Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2018: Updates Under Consideration for Offshore Production Emissions

1 Background

As an outcome to finalizing EPA's 2018 *Inventory of U.S. Greenhouse Gas Emissions and Sinks* (GHGI), EPA released a memo to document updates still under consideration for improving estimates, including for sources within the offshore production segment: *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2016: Additional Revisions Considered for 2018 and Future GHGIs* (April 2018)[1] ("Additional Revisions memo"). This memo builds upon those analyses and presents considerations for updating offshore production emissions estimates in natural gas systems and petroleum systems. All figures within this memo (i.e., Figure 1 through Figure 19) are shown in Appendix A.

1.1 Industry Overview

Offshore oil and gas production facilities can include production structures and supporting structures. A production structure can contain emission sources such as gas-oil separation, well unloading, fugitive leaks, gas dehydration, acid gas removal, liquid hydrocarbon storage, and gas compression. A portion of these production structures have associated support structures such as caissons, wellhead protectors, and living quarters. The production structure and any associated support structures form what is referred to as a *complex* for the purposes of this memo. Certain data sources use the term "platform"—typically interchangeably with "structure." For clarity, this memo uses a terminology convention of "structure" and "complex" when discussing offshore production facilities.

Offshore production complexes operate in waters that are under federal government jurisdiction (federal waters) or state government jurisdiction (state waters). Federal waters are referred to as the Outer Continental Shelf (OCS), and include producing regions in the Gulf of Mexico (GOM), the Pacific Ocean (off the continental U.S. western coast), and surrounding Alaska (including the Beaufort and Chukchi Seas, the Bering Sea, Cook Inlet and the Gulf of Alaska)[2]. To this point, there has not been production in the OCS surrounding Alaska.[3] State waters consist of the 3 nautical mile area that extends off state coasts, but some areas (including Texas, Puerto Rico, and the west coast of Florida) control the waters for as much as 9 or 12 nautical miles off their coasts. Offshore facilities in state waters are located in the same three geographic areas as federal waters facilities; in the GOM and off the coasts of California and Alaska.

An overview of offshore oil and gas production in federal and state waters is provided in Figure 1 for year 2014 (the most recent year with detailed emissions data available from data sources reviewed). The data sources for Figure 1 include the Department of Interior (DOI)/Bureau of Ocean Energy Management (BOEM)[4] for federal waters production, and state agencies for state waters production (see Section 3.6 for the data source specific to each state waters region). Offshore facilities in GOM federal waters produce the vast majority of both offshore oil and gas.

2 Overview of Current GHGI Methodology

EPA most recently updated the GHGI methodology for offshore production emissions in the 2015 GHGI, using emission factors (EFs) developed from year 2011 BOEM data across the entire time series. The following sections

[1] https://www.epa.gov/ghgemissions/natural-gas-and-petroleum-systems-ghg-inventory-additional-information-1990-2016-ghg
[2] https://www.boem.gov/Alaska-Region/
[3] https://www.doi.gov/pressreleases/interior-approves-long-awaited-first-oil-production-facility-federal-waters-offshore
[4] https://www.data.boem.gov/Production/OCSProduction/Default.aspx

summarize the data sources and methodology for the current GHGI approach to estimating vented and leak emissions (Section 2.1) and flaring emissions (Section 2.2).

2.1 Vented and Leak Emissions

To calculate vented and leak emissions from offshore production facilities in the 2015 and later GHGIs, EPA used EFs developed from BOEM's 2011 Gulfwide Emission Inventory (GEI), which relied on activity data from the 2011 Gulfwide Offshore Activity Data System (GOADS). Refer to Section 3.1 for more information on this data source. EPA developed EFs for four offshore production facility categories: deepwater gas, deepwater oil, shallow water gas, and shallow water oil. EPA calculated EFs on both a complex basis and a structure basis to compare and consider the appropriateness of each. The methodology to calculate the EFs is documented in the memo *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2013: Revision to Offshore Platform Emissions Estimate (2015 Offshore Updates memo).*[5]

Because the existing activity data in the GHGI were based on a count of structures, the 2015 GHGI used structure-based EFs. Table 1 presents the EFs in metric tons per year (mt/yr) for methane (CH_4) and carbon dioxide (CO_2) developed from the 2011 BOEM GEI. The complex-based EFs (considered but not used) are presented in the second column, and the structure-based EFs (used in the current GHGI) are presented in the third column.

