and tank-based options, and calculates the percent of total throughput or well counts that are reported under subpart W. Note that 2015 national throughput data are not yet available to put all data on the same year 2015 basis, however, the relationship between subpart W RY2015 data and 2014 national throughput provides an approximate comparison.

Table 16. Overall Scale-up Factors based on Throughput or Tank Basis Options

Parameter	Condensate Production	Oil Production
Throughput Basis Option		
2014 National Throughput (MMbbl)	277	2,998
Production (MMbbl) Reported for RY2015 under subpart W (a)	277	2,160
Percent of Total Reported under subpart W (b)	*100%*	*72%*
Tank Basis Option		
2015 National Well Count	440,496	607,559
Count of Wells Reported for RY2015 under subpart W	307,737	219,433
Percent of Total Reported under subpart W	70%	36%

a. Equals the Modified Subpart W Total Production in Table 6.
b. Note that this is a comparison between the 2015 GHGRP data and the most recently available national-level data (2014).

4. Revisions Under Consideration for Oil Well Associated Gas Venting and Flaring Emissions

This section discusses options for calculating EFs and AFs for the 2017 GHGI using subpart W data for associated gas venting and flaring. Although subpart W data do not cover all national activity and emissions due to the reporting threshold, reported emissions from associated gas venting are approximately an order of magnitude higher than current GHGI estimates for stripper well venting; stripper well venting is the emissions source category in the GHGI that best corresponds to the subpart W category of associated gas venting and flaring. The current GHGI methodology does not directly account for methane from venting or flaring of substantial associated gas volumes associated with newer, high-producing oil wells that are likely captured in subpart W reporting—for example, shale oil wells in the Bakken formation of North Dakota—so the subpart W data appear more consistent with industry activities in recent years. The EPA is considering using subpart W data to update the GHGI.

Table 17 summarizes data collected under subpart W for associated gas venting and flaring.

Table 17. GHGRP Subpart W Data for Associated Gas Venting and Flaring

Year	Dataset Overview		Associated Gas Venting		Associated Gas Flaring	
	Total # Reported Wells	Total # Reported Oil Wells	# Venting Wells	Venting CH_4 Reported Emissions (MMT CO_2e)	# Flaring Wells	Flaring CH_4 Reported Emissions (MMT CO_2e)
2011	371,604	(a)	8,863	3.26	5,628	0.41
2012	398,052	(a)	8,554	2.87	7,259	0.62
2013	415,270	(a)	6,980	1.24	8,880	0.85
2014	502,391	(a)	7,264	0.62	12,189	1.03
2015	565,334	219,433	4,286	0.40	21,453	0.99

a. Only the count of total wells was reported for 2011-2014, not differentiated by gas and oil production.

Figure 2 below illustrates subpart W reported associated gas venting and flaring emissions during RY2011–RY2015, along with stripper well venting emissions from the GHGI for 2011-2014.

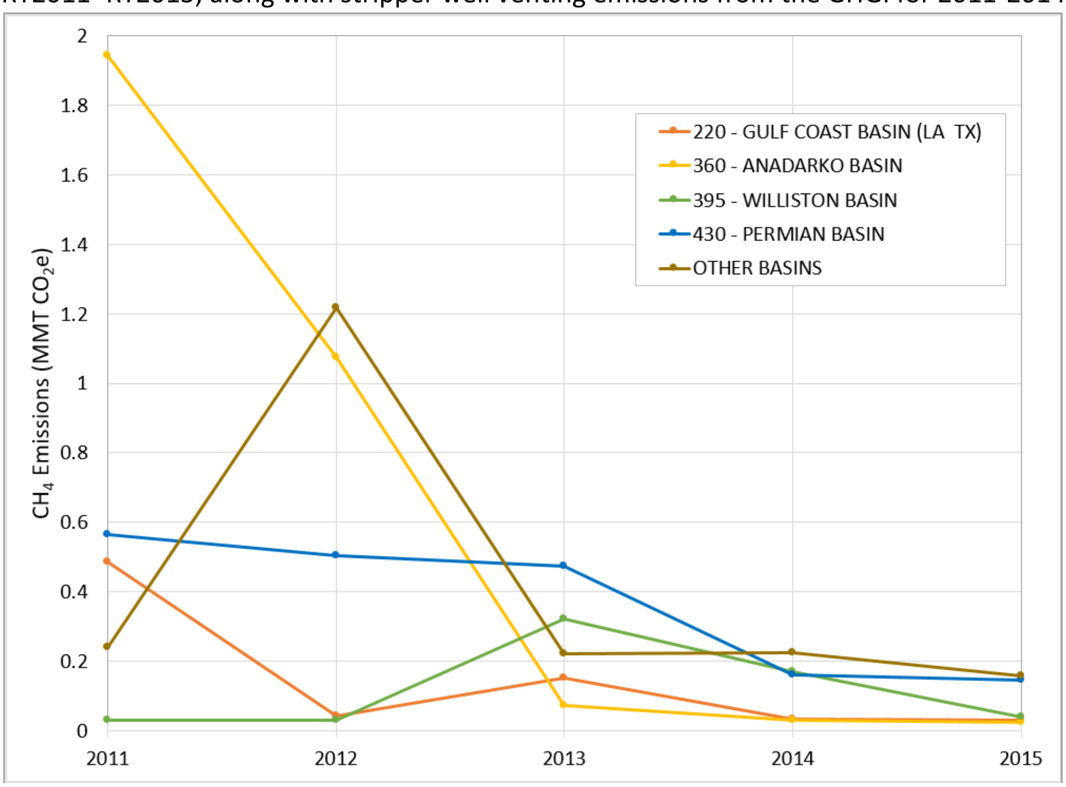

Figure 3 and Figure 4 below illustrate associated gas venting and flaring emissions reported under subpart W for RY2011–RY2015, for certain basins. The majority of emissions are attributed to activities in the Gulf Coast, Anadarko, Williston, and Permian Basins.

