Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2017: Updates Under Consideration for Liquefied Natural Gas Segment Emissions

In supporting documentation associated with the development of EPA's 2018 Inventory of U.S. Greenhouse Gas Emissions and Sinks (GHGI), EPA stated plans to consider reported data from EPA's Greenhouse Gas Reporting Program (GHGRP) that is not used in current GHGI methodologies for incorporation into the 2019 GHGI. In the June 2018 memo *Inventory of U.S. GHG Emissions and Sinks 1990-2017: Updates Under Consideration for Incorporating GHGRP Data* (June 2018 Preliminary Updates memo),[1] EPA described general plans to update emission estimates for LNG storage facilities and LNG terminals. This memo presents additional analyses of GHGRP data in Section 2 and presents updates under consideration for LNG storage and LNG import/export terminals in Section 3. Below, EPA summarizes the current GHGI methodology, available data (including subpart W data), and considerations for estimating national emissions that might be used to improve the current LNG segment estimates.

EPA received stakeholder feedback on the options discussed in the June 2018 Preliminary Updates memo and summarized the feedback in Section 4. EPA continues to seek stakeholder feedback on whether and how to incorporate data from the GHGRP, account for the different facility types, and apply EFs across the time series; refer to Section 4 for specific questions.

1 Current GHGI Methodology

The current GHGI estimates emissions from LNG storage stations and LNG import terminals in the transmission and storage segment of natural gas systems.

Each LNG facility type estimate includes estimates for station fugitives, reciprocating and centrifugal compressor vented and leak emissions, compressor exhaust, and station venting (i.e., blowdowns). The GHGI uses the same source-specific CH_4 EFs for both LNG storage stations and LNG import terminals. The CH_4 EFs are 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 current GHGI uses an assumed ratio of CO_2-to-CH_4 gas content to calculate CO_2 EFs from the CH_4 EFs. For compressor engine exhaust CH_4, the current GHGI uses 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 GHGI considers complete storage stations and satellite facilities, the latter of which do not perform liquefaction. The GHGI assumes that satellite facilities have approximately one-third of the equipment found at complete storage stations, and thus only includes one-third of the satellite facility count in the emissions calculations. Complete storage station and satellite facility counts are available for 1993 and 2003.[2] Storage station counts for years before 2003 are calculated by applying linear interpolation between the 1993 and 2003 values. Storage station counts for years after 2003 are set equal to the 2003 counts. The count of reciprocating and centrifugal compressors are estimated by applying a certain ratio of compressors per plant. Compressor exhaust activity data are estimated by applying assumptions regarding the number, type, and size of compressors at various facility types (including subcategory types of storage stations and terminals).

[1] https://www.epa.gov/sites/production/files/2018-06/documents/2019-ghgi-updates-incorporating-ghgrp-data_2018-06-08.pdf
[2] Energy Information Administration, Department of Energy. "US LNG Markets and Uses." 2004.

For LNG terminals activity data, the GHGI determines 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 are considered for the GHGI, since export terminals have only recently been constructed in the U.S. The GHGI assumes that import terminals have approximately two-thirds of the equipment found at complete facilities (as they do not perform liquefaction). Compressor counts and exhaust activity data are 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 subpart W emission calculation methodologies for each emission source are documented in Appendix A.

Comparison to Current GHGI

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

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

Emission Source	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.

[3] FERC. "North American LNG Import/Export Terminals – Existing." Available at http://www.ferc.gov/industries/gas/indus-act/lng/lng-existing.pdf.

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 are not currently estimated in the 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 2016. 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 Emissions, by Facility and Equipment Type