As seen in Table 1, when gas facilities are defined as producing more than 100 thousand cubic feet of gas per barrel of hydrocarbon liquid (mcf/bbl), there are no deepwater gas facilities in the 2011 BOEM GEI dataset, resulting in no EF for this facility group. EPA assigned the deepwater oil facility EF to deepwater gas facilities as a surrogate. Note, the calculated CO_2 EFs exclude flaring emissions (which are calculated as explained in Section 2.2), but the CH_4 EFs include CH_4 emissions from flaring as well as combustion engine exhaust.

Table 1. Methodology for 2015 GHGI—EFs Based on 2011 BOEM GEI

Pollutant/Facility Category	Complex EF[a] (mt/yr)	Structure EF (mt/yr)
CH_4		
Deep Gas	– [b]	– [b]
Deep Oil	656	656
Shallow Gas	71	62
Shallow Oil	137	116
CO_2 [c]		
Deep Gas	– [b]	– [b]
Deep Oil	7.7	7.7
Shallow Gas	1.3	1.2
Shallow Oil	2.3	1.9

a – EFs considered for updates to the 2015 GHGI, but not ultimately used.
b – No available data to calculate. EPA assigned the deepwater oil facility EF to deepwater gas facilities as a surrogate.
c – CO_2 EFs exclude flaring emissions.

The activity data paired with the structure-based EFs is the number of offshore structures in federal waters of the GOM that are existing in each year of the time series, in each category (deepwater gas, deepwater oil, shallow water gas, and shallow water oil), based on a nationwide Department of Interior (DOI)/Mineral Management Service (MMS) facility census. The MMS facility census has not been updated since 2010 (when the agency was reorganized), so the current GHGI uses year 2010 activity as surrogate for all later time series years. Additionally,

[5] https://www.epa.gov/sites/production/files/2015-12/documents/revision-offshoreplatforms-emissions-estimate-4-10-2015.pdf

the MMS data source did not differentiate between active and inactive structures, so all structures in the dataset were considered active. The current GHGI methodology also does not account for emissions from offshore structures that are located in state waters or in federal Pacific waters.

2.2 Flaring Emissions

In the current GHGI, EPA calculates CO_2 emissions from all offshore flaring activities as a single line item appearing within the natural gas systems segment. As stated in Section 2.1, the minimal CH_4 emissions from flaring are currently included in the CH_4 EFs calculated from the 2011 BOEM GEI data, shown in Table 1. The basis for the CO_2 estimate is the total volume of gas vented and flared at offshore facilities in federal waters of the GOM and the estimated percentage of this gas that is flared. These data were provided by DOI/MMS staff, based on annual data collected in their Oil and Gas Operations Reports (OGOR) covering 1990 through 2008. Since 2009, this data had not been available, so the current GHGI uses year 2008 values for all later time series years. Information that would allow separation of these data into flaring from oil versus gas facilities was not available from MMS, leading to the current GHGI approach of reporting all offshore CO_2 flaring emissions under natural gas systems. Similar to the vented and leak emissions methodology, the current GHGI flaring emissions methodology does not account for flaring at offshore facilities that are located in state waters or in federal Pacific waters. Note, while flaring emissions are calculated for the BOEM GEI, the current GHGI approach relies on the volume of flared gas because it is more readily available across the time series, compared to BOEM GEI data which are only available for certain years.

The current GHGI offshore flaring CO_2 EF, applied to the quantity of gas flared, is from the Energy Information Administration (EIA), and relies on the carbon content of natural gas. EIA provides a value of 54.7 kilograms of CO_2 per million BTU (kg/mmBTU) of flared natural gas.[6] The current GHGI methodology uses this EF for all time series years, with year-specific natural gas heat content (Btu/scf) from EIA's *Monthly Energy Review* publication.[7] Note, the flaring CO_2 EF from EIA (54.7 kg/mmBTU, equivalent to 120.6 lb/mmBTU) is similar to the EF of 114.285 lb/mmBTU that BOEM uses to calculate flaring CO_2 emissions for the GEI.

