# Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2017: Updates to Liquefied Natural Gas Segment

This memorandum documents the updates implemented in EPA's 2019 *Inventory of U.S. Greenhouse Gas Emissions and Sinks* (GHGI) for liquefied natural gas (LNG) storage facilities and LNG import and export terminals. Additional considerations for the LNG segment were previously discussed in memoranda released in June (*Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2017: Updates Under Consideration for Incorporating GHGRP Data)* and October 2018 (*Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2017: Updates Under Consideration for Liquefied Natural Gas Segment Emissions*).[1] During the stakeholder process for developing the 2019 GHGI, stakeholders supported making updates to estimate LNG segment emissions using Greenhouse Gas Reporting Program (GHGRP) subpart W data.

## 1 2018 (Previous) GHGI Methodology

In the 2018 (previous) GHGI, each LNG facility type estimate included estimates for station fugitives, reciprocating and centrifugal compressor vented and leak emissions, compressor exhaust, and station venting (i.e., blowdowns). The GHGI used the same source-specific $CH_4$ EFs for both LNG storage stations and LNG import terminals. The $CH_4$ EFs were based on the 1996 GRI/EPA study, which developed EFs using underground natural gas storage and transmission compressor station data. Specific emissions data for LNG storage stations and LNG import terminals were not available in the GRI/EPA study. For $CO_2$ emissions estimates from sources other than compressor engine exhaust, the previous GHGI used an assumed ratio of $CO_2$-to-$CH_4$ gas content to calculate $CO_2$ EFs from the $CH_4$ EFs. For compressor exhaust $CH_4$, the previous GHGI used EFs from the 1996 GRI/EPA study that were developed for engines and turbines in the natural gas industry (mt $CH_4$/MMHp-hr) ($CO_2$ estimates are not included within the natural gas systems estimates, but within separate fuel combustion estimates).

For LNG storage station activity data, the previous GHGI considered complete storage stations and satellite facilities, the latter of which do not perform liquefaction. The GHGI assumed that satellite facilities have approximately one-third of the equipment found at complete storage stations, and thus only included one-third of the satellite facility count in the emissions calculations. Complete storage station and satellite facility counts are available for 1992 and 2003.[2] Storage station counts for years before 2003 were calculated by applying linear interpolation between the 1992 and 2003 values. Storage station counts for years after 2003 were set equal to the 2003 counts. The count of reciprocating and centrifugal compressors were estimated by applying a certain ratio of compressors per plant. Compressor exhaust activity data were estimated by applying assumptions regarding the number, type, and size of compressors at various facility types (including subcategory types of storage stations and terminals).

For LNG terminals activity data, the previous GHGI determined import terminal counts using data available from the U.S. Department of Energy (DOE) Federal Energy Regulatory Commission (FERC).[3] The terminal counts include onshore and offshore facilities. FERC provides both import and export terminal data, but only import terminals were considered for the GHGI, since export terminals have only recently been constructed in the U.S. The previous GHGI assumed that import terminals have approximately two-thirds of the equipment found at complete

[1] EPA memoranda for the 1990 to 2017 Inventory stakeholder process are available at < https://www.epa.gov/ghgemissions/stakeholder-process-natural-gas-and-petroleum-systems-1990-2017-inventory>.
[2] Energy Information Administration, Department of Energy. "US LNG Markets and Uses." 2004.
[3] FERC. "North American LNG Import/Export Terminals – Existing." Available at http://www.ferc.gov/industries/gas/indus-act/lng/lng-existing.pdf.

storage facilities (as they do not perform liquefaction). Compressor counts and exhaust activity data were determined in the same manner as for LNG storage, applying ratios.

# 2 Analysis of Available Data

This section summarizes available emissions and activity data from GHGRP; and activity data from FERC, DOE's Energy Information Administration (EIA), and the U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA).

## 2.1 GHGRP Subpart W

GHGRP subpart W collects data from LNG storage and LNG import and export facilities that meet a reporting threshold of 25,000 metric tons of $CO_2$ equivalent (MT $CO_2e$) emissions. Subpart W collects emissions and activity data for centrifugal and reciprocating compressors, and equipment leaks for LNG storage and LNG import and export facilities. Subpart W also collects blowdown emissions for LNG import and export facilities. Facilities began reporting flare emissions under a unique flare stacks source starting in reporting year (RY) 2015; in prior RYs, compressor flaring emissions were reported with the centrifugal and reciprocating compressor emissions data. The GHGRP data used in the analyses discussed in this memo are those reported to the EPA as of August 19, 2018. The subpart W emission calculation methodologies for each emission source are documented in Appendix A.

### Comparison to Previous GHGI

Table 1 below shows source-level emission estimates from the previous GHGI compared to subpart W reported emissions, for year 2016.

**Table 1. Emission Estimates (mt) by LNG Source, Year 2016[a]**

| Emission Source | 2018 (Previous) GHGI (National Total) | | GHGRP Subpart W (As-Reported) | |
|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $CO_2$ | $CH_4$ |
| **Storage** | **2,409** | **73,124** | **2,507** | **152** |
| Station fugitives [b] | 363 | 10,623 | 0 | 112 |
| Reciprocating compressors | 1,373 | 40,147 | 1 | 23 |
| Centrifugal compressors | 471 | 13,766 | 0 | 0 |
| Compressor engine exhaust | - [c] | 2,678 | - [c] | - [c] |
| Compressor turbine exhaust | - [c] | 12.4 | - [c] | - [c] |
| Station venting (blowdowns) | 202 | 5,899 | 0 | 0 |
| Flares | - [d] | - [d] | 2,507 | 18 |
| **Terminals** | **300** | **10,741** | **98,753** | **18,472** |
| Station fugitives [b] | 40 | 1,164 | 0 | 40 |
| Reciprocating compressors | 190 | 5,552 | 1 | 48 |
| Centrifugal compressors | 49 | 1,419 | 0 | 1 |
| Compressor engine exhaust | - [c] | 1,951 | - [c] | - [c] |
| Compressor turbine exhaust | - [c] | 9.9 | - [c] | - [c] |
| Station venting (blowdowns) | 22 | 646 | 811 | 18,045 |
| Flares | - [d] | - [d] | 97,940 | 339 |

a - Subtotals might differ from sum of individual sources due to rounding.
b - GHGI estimate includes only non-compressor station components, while GHGRP reported equipment leaks estimate includes compressor components (with the more significant vented emissions separately estimated)
c - $CO_2$ estimates are not included within the natural gas systems estimates, but within separate fuel combustion estimate of the GHGI; $CO_2$ and $CH_4$ are reported under subpart C of the GHGRP.
d - Flare emissions from LNG segments were not estimated in the 2018 GHGI.

## LNG Storage

Table 2 and Table 3 below show that historically, eight LNG storage stations reported LNG activity and/or emissions to GHGRP subpart W at some point during 2011 through 2017. Each reporting storage station type has been identified using the 2016 PHMSA annual report for purposes of this analysis. According to PHMSA, two of these storage stations have terminal activities. Cove Point reported to GHGRP as a storage station in 2011; since then the facility has operated and reported as terminal. EcoEléctrica has consistently reported as a storage station; it is in Puerto Rico and was constructed to receive imports and provide natural gas to a nearby electric generation plant.[4]