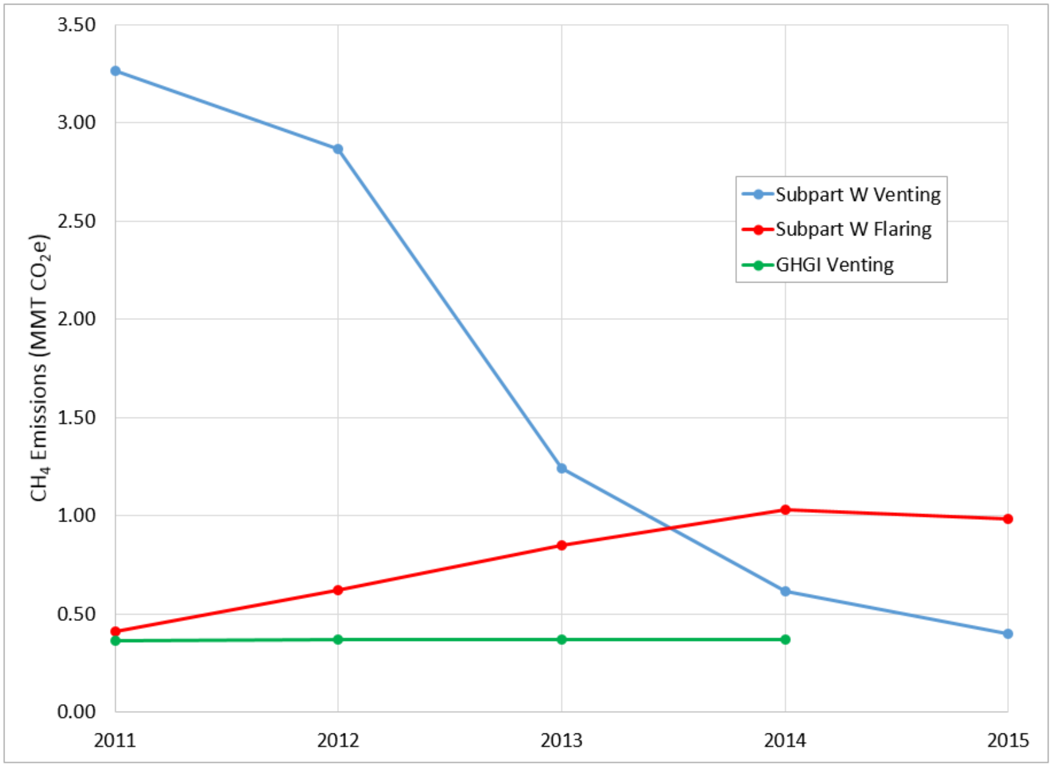

Figure 2. Subpart W Associated Gas Venting and Flaring Reported Emissions Compared to GHGI Stripper Well Venting Emissions, Years 2011–2015