3 Available Data

To calculate offshore production emissions in the upcoming GHGI, EPA is considering several data sources that provide emissions and/or activity data. The data sources currently under consideration include the BOEM GEI, BOEM OGOR data, BOEM Platform Database, and the Greenhouse Gas Reporting Program (GHGRP). Table 2 provides a general review of the information available from each source, and Sections 3.1 through 3.5 discuss each source in detail. Section 3.6 discusses other data sources that were evaluated, which are available from: the Oil and Gas Board of Alabama, the Louisiana Department of Wildlife and Fisheries, the Louisiana Department of Natural Resources, the Texas General Lands Office, the Texas Railroad Commission, the California State Lands Commission, the California Department of Conservation, and the Alaska Oil and Gas Conservation Commission. In Section 5, EPA seeks stakeholder feedback on the appropriateness of and approaches for using these data sources, and information on other data sources that should be considered for GHGI updates.

[6] https://www.eia.gov/environment/emissions/co2_vol_mass.php
[7] See Table A4, Approximate Heat Content of Natural gas (Btu per cubic foot), available at https://www.eia.gov/totalenergy/data/monthly/pdf/sec13_5.pdf

Table 2. Data Sources with Emissions and/or Activity Data for Offshore Production

Parameter	Data Source				
	BOEM GEI	**BOEM OGOR-A**	**BOEM OGOR-B**	**BOEM Platform Database**	**EPA GHGRP**
Summary	Triennial Gulfwide emissions inventory	Offshore oil and gas production data	Offshore vented and flared gas volumes	Offshore structures, dates, depths, etc.	Annual emissions data from facilities required to report
Geographic coverage	Gulf only	Gulf and Pacific	Gulf only	Gulf and Pacific	All that meet or exceed threshold
Federal vs. state waters	Federal only	Federal only	Federal only	Federal only	All that meet or exceed threshold
Estimation frequency	Triennial (2000, 2005, 2008, 2011, 2014)	Monthly	Monthly	Monthly	Annual (2011 – 2017)
Pollutants	Criteria, criteria precursors, GHG	n/a – activity (not emissions)	n/a – flared volumes data (not emissions)	n/a – activity (not emissions)	GHG
Emission sources	All	n/a – activity (not emissions)	Flares and vents	n/a – activity (not emissions)	Subpart W: Vented, leak, flares Subpart C: Combustion
Facility definition	Structures and complexes	Lease, Area/Block	Lease	Structures and complexes	Complexes
Reporting requirement	All active and inactive facilities, but some facilities fail to report for various reasons	All facilities	All facilities	All facilities	Only facilities with ≥ 25,000 mt CO2e emissions

3.1 BOEM Gulfwide Emissions Inventory (GEI)

This section summarizes the scope and available data from the BOEM GEI publications and provides considerations for using the data in updating the methodology for the 2020 GHGI.

3.1.1 Scope and Available Data

The BOEM GEI estimates criteria pollutant and GHG emissions from offshore oil and gas production sources in GOM federal waters. The BOEM GEI does not account for emissions from sources in GOM state waters or off the coasts of California and Alaska. All offshore facilities in GOM federal waters that are west of 87.5 degrees longitude are required to report data to BOEM[8], in order to comply with 30 CFR 550.304, and BOEM issues a Notice to Lessees and Operators (NTL) which provides instructions for each GEI.[9] BOEM collects monthly activity data from OCS operators in the GOM via the Gulfwide Offshore Activities Data System (GOADS), then BOEM calculates emission source-specific emissions. GEI studies are available for calendar years 2000, 2005, 2008, 2011, and 2014.[10] Each GEI provides emissions and activity data for active offshore structures, and counts of inactive structures. GHG emissions are estimated for the following emission sources on an active offshore structure: amine units; boilers, heaters, and burners; combustion flares; drilling equipment (for drilling rigs attached to an offshore structure); engines; fugitive sources (valves, flanges, connectors); glycol dehydrators; losses from flashing; mud degassing; turbines; pneumatic pumps; pressure and level controllers; storage tanks; and cold vents. Each