**Table 2. Reported Subpart W LNG Storage $CO_2$ Emissions, by Facility and Equipment Type**

| Facility or Equipment | Facility Type[a] | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|
| **Facility-Level Data** | | | | | | | | |
| Burlington Generating Station | Sat | 0[b] | 0[b] | 0[b] | 0[b] | 0[b] | 0[b] | 0[b] |
| MidAmerican, Bettendorf LNG | Sat | 1 | 8 | 71 | 29 | 0.2 | 1 | 0 |
| Williams | PS | 0[b] | 0[b] | 0[b] | 0[b] | 0[b] | 0[b] | 0[b] |
| Macon LNG | PS | -[c] | -[c] | -[c] | -[c] | 0[b] | 0[b] | 0[b] |
| Cherokee LNG | PS | -[c] | -[c] | -[c] | -[c] | 0[b] | 0[b] | 0[b] |
| Wrenshall LNG | PS | 0[b] | 0[b] | 0[b] | 0[b] | 27 | -[d] | -[d] |
| Ecoelectrica LP | MT | 0[b] | 0[b] | 13 | 45 | 233 | 2,507 | 6,049 |
| Cove Point LNG[e] | MT | 0[b] | -[c] | -[c] | -[c] | -[c] | -[c] | -[c] |
| **Equipment-Level Data[f]** | | | | | | | | |
| Equipment Leaks | - | 0 | 0 | 13 | 45 | 1 | 0 | 0 |
| Flare Stacks | - | - | - | - | - | 259 | 2,507 | 6,049 |
| Reciprocating Compressors | - | 1 | 8 | 71 | 29 | 0.2 | 1 | 0 |
| **Total** | **-** | **1** | **8** | **84** | **74** | **260** | **2,507** | **6,049** |

"-" indicates no data reported.
a - PHMSA facility types: (Sat) Satellite. (PS) Peak Shaving. (MT) Marine Terminal.
b - Zero emissions reported to subpart W, but emissions were reported under subpart C.
c - No LNG storage emissions were reported to either subpart C or W.
d - Emissions were reported for subpart C, but not subpart W.
e - Reported as both an LNG storage and LNG terminal in 2011. All other years reported only as a terminal.
f - No facilities reported centrifugal compressor emissions. LNG storage facilities are not required to report blowdown emissions.

**Table 3. Reported Subpart W LNG Storage $CH_4$ Emissions, by Facility and Equipment Type**

| Facility or Equipment | Facility Type[a] | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|
| **Facility-Level Data** | | | | | | | | |
| Burlington Generating Station | Sat | 0[b] | 0[b] | 0[b] | 0[b] | 0[b] | 0[b] | 0[b] |
| MidAmerican, Bettendorf LNG | Sat | 16 | 3 | 25 | 10 | 9 | 23 | 3 |
| Williams | PS | 41 | 1 | 0[b] | 0[b] | 0[b] | 1 | 1 |
| Macon LNG | PS | -[c] | -[c] | -[c] | -[c] | 3 | 1 | 1 |
| Cherokee LNG | PS | -[c] | -[c] | -[c] | -[c] | 3 | 1 | 1 |
| Wrenshall LNG | PS | 3 | 3 | 5 | 4 | 33 | -[d] | -[d] |
| Ecoelectrica LP | MT | 0[b] | 2 | 1 | 2 | 22 | 126 | 48 |
| Cove Point LNG[e] | MT | 7 | -[c] | -[c] | -[c] | -[c] | -[c] | -[c] |

[4] EIA, Department of Energy. "US LNG Markets and Uses." 2004.

| Facility or Equipment | Facility Type[a] | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|
| **Equipment-Level Data[f]** | | | | | | | | |
| Equipment Leaks | - | 11 | 6 | 6 | 6 | 59 | 112 | 9 |
| Flare Stacks | - | - | - | - | - | 2 | 18 | 45 |
| Reciprocating Compressors | - | 55 | 4 | 25 | 11 | 8 | 23 | 0 |
| **Total** | **-** | **67** | **10** | **31** | **17** | **70** | **152** | **54** |

"-" indicates no data reported.

a - PHMSA facility types: (Sat) Satellite. (PS) Peak Shaving. (MT) Marine Terminal.

b - Zero emissions reported to subpart W, but emissions were reported under subpart C.

c - No LNG storage emissions were reported to either subpart C or W.

d - Emissions were reported for subpart C, but not subpart W.

e - Reported as both an LNG storage and LNG terminal in 2011. All other years reported only as a terminal.

f - No facilities reported centrifugal compressor emissions. LNG storage facilities are not required to report blowdown emissions.

It should be noted that there is a significant population of LNG storage facilities reporting zero emissions under subpart W (with nonzero emissions reported under subpart C). Furthermore, the sector emission totals (and calculated facility-level average EFs) are driven by EcoEléctrica, MidAmerican, Williams, and Wrenshall. These are the only facilities to report annual $CO_2$ or $CH_4$ emissions greater than 30 metric tons. RY2015 through RY2017 have the highest annual sector $CO_2$ emissions, driven by high flare stack emissions (this source is included in previous years only to the extent it is associated with compressors).

For purposes of considering methodological updates in the 2019 GHGI, EPA calculated facility-level average EFs using combined RY2015 through RY2017 data for all LNG storage stations. The resulting EFs are presented in Table 4, and are compared to the 2018 (previous) GHGI EFs. Subpart W emissions prior to RY2015 are not used because these years may not include all flare emissions at a facility. Average EFs were calculated from three years of subpart W data, instead of calculating year-specific EFs, because of the limited number of LNG storage stations reporting to subpart W. Subpart W does not collect emissions data from LNG storage station blowdowns; EPA considered multiple approaches for developing an estimate for this source in the 2019 GHGI—including maintaining the existing GHGI EFs (also shown in Table 4) or using import/export terminal blowdown data to develop a surrogate EF.

**Table 4. Comparison of Subpart W and 2018 GHGI LNG Storage Facility-Level EFs**

| Parameter | Subpart W 2015-2017 Total Reported Emissions (mt) | Subpart W Average EF (mt/station) | 2018 GHGI EF (Year 2016) (mt/station) |
|---|---|---|---|
| **LNG Storage Stations** | | | |
| $CO_2$ | 8,816[a] | 464 | 31[b] |
| $CH_4$ | 276[a] | 15 | 919[b] |
| $N_2O$ | 0.16[a] | 0.008 | -[c] |
| Facility count | 19 | n/a | n/a[b] |
| **LNG Storage Station Blowdowns** | | | |
| $CO_2$ | -[d] | -[d] | 3 |
| $CH_4$ | -[d] | -[d] | 84 |

n/a - Not applicable.

a - Includes emissions from equipment leaks, flare stacks, and reciprocating compressors. Does not include emissions from compressor exhaust or station blowdowns.

b - EF is calculated from GHGI total emissions divided by facility count; in the GHGI, total emissions are not calculated using a facility-level EF, but activity-specific EFs. Includes emissions from equipment leaks, centrifugal compressors, and reciprocating compressors. Does not include emissions from compressor exhaust or station blowdowns.

c - $N_2O$ emissions were not calculated in the 2018 GHGI.

d - Subpart W does not collect emissions data from LNG storage station blowdowns.

To consider an alternative to the existing GHGI approach of using facility count-driven estimates (i.e., consider a throughput-based approach), EPA also investigated the impact of facility capacity and utilization on facility emissions. Table 5 presents LNG storage activity and emissions (including fuel combustion emissions reported under subpart C) for year 2016. For additional context, this table also shows national total withdrawal volumes from DOE/EIA; this data source is discussed further in Section 2.2. Possibly in part due to the small data set, there is not a clear relationship between the activity and emissions data in the table below, nor between facility type (e.g., peak shaving versus satellite) and emissions. For example, the reporter with the highest subpart W $CH_4$ emissions (MidAmerican Bettendorf LNG) is the second-smallest facility in terms of capacity, had the lowest withdrawal volume, and is a satellite station (which generally have less equipment than a peak shaving station). Further, subpart C emissions might be considered as reflecting utilization (e.g., compressor activity); however, there is no discernable trend between subpart C emissions and subpart W emissions or other facility activity parameters. Lastly, the national total withdrawals from DOE/EIA are not directly compatible with subpart W data as reported; the reported subpart W data account for 157% of the national total activity.[5] Therefore, EPA found support for maintaining the existing GHGI approach of a facility-based EF rather than a throughput-based EF.