Facility or Equipment	Facility Type[a]	CO_2 (mt)						CH_4 (mt)					
		2011	2012	2013	2014	2015	2016	2011	2012	2013	2014	2015	2016
Facility-Level Data													
Burlington Generating Station	Sat	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]
MidAmerican, Bettendorf LNG	Sat	1	8	71	29	0	1	16	3	25	10	9	23
Williams	PS	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	41	1	0[b]	0[b]	0[b]	1
Macon LNG	PS	-[c]	-[c]	-[c]	-[c]	0[b]	0[b]	-[c]	-[c]	-[c]	-[c]	3	1
Cherokee LNG	PS	-[c]	-[c]	-[c]	-[c]	0[b]	0[b]	-[c]	-[c]	-[c]	-[c]	3	1
Wrenshall LNG	PS	0[b]	0[b]	0[b]	0[b]	27	-[d]	3	3	5	4	33	-[d]
Ecoelectrica LP	MT	0[b]	0[b]	13	45	233	2,507	0[b]	2	1	2	22	126
Cove Point LNG[e]	MT	0[b]	-[c]	-[c]	-[c]	-[c]	-[c]	7	-[c]	-[c]	-[c]	-[c]	-[c]
Equipment-Level Data[f]													
Equipment Leaks	-	0	0	13	45	1	0	11	6	6	6	59	112
Flare Stacks	-	-	-	-	-	259	2,507	-	-	-	-	2	18
Reciprocating Compressors	-	1	8	71	29	0.2	1	55	4	25	11	8	23
Total	**-**	**1**	**8**	**84**	**74**	**260**	**2,507**	**67**	**10**	**31**	**17**	**70**	**152**
Facility Average[g]	**-**	**213**						**17**					

"-" 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.
g - Facility average considers facilities reporting emissions (including zero) for years 2015 and 2016 only, to consistently reflect the inclusion of flare emissions.

It should be noted that the 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 and RY2016 have

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

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 the purposes of further analysis and discussions of updates under consideration in this memo, EPA calculated facility-level average EFs using combined RY2015 and RY2016 data for all LNG storage reporters to GHGRP, including those reporting zero emissions in subpart W. As discussed in Section 3, source-level EFs would be considered for the 2019 GHGI; facility-level EFs are used to generally show the impacts of using subpart W data for EF development on calculated national emissions.

To consider an alternative to the current 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 3 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 is considering maintaining the current GHGI approach of a facility-based EF rather than a throughput-based EF.

Table 3. 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 4 and Table 5 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 4 includes reported subpart W emissions for 2011 through

[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.

2016. 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. For the purposes of further analysis and discussions of updates under consideration in this memo, and consistent with the approach for LNG storage, EPA calculated facility-level average EFs using combined RY2015 and RY2016 data.

Table 4. Reported Subpart W LNG Terminal Emissions, by Facility and Equipment Type

Facility Details		CO_2 (mt)						CH_4 (mt)					
GHGRP Facility	**Type[a]**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Facility-Level Data													
ConocoPhillips ANGC – LNG	Ex	53	58	45	31	23	0	1,826	1,990	1,572	1,067	801	2
Distrigas Of Mass. LLC	Im	0	0	0	0	0	0	23	18	20	13	13	23
Freeport LNG Terminal	Im	0	0	0	0	21	806	359	363	946	1,023	240	17,684
Trunkline LNG Co LLC	Im	0	0	1	0	-[c]	-[c]	71	3	36	-[c]	-[c]	-[c]
Golden Pass LNG, LLC	Im	28	0	0	0	0	-[c]	1,634	1,551	7	2	1	-[c]
SLNG Elba Island	Im	2	1	0	0	0	-[c]	98	31	65	49	67	-[c]
Magnolia LNG, LLC	Im	-[c]	-[c]	-[c]	-[c]	-[c]	0	-[c]	-[c]	-[c]	-[c]	-[c]	0
Gulf LNG Energy	Im	-[c]	-[c]	-[c]	-[c]	-[c]	-[c]	-[c]	-[c]	-[c]	-[c]	-[c]	-[c]
NorthEast Gateway	Im	-[c]	-[c]	-[c]	-[c]	-[c]	-[c]	-[c]	-[c]	-[c]	-[c]	-[c]	-[c]
Neptune LNG	Im	-[c]	-[c]	-[c]	-[c]	-[c]	-[c]	-[c]	-[c]	-[c]	-[c]	-[c]	-[c]
Cameron LNG	Im	-[c]	-[c]	-[c]	-[c]	-[c]	-[c]	-[c]	-[c]	-[c]	-[c]	-[c]	-[c]
Ecoelectrica LP	Im	-[d]	-[d]	-[d]	-[d]	-[d]	-[d]	-[d]	-[d]	-[d]	-[d]	-[d]	-[d]
Sabine Pass LN	I+E	3	3	2	1	77,410	97,936	151	173	101	5,634	290	401
Cove Point LNG[b]	I+E	4	3	2	7	1	10	145	12	74	217	40	363
Equipment-Level Data													
Blowdowns	-	29	2	1	5	1	811	1,804	1,629	59	5,799	53	18,045
Centrifugal Compressors	-	47	51	40	24	0	0	1,637	1,763	1,372	838	570	1
Equipment Leaks	-	0	0	0	0	0	0	389	392	392	388	27	40
Flares	-	0	0	0	0	77,420	97,940	0	0	0	0	268	339
Reciprocating Compressors	-	12	11	9	9	17	1	478	356	997	980	534	48
Total	-	**89**	**64**	**50**	**38**	**77,439**	**98,753**	**4,308**	**4,140**	**2,821**	**8,006**	**1,451**	**18,472**
Facility Average[e]	**-**	**13,554**						**1,808**					