[8] All existing offshore production facilities in the GOM are located west of 87.5 degrees longitude.
[9] The 2014 GEI NTL is available at https://www.boem.gov/BOEM-NTL-No-2014-G01/. Note, this NTL has been superseded by the current NTL for the 2017 GEI, which is available at https://www.boem.gov/BOEM-NTL-2016-N03/.
[10] Each GEI study is available online: https://www.boem.gov/Gulfwide-Offshore-Activity-Data-System-GOADS/

emission source uses a documented methodology to calculate emissions, and most rely on equations or EFs that relate throughput (or other activity data) to emissions. Sources for methods and EFs include, among others, API 1996 for fugitive EFs, EIIP 1999 for equations for pneumatic pumps and controllers, and AP-42 for EFs for engines.[11] BOEM also recognizes a non-reporter population (i.e., active structures that are expected to report but do not), and these non-reporters were evaluated in the 2014 GEI study. Table 3 provides a summary of the BOEM GEI activity and emissions data. EPA grouped the BOEM GEI emissions into categories of vent and leak (including engine exhaust CH_4) emissions and flaring emissions.

Table 3. BOEM GEI Reporting Overview

Data	2000	2005	2008	2011	2014
# Active & Inactive Structures	3,154	1,619	3,304	3,051	1,856
# Active Structures	2,873	1,585	3,026	2,544	1,651
# Non-Reporting Structures (estimate[a])	NE	NE	583	538	250
# Active Complexes	2,529	1,407	2,614	2,205	1,397
Flared Volume (MMcf)	2,498	5,104	6,985	10,074	5,123
Vent and Leak Emissions					
CH_4 (mt)	510,014	194,294	383,073	245,838	204,420
CO_2 (mt)	8,511	2,160	4,282	4,009	3,394
Flare Emissions					
CH_4 (mt)	144	296	401	332	301
CO_2 (mt)	263[b]	9,785[b]	380,186	547,942	278,861
N_2O (mt)	<1	0.2	7	10	5

NE – Not estimated.

a – The GEI estimated 85%-90% of all active offshore structures reported in the 2008, 2011, and 2014 GEIs.

b – The 2000 and 2005 BOEM GEIs calculated flaring CO_2 emissions based on the calculation requirements applicable to the GEI in those years (i.e., only flare pilot CO_2 emissions were calculated). See the following paragraph for information regarding flare emissions in early years.

The BOEM reporting requirements have changed across the GEIs, and certain years had unique circumstances that affected reporting which EPA plans to take into account when assessing data for incorporation into GHGI updates. Important changes and circumstances include:

- Flare CO_2 emissions in early years
    - Flare CO_2 emissions were not fully accounted for in the 2000 and 2005 GEIs, and only flare pilot CO_2 emissions are included—i.e., flare CO_2 emissions in these years are inconsistent with reported flared gas volumes (which are reported via GOADS for these years), so EPA would need to apply additional calculations to use such data for GHGI EFs.
- Minor source structure emissions in early years
    - Minor source structures include caissons, wellhead protectors, living quarters, and "other" unclassified structures.
    - In years 2000 and 2005, offshore operators were not required to report any data for minor source structures to GOADS.
    - In years 2008 and 2011, offshore operators were required to identify minor source structures in GOADS, but were not required to provide detailed activity data for the emission sources on the structures. BOEM calculated emissions from minor source structures for the 2008 and 2011 GEIs by applying default EFs to each type of minor source structure.

[11] Each GEI study documents the methodologies applied to each emission source. For example, see Section 4.2 in the 2014 GEI study for the complete emission estimation procedures.

    - Beginning in the 2014 GEI, minor source structures are treated the same as all other structures. As such, operators reported all activity data for emission sources on minor source structures through GOADS and the emissions were fully accounted for in the 2014 GEI.
- 2005 GEI hurricane season impact
    - There was a significant impact on offshore production operations in year 2005 due to a particularly severe hurricane season.
    - As a result, the number of structures and complexes reported was very low, and those that did report showed particularly low activity (and corresponding calculated emissions).
    - Therefore, as discussed in Section 4.1.1, it is likely appropriate to limit application of year 2005 GEI data in the GHGI (e.g., refrain from using year 2005 data as surrogate for surrounding years).
- Year 2000, first year of reporting
    - There have been updates in GEI inventory calculation methods and operator understanding and delivery of data since the first year of reporting underlying the year 2000 GEI (refer to the 2014 GEI report, Appendix B trends analysis discussion).
    - Therefore, as discussed in Section 3.1.2, it is likely appropriate to exclude year 2000 GEI data from consideration for GHGI updates.