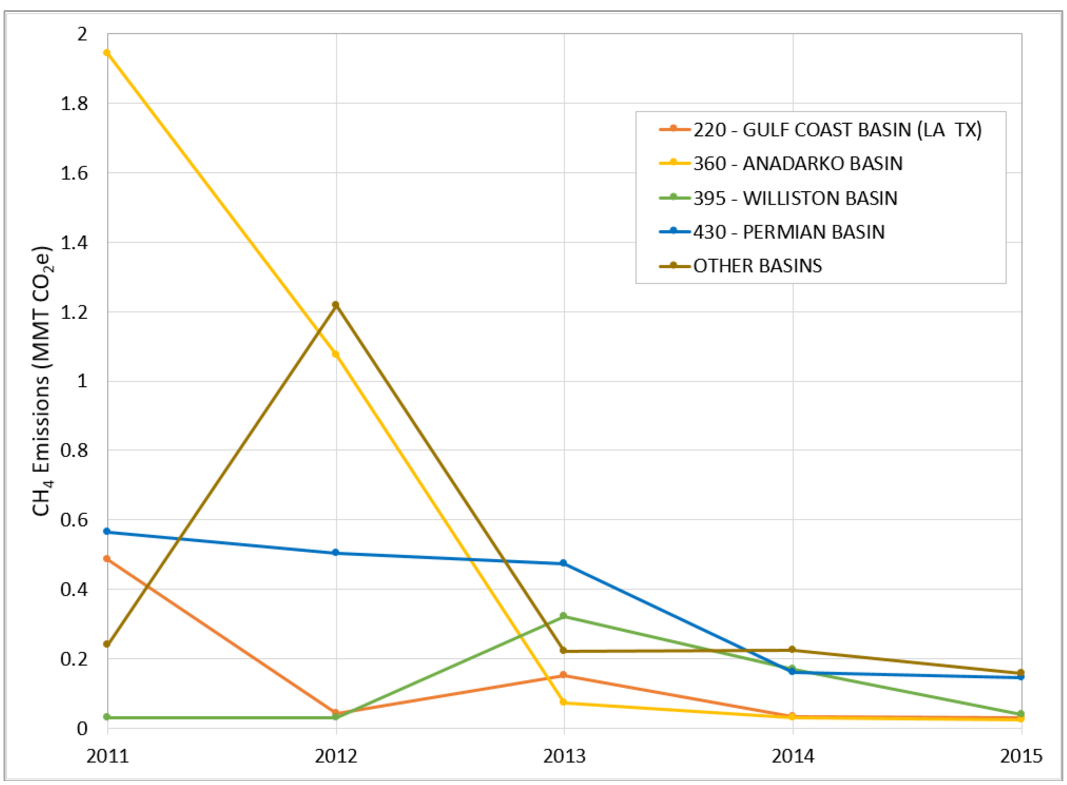

Figure 3. Subpart W Associated Gas Venting Reported Emissions, Years 2011–2015

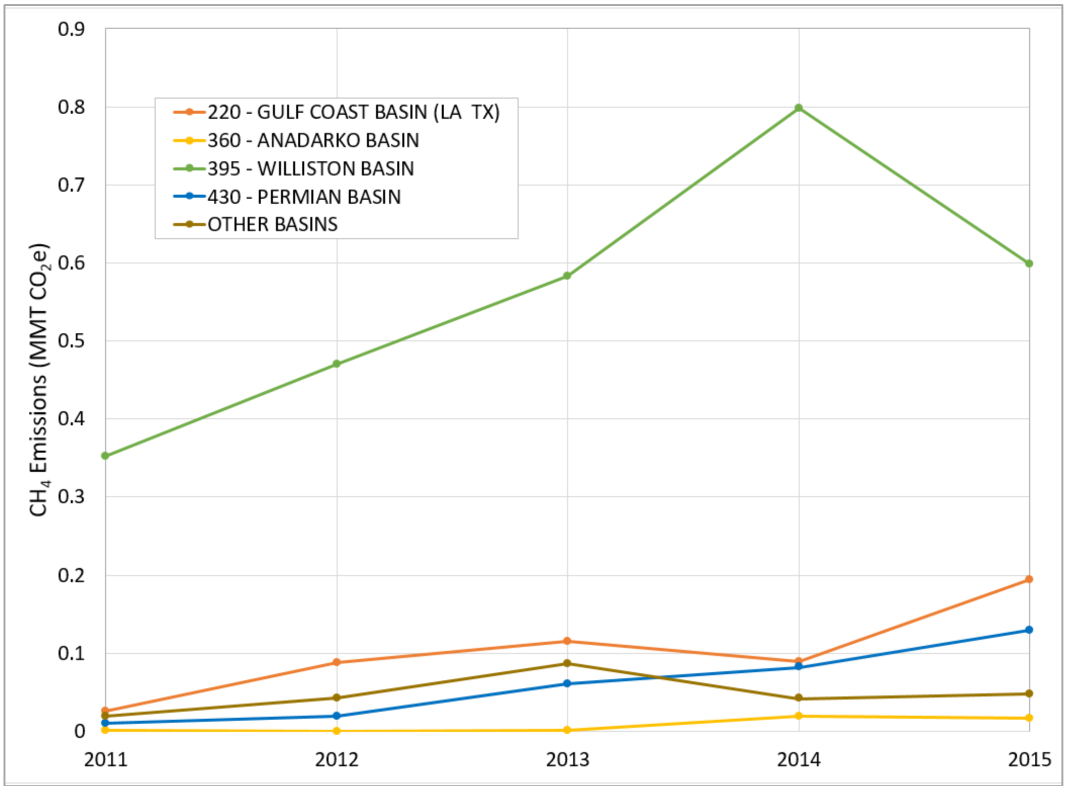

Figure 4. Subpart W Associated Gas Flaring Reported Emissions, Years 2011–2015

4.1 Associated Gas AF Development

Subpart W associated gas venting and flaring emissions, as presented in the preceding table and figures, notably change from year-to-year. We are considering the development of AFs that allow this change to be reflected in the GHGI. Two AFs were calculated to determine the number of wells that vent or flare associated gas.

First, we developed the total number of wells that either vent or flare associated gas from subpart W data. The EPA summed the well count data to obtain total oil wells for all subpart W reporters in RY2015. RY2015 is the first year where all oil wells are reported by each reporter. In prior reporting years, facilities reported total well counts not differentiated by production type (gas or oil), and they were only reported for one of multiple methodology options. We then divided the total number of wells that vented or flared associated gas for RY2015 by the total number of reported oil wells. Table 18 presents this information. While the percent of total oil wells that either vent or flare associated gas may change from year-to-year, RY2015 is the only year with detailed data available to calculate such an AF. This AF could be applied to all years with subpart W data (i.e., 2011-2015) and could be updated as data from future reporting years becomes available.

Table 18. GHGRP Subpart W RY2015 Data for Oil Wells and Associated Gas Wells

Total Oil Wells	Total # Venting & Flaring Wells	% of Total that Vent or Flare
219,433	25,739	12%

Second, we developed the percent of wells reporting associated gas that vent or flare using subpart W data for RY2011 through RY2015. We divided the number of wells that vent or flare by the total number of wells that vented or flared associated gas; see Table 19. This AF would allow the GHGI to reflect ongoing trends in the data.

Table 19. GHGRP Subpart W Data and AF for Associated Gas Venting and Flaring

Year	Subpart W				
	Total # Venting & Flaring Wells	Associated Gas Venting		Associated Gas Flaring	
		# Venting Wells	% of Total that Vent	# Flaring Wells	% of Total that Flare
2011	14,491	8,863	61%	5,628	39%
2012	15,813	8,554	54%	7,259	46%
2013	15,860	6,980	44%	8,880	56%
2014	19,453	7,264	37%	12,189	63%
2015	25,739	4,286	17%	21,453	83%

4.2 Associated Gas EF Development

The EPA calculated associated gas venting and flaring EFs using subpart W data for RY2011 through RY2015. We divided the reported associated gas or venting emissions by the number of reported wells with associated gas venting or flaring for each year to calculate EFs; see Table 20. Table 20 also presents the current GHGI stripper well venting EF.