"-" 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 3 because this facility reports to GHGRP as a storage facility.

e - Facility average considers facilities reporting emissions (including zero) for years 2015 and 2016 only, to consistently reflect the inclusion of flare emissions.

Table 5 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 is considering maintaining the current GHGI approach of a facility-based EF rather than a throughput-based EF.

Table 5. 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.

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 current 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. However, throughput data are still provided here for context.

LNG Storage

For storage facilities, two sources of activity data are available to cover portions of the GHGI time series (whereas the current GHGI uses surrogate activity data approaches for many years, as described in Section 1). 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 current GHGI methodology estimates emissions separately from satellite and complete storage stations using assumptions about equipment located at each type of facility. Table 6 below shows that the majority of storage facilities are peak shaving. As described in Section 2, recent GHGRP reporters include two satellite and five peak shaving facilities. In Section 4, EPA seeks stakeholder feedback on how PHMSA facility counts such as those shown in Table 6 might be used to develop national level activity data for pairing with GHGRP-based EFs in the 2019 GHGI.

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

Table 6. 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; facility counts are not reported in this source. Appendix B shows available data from both PHMSA and EIA over the GHGI time series. EPA is considering supplementing the current GHGI activity (which relies on point estimates specific to years 1993 and 2003) with PHMSA facility counts to increase accuracy of recent year estimates. For this approach, EPA could apply linear interpolation from the current year 2003 counts to the year 2010 PHMSA counts and use PHMSA data going forward.

LNG Terminals

The current 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 is considering 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.

3 Preliminary National Total Emissions Estimates

Based on the data sources and considerations discussed in Section 2, EPA developed the preliminary national emissions estimates presented below. These estimates generally include vented and fugitive emissions from compressors and other equipment, as well as emissions from flaring; these estimates do not include estimates for blowdown emissions from storage (not reported to GHGRP) or compressor exhaust emissions (EPA seeks stakeholder feedback particular to this source where the current GHGI EFs might be retained for consistency with other segments—see below). EPA divided total reported subpart W emissions by the reported facility total to develop EFs for each facility type (storage stations and terminals); see Table 2 and Table 4. In the 2019 GHGI, EPA could present these estimates at a more detailed source-level (e.g., emissions from reciprocating compressors per facility) developed with the same general calculation approach. The facility-level EFs were used to calculate national emissions for Table 7 in order to generally show the impacts of using subpart W data for EF development on national emissions compared to the current GHGI approach.

For national activity data to pair with such EFs, EPA is considering using storage facility counts from PHMSA and total terminal counts from FERC. Using total terminal counts (active plus inactive) is consistent with the current GHGI methodology, and with the observation that at least one facility reports emissions but zero throughput to GHGRP (refer to the Freeport LNG Terminal in Table 5).

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

Table 7 presents the resulting preliminary national emissions estimates.