3.1.2 Considerations for Use in GHGI Updates

The 2011 BOEM GEI is the basis of the current GHGI EFs, but GEIs are available for years 2000, 2005, 2008, 2011, and 2014. In considering updates for the 2020 GHGI, EPA calculated EFs using each year of the BOEM GEI data to assess how trends might be reflected over the time series. Additionally, EPA seeks to address stakeholder feedback received in response to recent GHGI stakeholder memos and workshops/webinars. EPA is considering updating the EF basis in two ways: (1) switching from a structure-basis to a complex-basis; and (2) establishing EF subcategories for "major" versus "minor" complexes, instead of the current water depth subcategories. This section details these and other considerations for updating the 2020 GHGI.

3.1.2.1 Complex-Level EFs

EPA is considering calculating EFs at the complex level from GEI data to emphasize the activity data unit most related to the presence of production operations and likely correlated to emissions levels (i.e., a complex produces oil and gas with possibly significant emissions, or is alternatively a collection of likely low-emitting supporting structures). Multi-structure complexes that have a production structure and other supporting structures would be considered as a single unit. Complexes with one or more non-production structures would also be considered a single unit, likely with low emissions. This level of categorization then leads to consideration of "major" versus "minor" complexes as discussed in Section 3.1.2.2.

3.1.2.2 Major versus Minor Complexes

In response to stakeholder feedback, EPA is considering introducing new EF subcategories to differentiate major and minor complexes in order to represent differences in complexity and processing capabilities (i.e., equipment types present) which are expected to correlate with emissions. This approach would replace the current subcategorization scheme based on water depth, which more indirectly correlates with emissions (i.e., while deep water facilities tend to have higher per-facility emissions than shallow water facilities, emissions are not a direct function of water depth).

To categorize GEI complexes as major versus minor, EPA is considering crosswalking individual complexes between the GEI and another BOEM data source, the BOEM Platform Database (discussed in Section 3.2). The BOEM Platform Database designates all structures as "major" or "minor" structures.[12] A major structure is defined

[12] This is not to be confused with minor source structures in the GEI, as discussed in Section 3.1.1. It is likely that GEI minor source structures are minor structures in BOEM's platform database (defined based on structure type), but not all minor structures in the BOEM Platform Database are minor source structures in the GEI.

as containing at least six well completions or containing more than two pieces of production equipment; otherwise the structure is defined as minor. Using this designation, EPA has conducted a preliminary analysis and classified each existing complex in the BOEM Platform Database that has at least one major structure as a major complex. EPA then matched the complex IDs in the BOEM GEI with the complex IDs and their major versus minor complex classifications from the BOEM Platform Database.

3.1.2.3 Facility Production Type Assignment

In reviewing the current GHGI methodology for developing EFs from GEI data, EPA identified an opportunity to improve estimates by utilizing more of the available GEI data. The current GHGI methodology, as discussed in Section 2, relies on matching lease IDs between BOEM GEI and year 2011 OGOR-A production data (see Section 3.3 for a detailed discussion of OGOR-A data) in order to assign a production type (oil or gas) for each complex. However, not all BOEM GEI lease IDs could be matched to an OGOR lease ID, and thus certain complexes were unmatched and could not be used in the EF calculations. This population was relatively small, but a methodology that would allow EPA to use all BOEM GEI data is preferred.

In addition to lease IDs, BOEM GEI and OGOR-A also provide Area and Block IDs for each record. A Block is 3 miles by 3 miles and an Area is comprised of multiple Blocks. The relationship between leases and Area/Blocks can vary – leases can be part of a Block or can be in multiple Blocks. Determining the gas-to-oil ratio (GOR) at the Area and Area/Block-level and assigning each as oil or gas was evaluated to gap-fill those complexes which could not be assigned at the lease-level.