Table 20. GHGRP Subpart W Associated Gas Venting and Flaring CH_4 EFs Compared to the GHGI Stripper Well Venting EF (mscfy/well)

Year	Subpart W Venting EF	Subpart W Flaring EF	GHGI Venting EF
2011	765	151	2.35
2012	696	178	
2013	369	198	
2014	176	176	
2015	193	95	

4.3 Time Series Considerations

Populating the 2017 GHGI time series for associated gas venting and flaring with a revised methodology based on subpart W data will present challenges. As illustrated above by Figure 2 and Figure 3, trends in venting and flaring can vary significantly over time and by basin. In the GHGI years before subpart W data are available, 1990 through 2010, there have likely been large fluctuations in national and basin level venting and flaring, due to the dynamics of petroleum resource development.

To cover the time series in the 2017 GHGI for the revisions under consideration, a simplistic approach would be to extrapolate from current GHGI estimates for 1992 base year emissions from stripper well venting, to revised estimates in year 2011 that incorporate subpart W data for all associated gas venting and flaring. This approach would not reflect fluctuations in national emissions over the time series. Additionally, this approach might underestimate emissions in years before 2011 since the 1992 base year estimate includes only emissions from stripper well venting.

For years prior to 2011, the EPA is also considering other activity data and EF options that would not rely on the current GHGI stripper well venting data. To determine activity data for years prior to 2011, the EPA is considering applying the subpart W-based percent of total oil wells that vent or flare associated gas from 2015 (12%) over the entire time series, assuming that all oil wells in the vent or flare category (12%) vented associated gas in 1990, and interpolating the flaring percent (of the total wells that vent or flare) between the 1990 (0%) and 2011 (39%) values. Alternatively, to reflect flaring occurring in earlier years, the EPA is considering applying the 2011 split between venting and flaring of associated gas to all prior years in the GHGI. To determine EFs for years prior to 2011, the EPA is considering applying the 2011 subpart W EFs or average associated gas venting and flaring EFs from subpart W (using 2011-2015 data).

In Section 8 below, the EPA seeks stakeholder feedback on potential approaches or data sources that could be used to inform scale-up of reported subpart W data and to populate the time series for associated gas venting and flaring. For example, it may be possible to reflect impacts of state regulations in the time series.

5. Gas Well and Oil Well Counts

5.1 Current GHGI Data

The EPA revised the data source and methodology to estimate gas well and oil well counts for the 2015 GHGI, when DrillingInfo was first used to determine gas well and oil well counts for each year. Prior to the 2015 GHGI, well counts were determined from a variety of sources.[4] The EPA continued to use DrillingInfo data for the 2016 GHGI.

5.2 Well Counts Revision

In developing the latest gas and oil well counts for the 2017 GHGI, the EPA updated its methodology for processing the DrillingInfo dataset to take into account a recent revision to the DrillingInfo dataset that clarified information on certain well records. In the previous DrillingInfo datasets, records for certain individual wells in Texas had been assigned multiple different state well identification numbers over time. These datasets include those used to calculate well counts in the 2015 and 2016 GHGI. The EPA's data processing methodology for well counts (described in EPA's 2015 memo "Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2013: Revision to Well Counts Data," available at https://www.epa.gov/sites/production/files/2015-12/documents/revision-data-source-well-counts-4-10-2015.pdf) resulted in certain duplicate well records being counted as unique wells for the 2015 and 2016 GHGI.[5] For the 2017 GHGI, the EPA has assessed the latest DrillingInfo data, with the clarified reporting of well identification numbers, and removed the duplicate records from the GHGI well counts. The revision has a small impact on gas well counts and a larger impact on oil well counts. Table 21 presents the revised well counts that would be used in the 2017 GHGI and the 2016 GHGI well counts,

[4] For more information, please see the memorandum, "Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2013: Revision to Well Counts Data", available at https://www.epa.gov/sites/production/files/2015-12/documents/revision-data-source-well-counts-4-10-2015.pdf.

along with estimated well counts from EIA[5,6] and World Oil.[7,8] Note that gas well and oil well counts may not match up between the datasets due to differing gas well and oil well definitions. For example, EIA uses a lower GOR threshold for the split between oil and gas, which would lead to higher gas well counts and lower oil well counts compared to the GHGI GOR threshold.

Table 21. Comparison of gas well and oil well counts for 2014 and 2015.

Well Type & Data Source	2014	2015
Gas Wells		
2017 GHGI	**452,870**	**440,496**
2016 GHGI	456,140	N/A
EIA	565,951	555,364
World Oil	no data	502,987
Oil Wells		
2017 GHGI	**619,818**	**607,559**
2016 GHGI	898,268	N/A
EIA	no data	470,000
World Oil	no data	594,436
Total Gas and Oil Wells		
2017 GHGI	**1,072,688**	**1,048,055**
2016 GHGI	1,354,408	N/A
EIA	N/A	1,025,364
World Oil	N/A	1,097,423

6. Equipment Counts

6.1 Current GHGI Methodology and Available Subpart W Data

In the 2016 GHGI, the EPA revised the equipment counts per well used to estimate emissions for onshore production equipment leaks. The updates used RY2014 GHGRP subpart W equipment count and well count data reported under the equipment leaks. The GHGRP subpart W equipment leak reporting includes data for wells, separators, meters/piping, compressors, in-line heaters, heater-treaters, headers, and separators. In the RY2014 GHGRP dataset used in the 2016 GHGI, facilities reported total equipment and well counts that were not differentiated by production type (i.e. oil versus gas), and the counts were only reported for one of multiple methodology options. As a result, the EPA's activity factor methodology required several assumptions to allocate the reported equipment counts and well counts to natural gas (NG) vs. petroleum systems (Petro)) for the GHGI. The 2016 GHGI AF revisions are documented in the memorandum, "Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2014: Revisions to Natural Gas and Petroleum Production Emissions." The AFs applied in the 2016 GHGI are presented in Table 23 below.