**Table 5. Reported GHGRP LNG Storage Activity and Emissions, Year 2016**

| Facility Details | | Activity | | | Emissions (metric tons) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Subpart W | | Subpart C | |
| GHGRP Facility | Type[a] | GHGRP Capacity (Bcf) | GHGRP Withdrawals (Bcf) | DOE/EIA Withdrawals (Bcf) | $CO_2$ | $CH_4$ | $CO_2$ | $CH_4$ |
| Burlington Generating Station | Sat | 0.35 | 0.21 | -[c] | - | - | 295 | 0 |
| MidAmerican, Bettendorf LNG | Sat | 0.50 | 0.07 | -[c] | 1 | 23 | 0 | 0 |
| Williams | PS | 0.98 | 0.70 | -[c] | 0 | 1 | 5,937 | 0.2 |
| Macon LNG | PS | 2.50 | 0.98 | -[c] | 0 | 1 | 24,593 | 0.5 |
| Cherokee LNG | PS | 2.09 | 0.50 | -[c] | 0 | 1 | 17,469 | 0.3 |
| Wrenshall LNG | PS | 2.10[b] | - | -[c] | - | - | 12,117 | 0.2 |
| Ecoelectrica LP | MT | 3.42 | 60.52 | -[c] | 2,507 | 126 | 1,367,397 | 26 |
| **Total** | | **11.9** | **63** | **40** | **2,507** | **152** | **1,427,808** | **27** |

"-" indicates no data reported. DOE data are reported at a company/state-level, not facility-level.
a - PHMSA facility types: (Sat) Satellite. (PS) Peak Shaving. (MT) Marine Terminal.
b - Facility did not report to subpart W for RY2016, RY2015 capacity is provided for reference.
c - Withdrawals are reported to DOE/EIA as corporate totals by state, and not by facility.

## LNG Terminals

Table 6, Table 7, and Table 8 show all LNG terminals included in DOE and FERC data, including a notation of the facility type (i.e., import or export terminal). Where available, Table 6 and Table 7 include reported subpart W emissions for 2011 through 2017. Five terminals are historically not GHGRP LNG terminal reporters. Similar to the LNG storage segment, a few facilities dominate reported emissions and certain facilities reported zero emissions.

[5] This high coverage is due to the inclusion of Ecoelectrica as an LNG storage facility in subpart W. DOE/EIA considers this facility to be an LNG terminal.

**Table 6. Reported Subpart W LNG Terminal $CO_2$ Emissions, by Facility and Equipment Type**

| Facility | Facility Type[a] | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|
| **Facility-Level Data** | | | | | | | | |
| ConocoPhillips ANGC – LNG | Ex | 53 | 58 | 45 | 31 | 23 | 0 | 9,213 |
| Cove Point LNG[b] | Im | 4 | 3 | 2 | 7 | 1 | 10 | 24,886 |
| Distrigas Of Mass. LLC | Im | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Freeport LNG Terminal | Im | 0 | 0 | 0 | 0 | 21 | 806 | 11 |
| Trunkline LNG Co LLC | Im | 0 | 0 | 1 | 0 | -[c] | -[c] | -[c] |
| Golden Pass LNG, LLC | Im | 28 | 0 | 0 | 0 | 0 | -[c] | -[c] |
| SLNG Elba Island | Im | 2 | 1 | 0 | 0 | 0 | -[c] | -[c] |
| Magnolia LNG, LLC | Im | -[c] | -[c] | -[c] | -[c] | -[c] | 0 | 0 |
| Gulf LNG Energy | Im | -[c] | -[c] | -[c] | -[c] | -[c] | -[c] | -[c] |
| NorthEast Gateway | Im | -[c] | -[c] | -[c] | -[c] | -[c] | -[c] | -[c] |
| Neptune LNG | Im | -[c] | -[c] | -[c] | -[c] | -[c] | -[c] | -[c] |
| Cameron LNG | Im | -[c] | -[c] | -[c] | -[c] | -[c] | -[c] | -[c] |
| Ecoelectrica LP | Im | -[d] | -[d] | -[d] | -[d] | -[d] | -[d] | -[d] |
| Sabine Pass LNG | I+E[e] | 3 | 3 | 2 | 1 | 77,410 | 97,937 | 268,767 |
| **Equipment-Level Data** | | | | | | | | |
| Blowdowns | - | 29 | 2 | 1 | 5 | 1 | 811 | 5 |
| Centrifugal Compressors | - | 47 | 51 | 40 | 24 | 16 | 0 | 1 |
| Equipment Leaks | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Flares | - | 0 | 0 | 0 | 0 | 77,420 | 97,940 | 302,850 |
| Reciprocating Compressors | - | 12 | 11 | 9 | 9 | 17 | 1 | 1 |
| **Total** | - | **89** | **64** | **50** | **38** | **77,455** | **98,753** | **302,856** |

"-" indicates no data reported or not applicable.

a - FERC/DOE terminal facility types: (Ex) Export, (Im) Import, (I+E) Both.

b - Reported as both an LNG storage and LNG terminal in 2011. All other years reported only as a terminal.

c - No emissions were reported to either subpart C or W.

d - Ecoelectrica is identified by FERC and DOE as an import terminal and is show here for completeness. Emissions data are shown only in Table 2 and Table 5 because this facility reports to GHGRP as a storage facility.

e - Facility started export operations in 2016, therefore the facility was assigned as an import terminal for 2011-2015 and an export terminal for 2016 and 2017.

**Table 7. Reported Subpart W LNG Terminal $CH_4$ Emissions, by Facility and Equipment Type**

| Facility | Facility Type[a] | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|
| **Facility-Level Data** | | | | | | | | |
| ConocoPhillips ANGC – LNG | Ex | 1,826 | 1,990 | 1,572 | 1,067 | 801 | 2 | 83 |
| Cove Point LNG[b] | Im | 145 | 12 | 74 | 217 | 40 | 363 | 124 |
| Distrigas Of Mass. LLC | Im | 23 | 18 | 20 | 13 | 13 | 23 | 15 |
| Freeport LNG Terminal | Im | 359 | 363 | 946 | 1,023 | 240 | 17,684 | 381 |
| Trunkline LNG Co LLC | Im | 71 | 3 | 36 | -[c] | -[c] | -[c] | -[c] |
| Golden Pass LNG, LLC | Im | 1,634 | 1,551 | 7 | 2 | 1 | -[c] | -[c] |
| SLNG Elba Island | Im | 98 | 31 | 65 | 49 | 67 | -[c] | -[c] |
| Magnolia LNG, LLC | Im | -[c] | -[c] | -[c] | -[c] | -[c] | 0 | 0 |
| Gulf LNG Energy | Im | -[c] | -[c] | -[c] | -[c] | -[c] | -[c] | -[c] |
| NorthEast Gateway | Im | -[c] | -[c] | -[c] | -[c] | -[c] | -[c] | -[c] |
| Neptune LNG | Im | -[c] | -[c] | -[c] | -[c] | -[c] | -[c] | -[c] |
| Cameron LNG | Im | -[c] | -[c] | -[c] | -[c] | -[c] | -[c] | -[c] |
| Ecoelectrica LP | Im | -[d] | -[d] | -[d] | -[d] | -[d] | -[d] | -[d] |
| Sabine Pass LN | I+E[e] | 151 | 173 | 101 | 5,634 | 290 | 400 | 931 |

| Facility | Facility Type[a] | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|
| **Equipment-Level Data** | | | | | | | | |
| Blowdowns | - | 1,804 | 1,629 | 59 | 5,799 | 53 | 18,045 | 397 |
| Centrifugal Compressors | - | 1,637 | 1,763 | 1,372 | 838 | 570 | 1 | 19 |
| Equipment Leaks | - | 389 | 392 | 392 | 388 | 27 | 40 | 37 |
| Flares | - | 0 | 0 | 0 | 0 | 268 | 339 | 1,059 |
| Reciprocating Compressors | - | 478 | 356 | 997 | 980 | 534 | 48 | 21 |
| **Total** | - | **4,308** | **4,140** | **2,821** | **8,006** | **1,451** | **18,472** | **1,533** |

"-" indicates no data reported or not applicable.

a - FERC terminal facility types: (Ex) Export, (Im) Import, (I+E) Both.

b - Reported as both an LNG storage and LNG terminal in 2011. All other years reported only as a terminal.

c - No emissions were reported to either subpart C or W.

d - Ecoelectrica is identified by FERC and DOE as an import terminal and is show here for completeness. Emissions data are shown only in Table 2 and Table 5 because this facility reports to GHGRP as a storage facility.

e - Facility started export operations in 2016, therefore the facility was assigned as an import terminal for 2011-2015 and an export terminal for 2016 and 2017.