Table 7. Comparison of National Emissions Estimates (Excluding Compressor Exhaust) for Year 2016

Segment/Approach	Facility Count	EF (mt/Facility)		National Emissions (mt)	
		CO_2	CH_4	CO_2	CH_4
Storage Stations					
2018 GHGI	70	34.4[a]	1,006[a]	2,409	70,434
Update Under Consideration	95[b]	213[c]	17[c]	20,224	1,621
Terminals					
2018 GHGI	8	37.5[a]	1,098[a]	300	8,781
Update Under Consideration	12[b]	13,554	1,533	162,653	18,391

a - EF is calculated from GHGI total emissions divided by facility count; in the GHGI, total emissions are not calculating using a facility-level EF, but activity-specific EFs.
b - As noted in Section 2.1 above, one facility (EcoElectrica) reports to GHGRP as a storage station but is generally considered by national activity data sources to be an import terminal. Therefore, for the GHGI, EPA is considering using GHGRP data as-reported (i.e., treating this facility as a storage station) but adjusting the national activity data estimates to subtract one facility from the national total terminal counts and add one facility to the national total storage station counts. The national total adjusted counts are shown here.
c - EFs do not reflect emissions from blowdowns, as subpart W does not require reporting for this source in the LNG storage segment. EPA seeks stakeholder feedback on how to estimate emissions from this source.

Compressor Exhaust Emissions

For compressor exhaust, EPA seeks stakeholder feedback in Section 4 on an appropriate approach for estimating emissions across the time series. 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 EFs. Table 8 below summarizes the current GHGI basis for compressor exhaust emissions in year 2016 and compares activity (MMHp-hr/station) to reported GHGRP data. This table also shows CH_4 emission estimates that would be calculated using GHGRP activity data paired with current GHGI EFs.

Table 8. Compressor Exhaust Estimates from the 2018 GHGI and GHGRP Subpart W Reported Data, Year 2016

LNG Segment	Emission Factor: mt CH_4/MMHp-hr from GHGI	Activity Factor: MMHp-hr/station		National CH_4 Emissions (mt)	
		GHGI	GHGRP	GHGI	GHGRP AF + GHGI EF
Storage Stations	-	**9.9**	**3.5**	**2,690**	**509**
Engines	4.6	8.2	1.1	2,678	483
Turbines	0.1	1.6	2.5	12	26
Terminals	-	**66.5**	**28.3**	**1,961**	**1,451**
Engines	4.6	54.8	26.1	1,951	1,448
Turbines	0.1	11.7	2.2	10	3

LNG Storage Facility Blowdown Emissions

Subpart W does not collect blowdown data from LNG storage facilities and EPA is considering options to include LNG storage facility blowdown emissions in the GHGI. The EPA could apply the current GHGI EFs (84 mt CH_4/facility and 2.9 mt CO_2/facility, based on transmission and storage station data) or use the subpart W LNG terminal blowdown data (1,392 mt CH_4/facility and 62 mt CO_2/facility for combined 2015 and 2016 data, for

example) for this source. If blowdowns were included using current GHGI EFs, the resulting blowdown emissions would equal 8,005 mt CH_4 and 274 mt CO_2. If blowdowns were included using the subpart W LNG terminal blowdown data, the resulting blowdown emissions would be 132,254 mt CH_4 and 5,934 mt CO_2. If subpart W LNG terminal blowdown emissions were used, EPA would also further consider what years of data are most appropriate to calculate EFs; one facility reports high blowdown emissions in 2016, so including additional years may result in a more reasonable EF.

Time Series Considerations

To develop estimates over the GHGI time series by an updated approach that incorporates the GHGRP data available in recent years, 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. Or, since the current 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 might also apply subpart W EFs to all time series.

4 Requests for Stakeholder Feedback

EPA seeks stakeholder feedback on the approaches under consideration discussed in this memo and the specific questions below. In the June 2018 Preliminary Updates memo, EPA also sought stakeholder feedback. Feedback is summarized here:

- A stakeholder supports 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.
- The stakeholder also recommends 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 5).

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 above 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[8]. 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).