[5] EIA. October 2016. "Number of Producing Gas Wells." http://www.eia.gov/dnav/ng/ng_prod_wells_s1_a.htm
[6] EIA. June 2016. "Stripper wells accounted for 10% of U.S. oil production in 2015." http://www.eia.gov/todayinenergy/detail.php?id=26872
[7] World Oil. February 2016. "Producing Gas Wells Hold Up Amid Commodities Rout." http://www.worldoil.com/magazine/2016/february-2016/special-focus/producing-gas-wells-hold-up-amid-commodities-rout
[8] World Oil. February 2016. "Producing Oil Wells Tick Down as Price Begins to Hit." http://www.worldoil.com/magazine/2016/february-2016/special-focus/producing-oil-wells-tick-down-as-price-begins-to-hit

Subpart W equipment leak reporting requirements changed for RY2015 compared to previous years, and equipment counts and well counts are now provided by all reporters, and by production type (gas or oil). The EPA has assessed the new subpart W data and is considering the development of updated AFs; the more detailed equipment counts and well counts data in subpart W allow the EPA to more directly develop AFs.

6.2 Revisions Under Consideration for Equipment Counts

The EPA evaluated the reported RY2015 subpart W equipment count data (available under the equipment leaks category). Table 22 presents the reported equipment counts for RY2015, and compares these data to RY2014 counts.

Table 22. Reported Subpart W Equipment Counts for RY2014 and RY2015

Equipment Type	RY2014 Subpart W Count (Split by production type for 2016 GHGI)	RY2015 Subpart W Count (for 2017 GHGI)
Wells		
Wells (NG)	223,192	307,737
Wells (Petro)	275,831	219,433
Separators		
Separators (NG)	149,912	210,836
Separators (Petro)	119,479	87,260
Heaters (NG)	48,460	63,523
Dehydrators (NG)	8,380	8,195
Meters/piping (NG)	256,340	263,870
Compressors (NG)	23,740	24,090
Heater-treaters (Petro)	34,902	51,364
Headers (Petro)	44,880	52,872

The EPA calculated AFs for each equipment type by dividing the reported equipment count by the number of reported gas or oil wells. Table 23 presents the calculated AFs for each equipment type based on RY2015 subpart W data, as compared to the current GHGI.

Table 23. AF Calculation from Subpart W Data

Source Category & Major Equipment	2016 GHGI AF (Based on Subpart W RY2014 Data)	Subpart W RY2015 Based AF
NG: Separators/Well	0.67	0.69
NG: Dehydrators/Well	0.04	0.03
NG: Heaters/Well	0.22	0.21
NG: Meters/piping per well	1.15	0.86
NG: Compressors/Well	0.11	0.08
Petro: Separators/Well	0.43	0.40
Petro: Heater-treaters/Well	0.13	0.23
Petro: Headers/Well	0.16	0.24

The EPA's estimates of national equipment counts for 2014, after applying the AFs from Table 23, are presented in Table 24.

Table 24. Subpart W Production Segment Equipment Counts Applied to National Activity Representation for Year 2014

Equipment / Source Category	2016 GHGI	2017 Update Using RY2015 AF (a)
Separators		
Separators (NG)	306,377	310,269
Separators (Petro)	389,094	246,478
Heaters (NG)	99,038	93,481
Dehydrators (NG)	17,126	12,060
Meters/piping (NG)	523,885	388,315
Compressors (NG)	48,518	35,451
Heater-treaters (Petro)	113,661	145,085
Headers (Petro)	146,156	149,344

a. Equipment counts are calculated using the revised national gas well (440,496) and oil well (607,559) counts, as discussed in section 6.

In addition, the EPA will update the GHGI to use the latest GHGRP data on equipment counts for other production sources that currently use GHGRP data, such as pneumatic controllers and pumps, using the same approach as the 2016 GHGI. Well count data associated with these sources are not reported by production type in 2015 (i.e. the same information for data relevant to the GHGI is available for 2015 as for 2014 for these sources) so the method has not changed for these sources.

6.3 Time Series Considerations

For the revisions under consideration, the EPA is considering an approach over the time series similar to that applied for the current GHGI and documented in "Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2014: Revisions to Natural Gas and Petroleum Production Emissions." The EPA would apply the revised AFs developed from subpart W RY2015 data for 2011 and continuing forward, along with total gas well and oil well counts specific to each year. We would then apply linear interpolation between 1992 and 2011 to estimate equipment counts for each intermediate year. However, the EPA is also considering an option where we would apply the revised subpart W AFs to 2015 and continuing forward, and would then apply linear interpolation between 1992 and 2015 to estimate equipment counts for each intermediate year.