Table 8 shows GHGRP data for RY2016 in greater detail. For additional context, this table also shows data from FERC and DOE on capacity and import/export volumes; these data sources are discussed further in Section 2.2. In 2016, eight terminals did not report subpart W or C emissions. Similar to the findings from the analysis of RY2016 storage station emissions, activity does not appear to be a good predictor of emissions (e.g., the highest subpart W emissions do not come from the most active terminal). Therefore, EPA found support for maintaining the existing GHGI approach of a facility-based EF rather than a throughput-based EF.

**Table 8. Reported GHGRP LNG Terminal Activity and Emissions, Year 2016**

| Facility Details | | Activity | | | | | Emissions (mt) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Subpart W | | Subpart C | |
| Facility | Type[a] | FERC Capacity (Bcfd) | GHGRP Import (Bcf) | GHGRP Export (Bcf) | DOE Import (Bcf) | DOE Export (Bcf) | $CO_2$ | $CH_4$ | $CO_2$ | $CH_4$ |
| ConocoPhillips ANGC – LNG | Ex | 0.2 | 0 | 0.8 | - | - | 0 | 2 | 12,195 | 0 |
| Distrigas Of Mass. LLC | Im | 1.035 | 69.8 | 69.7 | 69.9 | - | 0 | 23 | 58,301 | 1 |
| Freeport LNG Terminal | Im | 1.5 | 0 | 0 | - | - | 806 | 17,684 | 13,695 | 0 |
| Trunkline LNG Co LLC | Im | 2.1 | - | - | - | - | - | - | - | - |
| Golden Pass LNG, LLC | Im | 2.0 | - | - | - | - | - | - | - | - |
| SLNG Elba Island | Im | 1.6 | - | - | 8.7 | - | - | - | - | - |
| Magnolia LNG, LLC | Im | -[b] | - | - | - | - | 0 | 0 | 0 | 0 |
| Gulf LNG Energy | Im | 1.5 | - | - | - | - | - | - | - | - |
| NorthEast Gateway | Im | 0.8 | - | - | 2.3 | - | - | - | - | - |
| Neptune LNG | Im | 0.4 | - | - | - | - | - | - | - | - |
| Cameron LNG | Im | 1.8 | - | - | - | - | - | - | - | - |
| Ecoelectrica LP | Im | 0.3 | - | - | 0.06 | - | - | - | - | - |
| Sabine Pass LNG | I+E | 4.0/2.8 | 0 | 0.3 | - | 0.2 | 97,936 | 401 | 1,151,305 | 22 |
| Cove Point LNG Facility | I+E | 1.8/0.82 | 6.0 | 8.7 | 6.5 | - | 10 | 363 | 174,692 | 3 |
| **Total** | | **19** | **75.8** | **79.6** | **87.5** | **0.2** | **98,753** | **18,472** | **1,410,187** | **27** |

"-" indicates no data reported.

a - FERC terminal facility types: (Ex) Export, (Im) Import, (I+E) Both.

b - This facility reported zero subpart C and W emissions, and it is not included in the FERC data.

For purposes of considering methodological updates in the 2019 GHGI, EPA calculated facility-level average EFs using combined RY2015 through RY2017 data for all LNG import terminals (including separate facility-level

average EFs for blowdowns) and facility-level year-specific EFs for LNG export terminals using RY2015 through RY2017 data (including separate facility-level EFs for blowdowns). The resulting EFs are presented in Table 9 and Table 10, and are compared to the 2018 (previous) GHGI EFs. Subpart W emissions prior to RY2015 are not used because these years may not include all flare emissions at a facility. Year-specific EFs were calculated for LNG export terminals because all export terminals report to subpart W.

**Table 9. Comparison of Subpart W and 2018 GHGI LNG Import Terminal Facility-Level EFs**

| Parameter | Subpart W 2015-2017 Total Reported Emissions (mt) | Subpart W Average EF (mt/ terminal) | 2018 GHGI EF (Year 2016) (mt/terminal) |
|---|---|---|---|
| **Import Terminals[a]** | | | |
| $CO_2$ | 102,310[a] | 7,308 | 36[b] |
| $CH_4$ | 796[a] | 57 | 1,056[b] |
| $N_2O$ | 0.20[a] | 0.01 | -[c] |
| Terminal count | 14 | n/a | n/a[b] |
| **Import Terminal Blowdowns** | | | |
| $CO_2$ | 815 | 58 | 3 |
| $CH_4$ | 18,443 | 1,317 | 84 |
| Terminal count | 14 | n/a | n/a[b] |

n/a - Not applicable.
a - Includes emissions from centrifugal compressors, equipment leaks, flare stacks, and reciprocating compressors. Does not include emissions from compressor exhaust or terminal blowdowns.
b - EF is calculated from GHGI total emissions divided by facility count; in the GHGI, total emissions are not calculated using a facility-level EF, but activity-specific EFs. Includes emissions from equipment leaks, centrifugal compressors, and reciprocating compressors. Does not include emissions from compressor exhaust or station blowdowns.

**Table 10. Subpart W LNG Export Terminal Facility-Level EFs**

| Parameter | 2015 EF (mt/terminal) | 2016 EF (mt/terminal) | 2017 EF (mt/terminal) |
|---|---|---|---|
| **Export Terminals[a]** | | | |
| $CO_2$ | 23 | 48,968 | 138,990 |
| $CH_4$ | 801 | 175 | 507 |
| $N_2O$ | 0.0 | 0.12 | 0.25 |
| Terminal count | 1 | 2 | 2 |
| **Export Terminal Blowdowns** | | | |
| $CO_2$ | 0.0 | 0.75 | 0.0 |
| $CH_4$ | 0.04 | 25.89 | 0.0 |
| Terminal count | 1 | 2 | 2 |

a - Includes emissions from centrifugal compressors, equipment leaks, flare stacks, and reciprocating compressors. Does not include emissions from compressor exhaust or terminal blowdowns.

## Compressor Exhaust Activity

Facilities report reciprocating and centrifugal compressor operating hours and horsepower to subpart W. Multiplying the operating hours by the horsepower provides the annual power output for engines and turbines. Table 11 through Table 13 present the calculated power output data, along with calculated activity factors (AF) (power output per facility), for LNG storage stations and LNG import and export terminals. In considering updates for the 2019 GHGI, EPA calculated compressor AFs in the same manner as facility-level EFs: the AFs for LNG

storage stations and import terminals are average factors based on combined RY2015 through RY2017 data, and year-specific AFs were calculated for RY2015 through RY2017 for LNG export terminals.

**Table 11. Comparison of Subpart W and 2018 (Previous) GHGI LNG Storage Compressor Engine and Turbine Power Output**

| Parameter | Subpart W 2015-2017 Total Reported Power Output (MMhp-hr) | Subpart W Average AF (MMhp-hr/station) | 2018 GHGI AF (Year 2016) (MMhp-hr/station) |
|---|---|---|---|
| Engines | 25.0 | 1.3 | 8.2 |
| Turbines | 58.2 | 3.1 | 1.6 |
| # Stations | 19 | n/a | n/a |

n/a – Not applicable.