[8] 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. 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. 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: • Population counts and EF approach, estimate time emission source was operational, and • 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. 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: • Wet seals, blowdown vents, and isolation valves; or • Manifolded groups of compressor sources.	LNG Storage: Emissions data (for 2016) are available from 1 station and a total of 1 centrifugal compressor. 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: • Blowdown valves, rod packing, and isolation valves; or • Manifolded groups of compressor sources.	LNG Storage: Emissions data (for 2016) are available from 2 stations and a total of 6 reciprocating compressors. 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 Facility and Terminals Activity Data

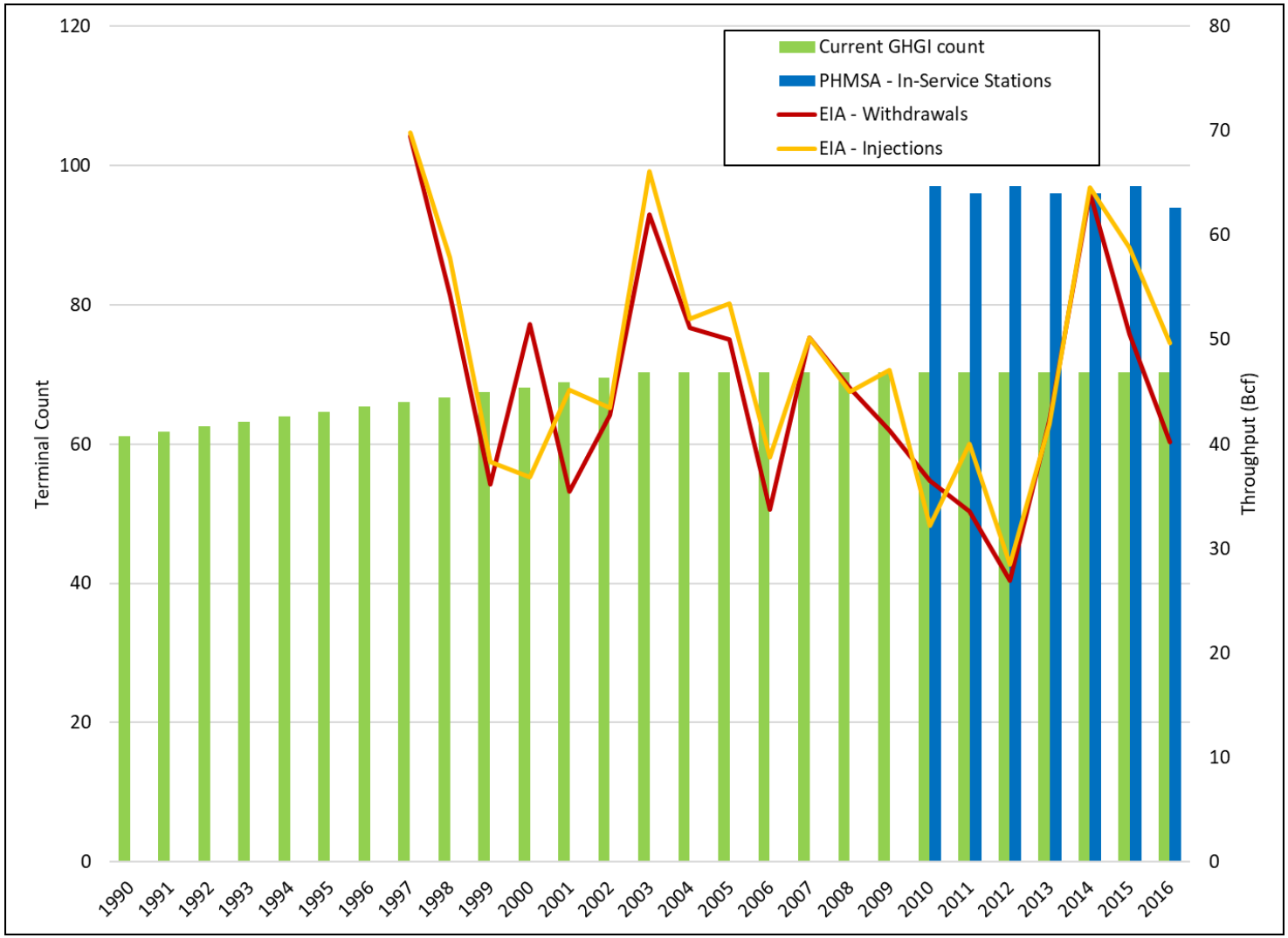

Figure 1. LNG Storage Facility Counts and Throughput Volumes from Various Data Sources