Table 25. Reported Subpart W Equipment Counts for RY2011 - RY2015

Equipment / Source Category	RY11	RY12	RY13	RY14	RY15
Wells (NG & Petro)	371,604	398,052	415,270	502,391	527,170
Separators (NG & Petro)	201,642	221,669	234,482	270,144	298,096
Heaters (NG)	46,344	48,883	43,564	48,641	63,523
Dehydrators (NG)	8,030	9,547	7,965	8,401	8,195
Meters/piping (NG)	238,044	231,337	216,212	258,837	263,870
Compressors (NG)	22,034	20,655	20,912	23,299	24,090
Heater-treaters (Petro)	25,174	23,082	26,518	34,735	51,364
Headers (Petro)	32,767	29,678	31,843	45,368	52,872

7. Liquids Unloading

7.1 Current GHGI Methodology and Available Subpart W Data

In the 2013 GHGI, data from a 2012 report published by the American Petroleum Institute (API) and America's Natural Gas Alliance (ANGA) were incorporated to update estimates for liquids unloading, after the EPA reviewed the data and compared it with preliminary subpart W data, which showed similar emissions levels.[9] The EPA developed regional activity factors and regional emission factors from the API/ANGA report for gas well liquids unloading activities in natural gas systems.[10] The EPA noted its plans to revisit this estimate as additional subpart W data became available.

Liquids unloading data are reported under subpart W of the GHGRP, including the number of wells vented, the number of unloading events, whether plunger lifts were used, and CH_4 emissions. Well counts are reported under the equipment leak reporting section of subpart W, and the 2015 reporting year data distinguishes between oil and gas well counts, which improves the data available to develop activity data for liquids unloading. The EPA has assessed the subpart W data and is considering the development of revised EFs and AFs for the GHGI.

7.2 Revisions Under Consideration for Liquids Unloading

The EPA evaluated the reported RY2011-RY2015 subpart W liquids unloading data. Table 26 presents the number of wells venting during liquids unloading (with and without plunger lifts) and their percent of the total gas well population in GHGRP, and compares this to the 2016 GHGI. The percent of wells that vent were determined from subpart W RY2015 data, because of the updated reporting distinguishing between gas and oil wells.

Table 26. Subpart W and 2016 GHGI Liquids Unloading Activity Data

Data Source	Year or NEMS	Total # Gas Wells	With Plunger Lifts		Without Plunger Lifts	
			# Wells Vented	% of Wells That Vented	# Wells Vented	% of Wells That Vented
Subpart W	2011	(a)	42,826		26,679	
	2012	(a)	34,136		25,262	
	2013	(a)	30,922		27,723	
	2014	(a)	26,859		23,068	
	2015	307,737	30,757	**10.0%**	20,886	**6.8%**
2016 GHGI (data for 2014)	National Total/ Average	456,140	22,477	**4.9%**	37,912	**8.3%**

a. Only the count of total wells was reported for 2011-2014, not differentiated by gas and oil production.

[9] API/ANGAA. September 2012. "Characterizing Pivotal Sources of Methane Emissions from Natural Gas Production." http://www.api.org/~/media/Files/News/2012/12-October/API-ANGA-Survey-Report.pdf

[10] For more information, see the memo "Overview of Updates to the Natural Gas Sector Emissions Calculations for the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2011," https://www.epa.gov/ghgemissions/updates-2013-greenhouse-gas-inventory, and pages 3.68 to 3.69 of the 2013 GHGI, available at https://www.epa.gov/sites/production/files/2015-12/documents/us-ghg-inventory-2013-main-text.pdf.

The EPA calculated subpart W liquids unloading EFs for each year by summing the CH_4 emissions and dividing by the number of wells that vented for the categories for wells venting with plunger lifts and wells venting without plunger lifts. The EPA then calculated an average EF by summing the emissions reported in those categories for RY2011-RY2015 and dividing by the total number of wells that vented during liquids unloading for RY2011-RY2015. Table 27 presents the calculated subpart W liquids unloading EFs (with and without plunger lifts) and compares this to the 2016 GHGI.

The 2016 GHGI applies regional emission factors developed from API/ANGA for liquids unloading. The API/ANGA data showed large regional differences in average emissions. For certain regions these EFs are much higher than average national emissions. For example, the Rocky Mountain EF in the 2016 GHGI is 2,002,960 scfy CH_4/well for wells without plunger lifts and the Mid-Continent EF is 1,137,406 scfy CH_4/well for wells with plunger lifts. These EFs, particularly the Rocky Mountain EF for wells without plunger lifts, result in high emissions over the time series. The EPA reviewed the subpart W data to determine if similar differences between regions were present. The subpart W EFs for five of the six regions were all within a similar range of each other; this includes the Rocky Mountain and Mid-Continent regions. The subpart W liquids unloading average emissions for wells with plunger lifts in the West Coast region were higher than other regions. However, few liquids unloading events were reported in the West Coast region and, therefore, this data would have minimal impact on the national level EF and emissions calculated with this data.

Table 27. Subpart W and 2016 GHGI Liquids Unloading CH_4 Average Emissions per Well (scfy CH_4/well)

Data Source	Year or NEMS	With Plunger Lifts	Without Plunger Lifts
Subpart W	2011	205,387	149,023
	2012	166,144	133,689
	2013	162,485	160,865
	2014	104,863	194,842
	2015	74,236	168,647
	Average	***148,589***	***160,411***
2016 GHGI (for 2014) (a)	***Average***	***200,791***	***260,030***

a. The 2016 GHGI is calculated on a regional basis. Regional emission factors range from 2,856 to 1,127,406 scfy CH_4/well for wells with plunger lifts, and 77,891 to 2,002,960 scfy CH_4/well for wells without plunger lifts.

7.3 Time Series Considerations

Calculating the full 1990-2015 time series for liquids unloading requires an estimate of the percent of wells conducting liquids unloading and the technologies used for unloading over that time period. The current GHGI used the total percentage of wells conducting liquids unloading in the API/ANGA study (56%) for each year of the time series. The total percentage was developed by summing the percent of wells that vent without plunger lifts, wells that vent with plunger lifts, and wells that use lift technologies without venting. In the current GHGI, for years 2010 and later, the percent of wells in each category as presented in the API/ANGA survey is applied. The current GHGI assumes that in 1990 all wells conducting liquids unloading (56% of wells) vented without plungers. Interpolation between the 1990 data point and the API/ANGA percentages was then applied to develop estimates from 1990-2009.