**Table 12. Comparison of Subpart W and 2018 (Previous) GHGI LNG Import Terminal Compressor Engine and Turbine Power Output**

| Parameter | Subpart W 2015-2017 Total Reported Power Output (MMhp-hr) | Subpart W Average AF (MMhp-hr/terminal) | 2018 GHGI AF (Year 2016) (MMhp-hr/terminal) |
|---|---|---|---|
| Engines | 342.9 | 24.5 | 54.8 |
| Turbines | 0.28 | 0.02 | 11.7 |
| # Terminals | 14 | n/a | n/a |

n/a – Not applicable.

**Table 13. Subpart W LNG Export Terminal Compressor Engine and Turbine Power Output AFs**

| Parameter | 2015 AF (MMhp-hr/terminal) | 2016 AF (MMhp-hr/terminal) | 2017 AF (MMhp-hr/terminal) |
|---|---|---|---|
| Engines | 0.0 | 9.2 | 0.0 |
| Turbines | 104.1 | 5.3 | 4.7 |
| Terminal count | 1 | 2 | 2 |

## 2.2 National Activity Data Sources

This section summarizes data sources that provide national activity data in terms of both facility counts and throughput. As discussed in Section 2.1, EPA considered an alternative to the existing GHGI approach of using facility count-driven estimates—i.e., considered a throughput-based approach—but did not identify a clear relationship between reported emissions and activity level.

### LNG Storage

For storage facilities, two sources of activity data are available to cover portions of the GHGI time series. First, the national LNG storage database maintained by PHMSA provides in-service facility counts and storage capacity from year 2010 forward.[6] PHMSA classifies facilities as one of five types (i.e., peak shaving, satellite, base load, mobile/temporary, other). Subpart W does not include information on facility type. The previous GHGI methodology estimated emissions separately from satellite and complete storage stations using assumptions about equipment located at each type of facility. Table 14 below shows that the majority of storage facilities are peak shaving. As described in Section 2.1, recent GHGRP reporters include two satellite and five peak shaving facilities.

[6] https://www.phmsa.dot.gov/pipeline/liquified-natural-gas/lng-data-and-maps

**Table 14. PHMSA LNG Storage Facility Data, Year 2016**

| Facility Types | Facility Count | Storage Capacity (Mcf) | Average Storage Capacity (Mcf) |
|---|---|---|---|
| Base Load | 2 | 27,963 | 13,681 |
| Mobile/Temporary | 2 | 0 | 0 |
| Other | 2 | 1,022,441 | 511,221 |
| Peak Shaving | 68 | 75,806,961 | 1,114,808 |
| Satellite | 20 | 1,695,481 | 84,774 |
| **Total** | **94** | **78,552,847** | **835,669** |

Second, historical system injections and withdraws (from 1997 through 2016) are available from EIA. Appendix B shows available data from both PHMSA and EIA over the GHGI time series. Facility counts are not reported in EIA; therefore, it was not further considered for updating national level activity.

EPA considered supplementing the existing GHGI activity (which relies on point estimates specific to years 1992 and 2003) with PHMSA facility counts to increase accuracy of recent year estimates. For this approach, EPA could apply linear interpolation from the year 2003 counts to the year 2010 PHMSA counts and use PHMSA data going forward. EPA would also increase the counts by 1 starting in 2011, to include EcoElectrica as an LNG storage station (this facility is identified as a terminal in the PHMSA data, but reports as an LNG storage station under subpart W). Counts are also not separated by station type, to be consistent with the EF; for example, peak shaving and satellite stations are treated the same and satellite station counts are not reduced by one-third as in the previous GHGI (see Section 1). Table 15 provides the LNG storage station counts by this methodology, compared to those in the 2018 GHGI. Appendix B also compares the LNG storage station counts over the time series.

**Table 15. Comparison of 2018 GHGI and 2019 GHGI LNG Storage Stations Counts, for Certain Years**

| Basis | 1992 | 2003 | 2010 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|
| 2018 GHGI | 63 | 70 | 70 | 70 | 70 | - |
| Update considered | 81 | 96 | 97 | 98 | 95 | 96 |

## LNG Terminals

The previous GHGI data source for terminal counts, FERC, documents existing import and export facilities (including inactive facilities). The DOE publishes annual estimates of terminal-specific import and export activity, available from year 2004 forward.[7] Based on available data, all existing terminals were active until 2008, after which there is a mix of active and inactive terminals. EPA considered whether it is most appropriate to use total *existing* terminal counts or only the *active* terminals counts in order to calculate national emissions over the time series. Appendix B shows available data from these sources over the GHGI time series. PHMSA also publishes data on terminal capacities and terminal counts, but these estimates do not include offshore facilities, which are historically included in the GHGI.

For import terminal counts in the 2019 GHGI, EPA considered maintaining the existing GHGI terminal counts for 1990-2003 (although the terminal counts wound not be reduced by two-thirds, as in the previous GHGI) and then using the total count of existing import terminals from the DOE dataset for years 2004 and forward. To determine export terminal counts in the 2019 GHGI, EPA considered using the DOE dataset and historical information from EIA.[8] One export terminal in Alaska started operations prior to 1990, and this terminal is included in the counts for all years of the time series. The Sabine Pass terminal started export operations in 2016 and is thus included as an

[7] https://www.energy.gov/fe/listings/lng-reports

[8] Energy Information Administration, Department of Energy. "US LNG Markets and Uses." 2004.

export terminal for 2016 forward. Table 16 provides the LNG import and export terminal counts by these updated methodologies, compared to terminal counts in the 2018 GHGI. Appendix B also compares the LNG import and export terminal counts over the time series.

**Table 16. Comparison of 2018 (Previous) GHGI and 2019 GHGI LNG Import and Export Terminal Counts, for Certain Years**

| Basis | 1990 | 2003 | 2004 | 2010 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|
| **Import Terminals** | | | | | | | |
| 2018 GHGI | 1 | 3 | 3 | 8 | 8 | 8 | n/a |
| Update considered | 2 | 4 | 4 | 11 | 11 | 10 | 10 |
| **Export Terminals** | | | | | | | |
| 2018 GHGI | NE | NE | NE | NE | NE | NE | NE |
| Update considered | 1 | 1 | 1 | 1 | 1 | 2 | 2 |

n/a – Not applicable.
NE – Not estimated.

# 3 Time Series Considerations

To develop estimates over the GHGI time series by an updated approach that incorporates the GHGRP data available in recent years, EPA considered two approaches. First, an updated GHGI methodology might use existing EFs through year 1992, EFs calculated from GHGRP data in recent years, and linear interpolation to calculate EFs in intermediate years. Second, since the existing GHGI EFs are not based on data specific to LNG facilities (they are based on data from underground natural gas storage and transmission compressor stations), EPA could apply subpart W EFs to all years of the time series. As noted in Section 5, stakeholders believe that subpart W data more accurately reflects LNG operations, and supported the use of subpart W EFs.

# 4 Updated Methodology and National Total Emissions Estimates in the 2019 GHGI

Based on the data sources and considerations discussed in Sections 2 and 3 and stakeholder feedback supporting updates that incorporate available GHGRP data (see Section 5), EPA implemented the following updates to LNG segment emissions estimation methodologies:

- LNG Storage Station EFs
    - EPA calculated facility-level average EFs using combined RY2015 through RY2017 data for all LNG storage stations and applied the average EFs to all years of the time series.
        - Note: Subpart W emissions prior to RY2015 are not used because these years may not include all flare emissions at a facility. Average EFs were calculated from three years of subpart W data, instead of calculating year-specific EFs, because of the limited number of LNG storage stations reporting to subpart W.
    - Subpart W does not collect emissions data from LNG storage station blowdowns, and EPA maintained the existing GHGI EFs to estimate LNG storage station blowdown emissions for the 2019 GHGI.
    - Refer to Table 4 ("Subpart W Average EFs") for the updated EFs used in the 2019 GHGI.
- LNG Import/Export Terminal EFs
    - EPA calculated facility-level average EFs using combined RY2015 through RY2017 data for all LNG import terminals (including separate facility-level average EFs for blowdowns) and applied the average EFs to all years of the time series.