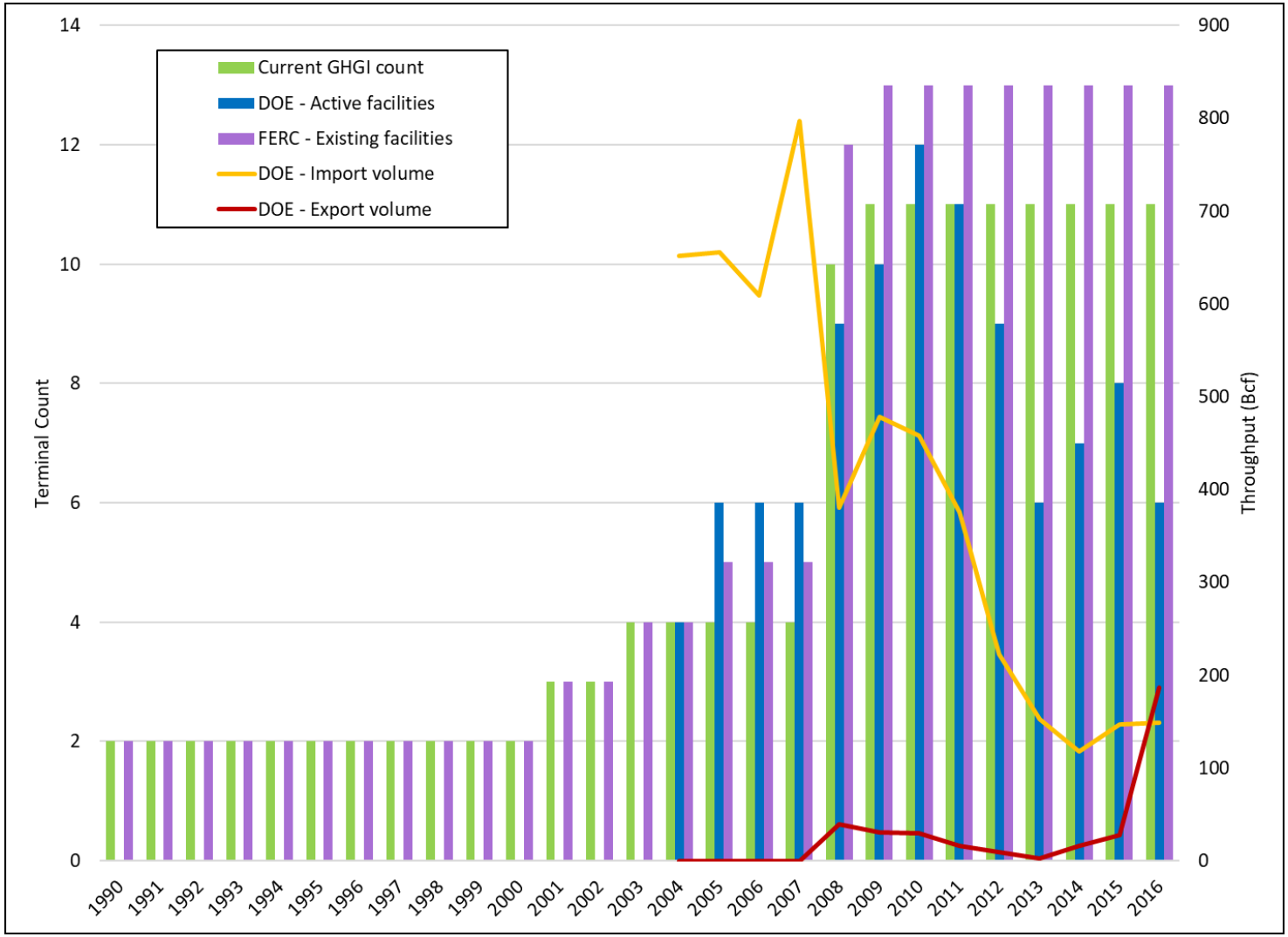

Figure 2. LNG Terminal Counts and Throughput Volumes from Various Data Source