For the activity data revisions under consideration, the EPA is considering multiple options to determine activity over the GHGI time series. The EPA could use the subpart W RY2015 AF for the percent of total wells that vent during liquids unloading with and without plunger lifts, 16.8%, shown in Table 26 to calculate activity data for 2015, and potentially 2011-2014 as well. The EPA could then apply the year-specific fraction of wells that vent with plunger lifts (varies from 53-62%) and wells that vent without plunger lifts (varies from 38-47%) for 2011-2015. The EPA could also retain the total percent of wells requiring liquids unloading (56%) from the API/ANGA report (this information is not available in subpart W) throughout the time series. Using the same approach as in the current GHGI, the EPA could assume that in 1990, all wells conducting liquids unloading vent without plunger lifts (and that no wells vent with plunger lifts or use non-emitting technologies). The EPA could then use linear interpolation from the 1990 data points to the 2011 or 2015 data points (10% vent with plunger lifts, 6.8% vent without plunger lifts, and 39% conduct liquids unloading without venting). For the EF revisions under consideration, the EPA is considering applying the average subpart W EFs to each year of the GHGI time series.

8. Gathering and Boosting (G&B) Station Episodic Events

As part of the 2016 GHGI revisions, by using the GHGRP onshore production data, the scope of activity data for various production segment equipment fugitive sources—including heaters, separators, dehydrators, and compressors—was revised to reflect activities only at well pads, and not equipment at G&B stations (equipment at G&B stations were for the most part included in the updated G&B station category). These activity data revisions impacted the calculated activity data for certain emission sources in the “Blowdowns” category (vessel blowdowns, compressor blowdowns, and compressor starts) which were not included in the G&B station estimate. The GHGI emission calculations for these three blowdown sources directly rely on equipment counts; so as the equipment count methodology was revised in the 2016 GHGI to reflect only well pad activities, emissions from these three blowdown sources in the 2016 GHGI reflect only well pad activities, and do not account for activities at G&B facilities. This impact was not identified in the supporting memoranda for the 2016 GHGI revisions.

The EPA revisited the current data sources and methodology to assess whether available data could supplement current estimates to account for blowdown sources at G&B facilities. The 2015 Marchese study, which the EPA used to develop the 2016 GHGI station-level emission factor, excluded episodic events. The Marchese study did however estimate the impact of episodic emission events on G&B facility model predictions using a separate Monte Carlo model. Episodic emissions events included in their estimate included blowdowns of pressurized equipment, compressor engine starts utilizing gas-pneumatic starters, pig launch and receive operations, and similar events. The Marchese analysis resulted in CH_4 emissions of 37 MT per G&B station. The Marchese study notes that their national emission estimate for these sources is higher than the existing GHGI estimate for such sources in the production segment, and that excluding these episodic G&B sources would most likely result in an incomplete national emission estimate for G&B stations.

EPA is considering adding the emission source "G&B station episodic events" under the existing "Blowdowns" category in the natural gas systems production segment to account for these emissions from G&B stations. For consistency with G&B station-level emissions already presented in the 2016 GHGI, the 2012 emission factor would be applied to all time series years. See Table 28 below.

Table 28. G&B Station Episodic Event CH_4 Emission Estimates with Update Under Consideration

Parameter	1990	1995	2000	2005	2010	2014

Station Count	2,565	2,732	2,843	2,968	3,838	4,999
Emissions from Episodic Events (mt CH_4)	94,905	101,084	105,191	109,816	142,006	184,963

Beginning in 2017, GHGRP subpart W data will be available for G&B facilities subject to reporting, including calculated blowdown emissions from equipment with a physical volume of at least 50 cubic feet. These data might be used in the 2018 GHGI to validate or replace Marchese estimates of episodic event emissions at G&B stations.

9. Requests for Stakeholder Feedback

Tanks

1. The EPA seeks feedback on the throughput-based and tank-based subpart W EF and AF data approaches and the potential benefits and challenges of each approach.

2. The EPA seeks stakeholder feedback on assumptions applied to determine the split between condensate and oil production within the subpart W data for the throughput basis. Are other options available to distinguish between condensate and oil production?

3. The EPA requests stakeholder feedback on how to determine the appropriate national condensate and oil tank throughput data for the throughput option to ensure that the calculated national emissions for this source accurately reflect storage tank emissions at well pad production sites (and not at gathering and boosting stations which are calculated separately). Alternatively, the EPA requests feedback on if the differences between the total subpart W production and the total subpart W tank throughput are partially due to G&B tanks not reporting, and thus the issue is ultimately resolved by the subpart W data itself.

4. For the throughput basis option, the EPA seeks feedback on the appropriate data source to use for national condensate and oil production. EIA production data are currently used, however, other sources, such as DrillingInfo, are also available. DrillingInfo is used to determine well counts, and using the same data source could create better consistency in the GHGI.

5. The EPA seeks feedback on how to best estimate emissions over the GHGI time series using a throughput-based approach.

6. The EPA seeks stakeholder feedback on developing activity data over the GHGI time series for the tank basis option.

7. Subpart W includes reporting of malfunctioning dump valves from large tanks but not from small tanks. The EPA seeks stakeholder feedback on malfunction rates and emissions from small tanks, including whether small tanks are more or less likely to have malfunctioning dump valves, and whether it may be appropriate to apply the EFs and AD assumptions from large tanks to small tanks.