  - EPA calculated facility-level year-specific EFs for LNG export terminals using RY2015 through RY2017 data (including separate facility-level EFs for blowdowns) and applied the year 2015 EFs to all prior years of the time series.
  - Note, Subpart W emissions prior to RY2015 are not used because these years may not include all flare emissions at a facility. Year-specific EFs were calculated for LNG export terminals because all export terminals report to subpart W.
  - Refer to Table 9 and Table 10 ("Subpart W Average EFs") for the updated EFs used in the 2019 GHGI.
- Compressor Exhaust AFs
  - EPA calculated compressor AFs in the same manner as facility-level EFs: the AFs for LNG storage stations and import terminals are average factors based on combined RY2015 through RY2017 data, and year-specific AFs were calculated for RY2015 through RY2017 for LNG export terminals.
  - For LNG storage stations and LNG import terminals, EPA applied the average AFs from Table 11 and Table 12 ("Subpart W Average AFs") to all years of the time series.
  - For LNG export terminals, EPA applied the year-specific AFs in Table 13 for each year from 2015 through 2017 and applied the year 2015 AFs for 1990 through 2014.
  - Note, EPA maintained the existing GHGI engine and turbine exhaust EFs. This approach to use subpart W engine and turbine power output data in the GHGI methodology is identical to the approach currently used for the recently-updated natural gas processing segment.
- National Activity
  - For LNG storage stations, EPA supplemented the existing GHGI activity (which relies on point estimates specific to years 1992 and 2003) with PHMSA facility counts[9] to increase accuracy of recent year estimates. For this approach, EPA applied linear interpolation from the year 2003 counts to the year 2010 PHMSA counts and used PHMSA data going forward. EPA also increased the counts by 1 starting in 2011, to include EcoElectrica as an LNG storage station (this facility is identified as a terminal in the PHMSA data, but reports as an LNG storage station under subpart W). Counts are also not separated by station type, to be consistent with the EF; for example, peak shaving and satellite stations are treated the same and satellite station counts are not reduced by one-third as in the previous GHGI (see Section 1). Table 15 provides the LNG storage station counts used in the 2019 GHGI ("Update considered") and compares these to the 2018 GHGI.
  - For import terminal counts, EPA maintained the existing GHGI terminal counts for 1990-2003 and then used the total count of existing import terminals from the DOE dataset[10] for years 2004 and forward. EcoElectrica is excluded from the DOE terminal counts. Table 16 provides the LNG import terminal counts used in the 2019 GHGI ("Update considered") and compares these to the 2018 GHGI.
  - For export terminal counts, EPA used the DOE dataset[11] and historical information from EIA.[11] One export terminal in Alaska started operations prior to 1990, and this terminal is included in the counts for all years of the time series. The Sabine Pass terminal started export operations in 2016 and is thus included as an export terminal for 2016 forward. Table 16 provides the LNG and export terminal counts used in the 2019 GHGI ("Update considered") and compares these to the 2018 GHGI.

[9] https://www.phmsa.dot.gov/pipeline/liquified-natural-gas/lng-data-and-maps

[10] https://www.energy.gov/fe/listings/lng-reports

[11] Energy Information Administration, Department of Energy. "US LNG Markets and Uses." 2004.

Using these updated methodologies, EPA developed the national emissions estimates presented in Table 17 through

Table 19 for the 2019 GHGI; each table includes a comparison to 2018 (previous) GHGI emissions.

**Table 17. Comparison of LNG Storage Station National Emissions Estimates for Year 2016**

| Segment/Approach | $CO_2$ (mt) | $CH_4$ (mt) | $N_2O$ (mt) |
|---|---|---|---|
| **LNG Storage Stations** | | | |
| 2018 GHGI | 2,207 | 64,535 | -[d] |
| 2019 GHGI[a] | 44,081 | 1,382 | 0.79 |
| **LNG Storage Station Blowdowns** | | | |
| 2018 GHGI | 202 | 5,899 | -[d] |
| 2019 GHGI[b] | 273 | 7,976 | 0 |
| **LNG Storage Station Engine Exhaust** | | | |
| 2018 GHGI | -[e] | 2,678 | -[e] |
| 2019 GHGI[c] | -[e] | 578 | -[e] |
| **LNG Storage Station Turbine Exhaust** | | | |
| 2018 GHGI | -[e] | 12 | -[e] |
| 2019 GHGI[c] | -[e] | 32 | -[e] |

a - Uses the subpart W EFs in Table 4 and the station counts in Table 15.
b - Uses the existing GHGI EFs in Table 4 and the station counts in Table 15.
c - Uses the existing GHGI EFs, the subpart W AFs in Table 11, and the station counts in Table 15.
d - $N_2O$ emissions were not calculated in the 2018 GHGI.
e - $CO_2$ and $N_2O$ estimates are not included within the natural gas systems estimates, but within separate fuel combustion estimate of the GHGI.

**Table 18. Comparison of LNG Import Terminal National Emissions Estimates for Year 2016**

| Segment/Approach | $CO_2$ (mt) | $CH_4$ (mt) | $N_2O$ (mt) |
|---|---|---|---|
| **LNG Import Terminals** | | | |
| 2018 GHGI | 278 | 8,134 | -[c] |
| 2019 GHGI[a] | 73,079 | 568 | 0.14 |
| **LNG Import Terminal Blowdowns** | | | |
| 2018 GHGI | 22 | 646 | -[c] |
| 2019 GHGI[a] | 582 | 13,174 | 0 |
| **LNG Import Terminal Engine Exhaust** | | | |
| 2018 GHGI | -[d] | 1,951 | -[d] |
| 2019 GHGI[b] | -[d] | 1,132 | -[d] |
| **LNG Import Terminal Turbine Exhaust** | | | |
| 2018 GHGI | -[d] | 10 | -[d] |
| 2019 GHGI[b] | -[d] | 0.02 | -[d] |

a - Uses the subpart W EFs in Table 9 and the terminal counts in Table 16.
b - Uses the existing GHGI EFs, the subpart W AFs in Table 12, and the station counts in Table 16.
c - $N_2O$ emissions were not calculated in the 2018 GHGI.
d - $CO_2$ and $N_2O$ estimates are not included within the natural gas systems estimates, but within separate fuel combustion estimate of the GHGI.

**Table 19. Comparison of LNG Export Terminal National Emissions Estimates for Year 2016**

| Segment/Approach | $CO_2$ (mt) | $CH_4$ (mt) | $N_2O$ (mt) |
|---|---|---|---|
| **LNG Export Terminals** | | | |
| 2018 GHGI[a] | - | - | - |
| 2019 GHGI[b] | 97,935 | 350 | 0.49 |
| **LNG Export Terminal Blowdowns** | | | |
| 2018 GHGI[a] | - | - | - |
| 2019 GHGI[b] | 1.5 | 52 | 0 |
| **LNG Export Terminal Engine Exhaust** | | | |
| 2018 GHGI[a] | - | - | - |
| 2019 GHGI[c] | - | 85 | - |
| **LNG Export Terminal Turbine Exhaust** | | | |
| 2018 GHGI[a] | - | - | - |
| 2019 GHGI[c] | - | 1.2 | - |

a - 2018 GHGI did not estimate LNG export terminal emissions.
b - Uses the subpart W EFs in Table 10 and the terminal counts in Table 16.
c - Uses the existing GHGI EFs, the subpart W AFs in Table 13, and the station counts in Table 16.

# 5 Requests for Stakeholder Feedback

EPA sought stakeholder feedback on the approaches under consideration discussed in the June and October 2018 memoranda, including the specific questions below. The questions below were not updated for this memorandum and are verbatim from the October 2018 memorandum. Stakeholder feedback in response to those memoranda is summarized here:

- Stakeholders supported the use of data collected under Subpart W for LNG storage and LNG import/export facilities and believes GHGRP more accurately reflects the current state of LNG operations in the U.S.
- A stakeholder recommended calculating emissions for LNG import terminals separately from LNG export terminals, due to their differences in operations.
- Stakeholders recommended that the emissions data for LNG operations be updated annually for each calendar year to reflect the current dynamic trends in this sector.

1. General incorporation of GHGRP data
    a. How should EPA use the RY2011 – RY2016 subpart W data to calculate EFs? The EFs presented in Section 2 are an average of facility-level emissions from RY2015 and RY2016. These two years appear to be the most comprehensive, because they include all flaring emissions. EPA is also considering year-specific EFs, although the number of facilities with data is minimal in a given year. As new subpart W data are reported, EPA could calculate average EFs using 2 or more years to apply to all years, calculate rolling average EFs from 2 or more years, or calculate year-specific EFs. EPA could take different approaches for different facility types; for example, an average of RY2015 and RY2016 data could be used to develop factors for all years for storage and import-only stations, while year-specific factors could be developed for stations that export LNG.
    b. EPA calculated facility-level EFs in Section 2, but is considering developing EFs for each emission source. Are emission source-specific EFs warranted, or is it appropriate for EPA to develop facility-level EFs using subpart W data due to the minimal emissions from LNG facilities?

2. Accounting for different facility types
    a. While there are differences between types of LNG storage facilities (e.g., there is less equipment at satellite versus peak shaving facilities), the reported subpart W data did not show a clear relationship between station type and emissions. As such, in this memo, EPA included data from all station types for the EFs and national activity. Should EPA further consider segregating the data by storage station type similar to the current GHGI approach; station types include satellite, peak shaving, or other categories as shown in Table 5?
    b. EPA included data from both import and export terminals for the EFs calculated in Section 2, but requests feedback on if EPA should consider LNG import-only terminals separately from terminals with export capability?
    c. How should EPA consider inactive facilities in terms of EF development and national activity? For example, DOE provides data that would allow EPA to distinguish between active versus inactive LNG terminals. In addition, the LNG terminal EFs calculated in Section 2 do include emissions from a terminal with zero throughput (refer to the Freeport LNG Terminal in Table 8).

3. Should EPA use the current GHGI EFs for early years of the time series (which rely on GRI data for underground natural gas storage and transmission compressor station data) or apply the subpart W EFs to all years of the time series?

4. Subpart W does not collect blowdown emissions data from LNG storage facilities. Should EPA apply the current GHGI EF for blowdowns, use the subpart W LNG terminals blowdown data, or not include blowdown emissions from LNG storage facilities?

5. Should EPA consider an updated approach for estimating compressor exhaust emissions from LNG storage stations and terminals? For other segments in natural gas systems that have been recently revised to incorporate GHGRP or other recent data (gas processing, transmission, and distribution), EPA has retained parts of the existing GHGI methodology for this source instead of wholly incorporating GHGRP data. EPA is considering implementing a similar approach as used for these segments, wherein updated activity factors (e.g., MMhp-hr/station for each compressor driver type) could be calculated from subpart W data and paired with the current GHGI EF. Table 8 in the Oct. 2018 memo shows data from the current GHGI compared to factors calculated from subpart W reporting for year 2016 and emissions estimates using current GHGI EFs paired with subpart W activity data. EPA also acknowledges that compressors in the LNG segment can be driven by electric motors, such as observed in a recent site visit[12]. EPA seeks stakeholder feedback on how to appropriately reflect available data in the GHGI for this source, including time series considerations (e.g., current GHGI estimates could be used for early years' activity data with linear interpolation to GHGRP-based estimates in later years).

[12] EPA. Site Visit Report - BGE Spring Gardens LNG Facility, Baltimore, Maryland. Docket Number EPA-HQ-OAR-2010-0505-7726. February 9, 2017.

# Appendix A – GHGRP Subpart W Emission Calculation Methodologies

| Emission Source | Measurement and/or Calculation Type | # Sources | Location & Representativeness | EF Calculation Method |
|---|---|---|---|---|
| **GHGRP Subpart W** | | | | |
| LNG Storage, & LNG Import/Export - Flare Stacks | Emissions calculated using: (1) gas volume sent to the flare, (2) combustion efficiency (from manufacturer or assume 98%), fraction of feed gas sent to an un-lit flare, and (3) gas composition for $CO_2$, $CH_4$, and hydrocarbon constituents. | LNG Storage: Emissions data (for 2016) are available from 1 station and a total of 1 flare stack.<br><br>LNG Import/Export: Emissions data (for 2016) are available from 2 stations and a total of 6 flare stacks. | Facilities in the U.S. that exceed 25,000 mt CO2e reporting threshold. | For this memo, EPA calculated facility-level average EFs using combined RY2015 and RY2016 data.<br><br>Facilities began reporting flare emissions under a unique flare stacks source starting in RY 2015. |
| LNG Import/Export - Blowdown Vent Stacks | Emissions calculated from the available methods: (1) use blowdown volumes, the number of blowdowns, and the ideal gas law modified with a compressibility factor, or (2) used a flowmeter to directly measure emissions for each equipment type or all equipment associated with a blowdown event. | LNG Import/Export: Emissions data (for 2016) are available from 5 stations and a total of 5 blowdown vent stacks. | Facilities in the U.S. that exceed 25,000 mt CO2e reporting threshold. | For this memo, EPA calculated facility-level average EFs using combined RY2015 and RY2016 data. |
| LNG Storage & LNG Import/Export – Equipment Leaks | Emissions calculated using:<br>• Population counts and EF approach, estimate time emission source was operational, and<br>• Leak surveys (>1 per year) to identify leaking components, estimate time assumed to be leaking, and use component type EFs in the rule. | LNG Storage: Emissions data (for 2016) are available from 5 stations and a total of 5 leak surveys and population counts.<br><br>LNG Import/Export: Emissions data (for 2016) are available from 5 stations and a total of 5 leak surveys and population counts. | Facilities in the U.S. that exceed 25,000 mt CO2e reporting threshold. | For this memo, EPA calculated facility-level average EFs using combined RY2015 and RY2016 data. |
| LNG Storage & LNG Import/Export – Centrifugal Compressors | Direct measurement of emissions from:<br>• Wet seals, blowdown vents, and isolation valves; or<br>• Manifolded groups of compressor sources. | LNG Storage: Emissions data (for 2016) are available from 1 station and a total of 1 centrifugal compressor.<br><br>LNG Import/Export: Emissions data (for 2016) are available from 2 stations and a total of 9 centrifugal compressors. | Facilities in the U.S. that exceed 25,000 mt CO2e reporting threshold. | For this memo, EPA calculated facility-level average EFs using combined RY2015 and RY2016 data. |
| LNG Storage & LNG Import/Export – Reciprocating Compressors | Direct measurement of emissions from:<br>• Blowdown valves, rod packing, and isolation valves; or<br>• Manifolded groups of compressor sources. | LNG Storage: Emissions data (for 2016) are available from 2 stations and a total of 6 reciprocating compressors.<br><br>LNG Import/Export: Emissions data (for 2016) are available from 4 stations and a total of 16 reciprocating compressors. | Facilities in the U.S. that exceed 25,000 mt CO2e reporting threshold. | For this memo, EPA calculated facility-level average EFs using combined RY2015 and RY2016 data. |