8. Recent studies have observed (but not quantified) very high emissions from tanks. However, GHGRP data is showing lower, not higher emissions than the GHGI. The EPA seeks stakeholder feedback on this apparent discrepancy.

Associated Gas Venting and Flaring

9. The EPA seeks stakeholder input on the use of subpart W data for associated gas venting and flaring and on approaches for scaling subpart W data to national representation for use in the GHGI.

10. The EPA seeks stakeholder input on approaches for populating the GHGI time series using subpart W data for associated gas venting and flaring. Are there specific factors that may lead to higher or lower levels of venting and flaring in certain years?

Well Counts

11. The EPA seeks stakeholder feedback on other available national data sets for well counts for direct use in the GHGI or for validation of GHGI well counts.

12. The EPA seeks feedback on whether and how to distinguish between stripper and non-stripper oil wells in applying the subpart W data.

Equipment Counts

13. The EPA seeks stakeholder input on which years to apply RY2015 data for estimating emissions. For example, the revised subpart W AFs based on RY2015 could be applied to 2011 and on (with interpolation from previous data point up to 2010), or for 2015 and on (with interpolation from previous data point up to 2014). As shown in Table 25, in relation to the increasing wells counts for each year, certain equipment counts are generally similar over the time series but other equipment counts are dissimilar over the time series. Are there certain sources for which subpart W data should be applied on a year-specific basis? The EPA is requesting feedback on which approach is most appropriate to estimate emissions over the time series.

Liquids Unloading

14. The EPA seeks stakeholder feedback on approaches for calculating liquids unloading emissions and activity using subpart W data, including:
    - Use of national versus regional emission factors and activity factors
    - Use of all reporting years (as an average or for year-specific factors) versus only RY2015 for emissions and or activity data

15. The EPA seeks stakeholder feedback on data sources for emission factors for liquids unloading including GHGRP and Allen et al.[11]

16. The EPA seeks feedback on options to determine activity data over the GHGI time series. Subpart W AFs could be applied to each year of the time series, or the current approach could be retained to some extent for 1990-2010.

17. The current GHGI approach assumes that the fraction of wells requiring liquids loading (56%) remains constant over the time series and that only the fraction of wells in different categories of unloading approaches (venting without plunger lifts, venting with plunger lifts, use of non-emitting approaches) varies. The EPA seeks feedback on whether the fraction of wells with liquids loading problems may change over time and if so how. Are other data sources available?

[11] https://www.epa.gov/sites/production/files/2015-12/documents/ng-inv-improvement-liquids-unloading-4-10-2015.pdf

Gathering and Boosting Station Episodic Events

18. The EPA seeks stakeholder feedback on approaches for addressing this emission source in the 2017 GHGI including implementing a revision to include gathering and boosting station episodic events based on Marchese et al. estimates and/or review and potentially include GHGRP subpart W data for gathering and boosting facilities when available in late 2017.

Appendix A. Measurement Methodologies for Emission Factor Updates under Consideration

Emission Source	Measurement or Calculation Type	# Sources	Location & Representativeness
GHGRP Subpart W (RY2015)			
Production Storage Tanks: -Large (≥10 bbl/ day) -Small (<10 bbl/day)	**Large Tanks** (facilities have multiple options to calculate emissions): 1. Use software (e.g., AspenTech HYSYS or API 4697 E&P Tank) to calculate emissions 2. Assume all CH_4 and CO_2 at separator conditions is emitted 3. Determine composition of produced oil and gas and assume all CH_4 and CO_2 is emitted **Small Tanks**: Count the number of wells (sending oil or condensate direct to tanks) or separators with throughput <10 bbl/day and apply a population EF For both large and small tanks: If applicable, emissions are adjusted downward by applying a flare control efficiency of 98% or by estimating the magnitude of emissions recovered using a vapor recovery system.	--2015 emissions data were available for 144,777 large tanks, of which we assigned 117,683 to oil production and 27,094 to gas production. Software was used to calculate emissions for 118,793 large tanks. --2015 emissions data were available for 143,655 small tanks, of which we assigned 46,535 to oil production and 97,120 to gas production. --Tanks were assigned to oil and gas production using the formation type in sub-basin IDs.	Onshore production facilities were spread across the United States, but must exceed 25,000 mt CO_2e threshold to report.
Associated Gas Venting and Flaring	Facilities determine the gas-to-oil ratio (GOR) for each well and assume that all gas is emitted, based on the liquid throughput. Facilities also subtract the volume of associated gas that is sent to sales. If associated gas is flared, the emissions are then adjusted by applying a flare control efficiency of 98%.	2015 emissions data were available for 25,739 wells, of which 21,453 were controlled with a flare and the remaining 4,286 vented directly to the atmosphere.	
Liquids Unloading	Facilities have 3 methods to select from: 1. Measure flow rate of gas vented during liquids unloading along with duration (hours) of liquids unloading events for each well group (if the gas flow rate during liquids unloading is measured for at least one unloading event for a unique well tubing diameter group and pressure group combination in a sub-basin category)	2015 emissions were available for 30,757 wells with plunger lifts and 20,886 wells without plunger lifts. Facilities applied an equation to calculate emissions (methodology 2 or 3) for 49,121 wells (with and without plunger lifts).	

	2. For wells without plunger lift assist: Apply equation that uses well depth, casing diameter, shut-in pressure, and the average gas flow rate to calculate emissions 3. For wells with plunger lift assist: Apply equation that uses well depth, tubing diameter, shut-in pressure, and the average gas flow rate to calculate emissions		