# Appendix B – LNG Storage and Import/Export Terminals Activity Data

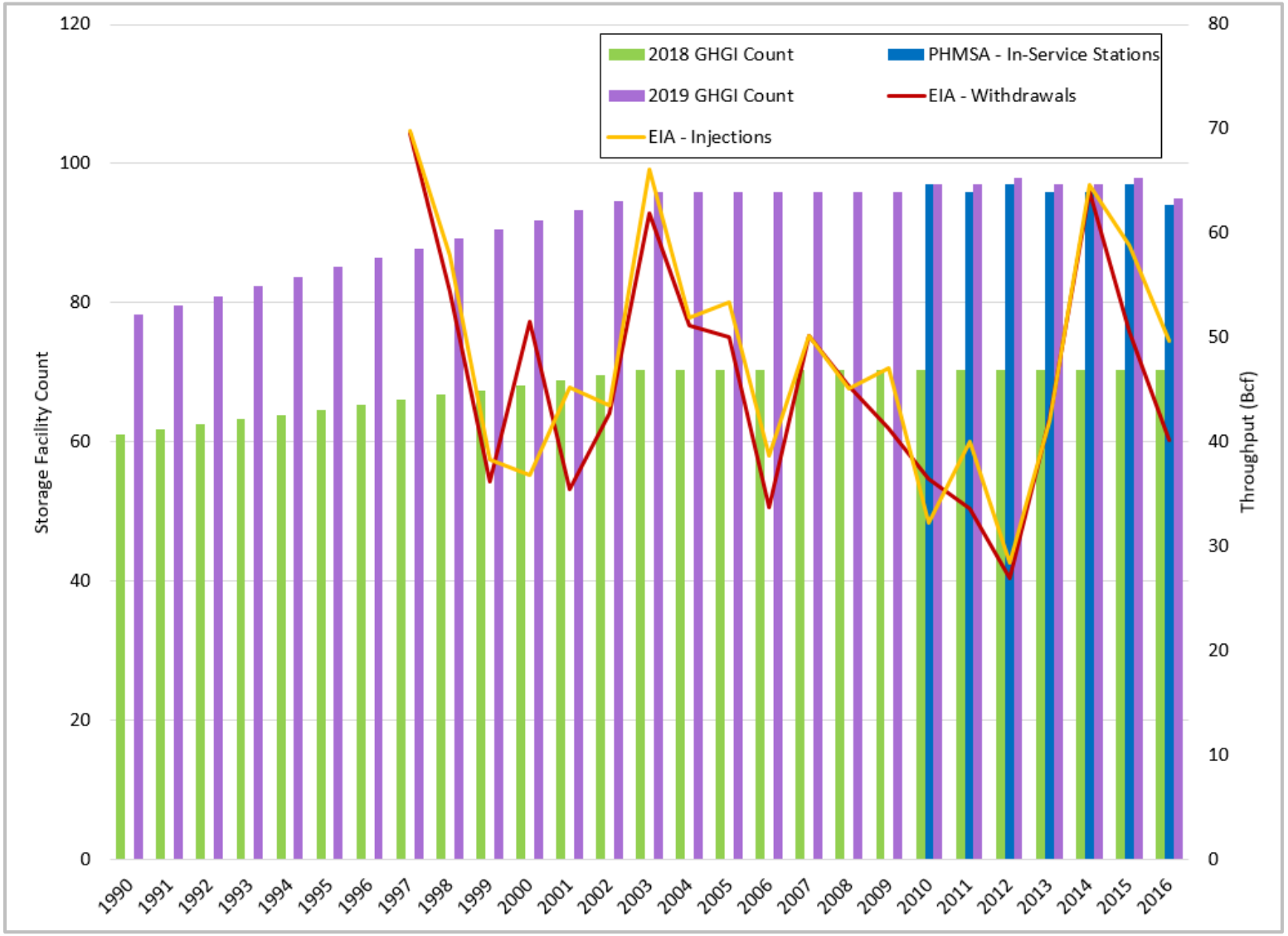


**Figure 1. LNG Storage Facility Counts and Throughput Volumes from Various Data Sources**

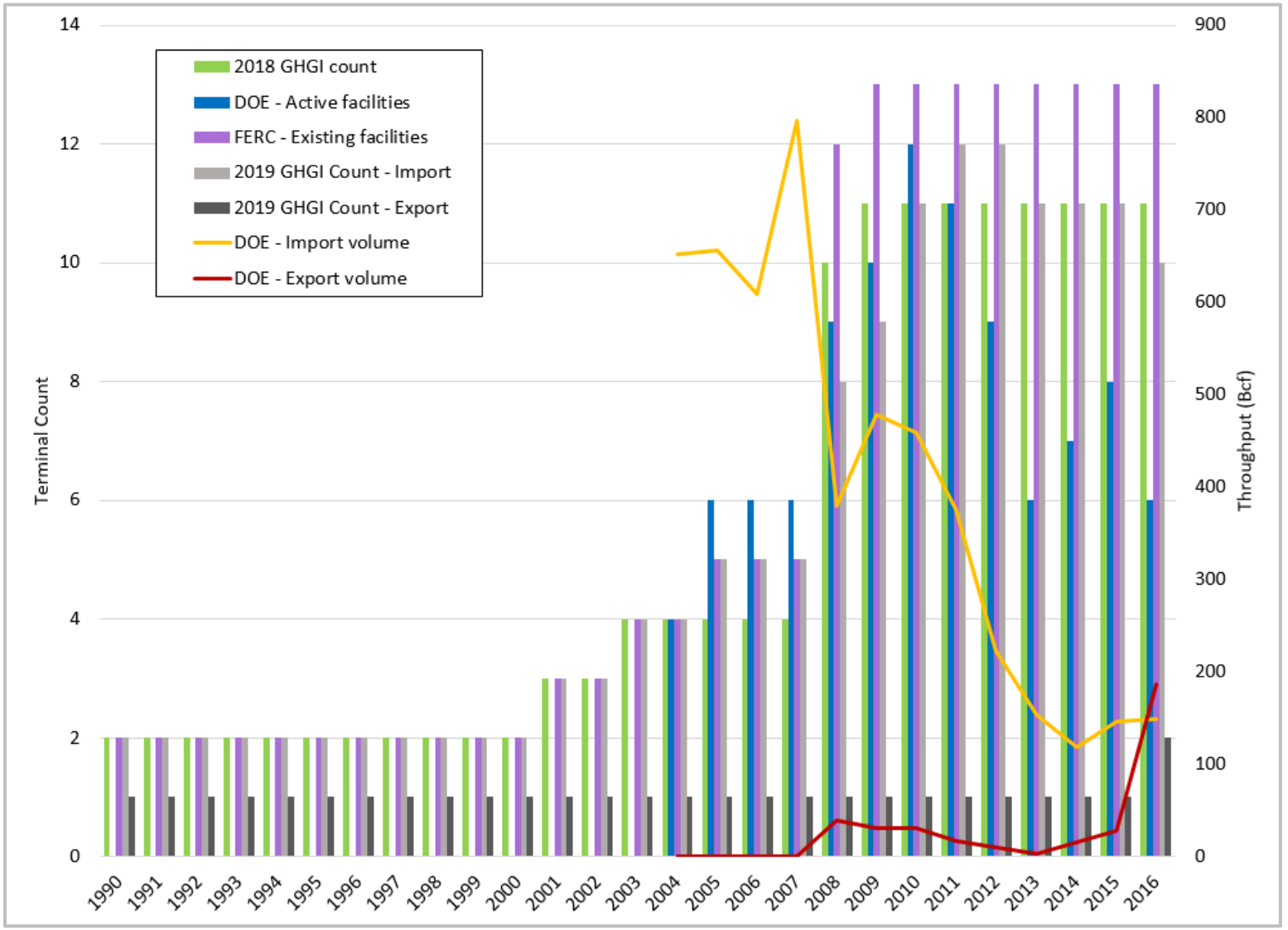


**Figure 2. LNG Import/Export Terminal Counts and Throughput Volumes from Various Data Sources**