The current GHGI oil versus gas assignments for each complex rely on year 2011 data, because the 2011 GEI is the basis of the EFs. However, EPA evaluated data from additional GEI years and thus assigned production type for each complex based on data specific to that year, when possible. EPA used the existing GHGI convention that defines entities with a GOR greater than 100 thousand cubic feet (mcf) of gas per barrel (bbl) of hydrocarbon liquid as gas-producing, and defines entities with a GOR less than 100 mcf/bbl as oil-producing. Certain leases did not have production in a given GEI year, but did have production in surrounding years, and this information was used in the assignments.

EPA is considering a four-step process to assign production type for each complex:

- Step 1: Assign production type as oil versus gas based on year-specific lease-level production in OGOR-A (similar to current GHGI approach).
- Step 2: For those complexes not assigned in Step 1 because the lease did not have production in the specific GEI year, assign production type based on a nearest-year approach. The nearest-year approach looks to Step 1 production type assignments for a given complex in the years surrounding a particular GEI. For example, a complex in the 2008 GEI dataset that was not assigned a production type based on year 2008 data would look to assignments for that complex in the following preferential order: year 2007, 2009, 2006, 2010, etc.
- Step 3: For those complexes not assigned in Step 1 or 2, assign complex to oil versus gas based on year-specific Area/Block-level production in OGOR-A.
- Step 4: For those complexes not assigned in Steps 1 - 3, assign complex to oil versus gas based on year-specific Area-level production in OGOR-A.

Table 4 summarizes the number of complexes that were assigned as oil or gas in each step, considering all complexes in the GEIs for 2005, 2008, 2011, and 2014.[13]

[13] Table 4 does not provide unique complex counts (that information is available in Table 3). Rather, if a complex reports to each of the four GEIs, it would be counted four times in Table 4.

Table 4. Number of GEI Complexes Assigned to Oil versus Gas, by Data Processing Step

Data Processing Step	# Complexes Assigned to Oil in Step	# Complexes Assigned to Gas in Step
Step 1: Year-Specific Lease-Level Production	7,789	3,185
Step 2: Nearest-Year Lease-Level Production	375	476
Step 3: Area/Block-Level Production	104	54
Step 4: Area-level Production	275	196
Total Complexes	**8,543**	**3,911**

3.1.2.4 Emission Factors

With the BOEM GEI complexes assigned to gas versus oil and major versus minor, according to the considerations in the preceding subsections, EPA calculated EFs for each subcategory. A summary of the number of complexes reporting to BOEM GEI under each subcategory, including the number of complexes with flares, is shown in Table 5. EPA calculated EFs for the 2005, 2008, 2011, and 2014 GEIs on a complex basis for each subcategory; vent and leak EFs are in Table 6 and flaring EFs are in Table 7. Vent and leak CH_4 EFs and flaring CO_2 EFs (the dominant emission categories) are depicted in Figure 2 and Figure 3. Offshore operators were not required to report data for minor source structures in the 2005 GEI (as discussed in Section 3.1.1) and there were fewer minor complexes that reported to the 2005 GEI as a result (see Table 5). In addition, the 2005 minor complex EFs are higher than minor complex EFs for other GEI years, because the 2005 GEI only includes the higher emitting minor complexes (compared to the lower emitting minor source structures, which are included in other GEI years). Note, the 2000 BOEM GEI (i.e., the first year of the GEI) was not considered for this analysis; see discussion in Section 3.1.1.

Table 5. Summary of BOEM GEI Complex Counts, by Subcategory

Oil/Gas Complex	Major/ Minor Complex	2005		2008		2011		2014	
		# Complexes	# Complexes w/Flares	# Complexes	# Complexes w/Flares	# Complexes	# Complexes w/Flares	# Complexes	# Complexes w/Flares
Gas	Major	438	5	487	14	319	14	181	6
Oil	Major	791	52	845	76	728	81	660	52
Total	**Major**	**1,229**	**57**	**1,332**	**90**	**1,047**	**95**	**841**	**58**
Gas	Minor	69	4	418	4	360	4	110	4
Oil	Minor	107	4	844	5	780	8	444	9
Total	**Minor**	176	**8**	1,262	**9**	1,140	**12**	554	**13**
Total Used in EF Calcs		**1,405**	**65**	**2,594**	**99**	**2,187**	**107**	**1,395**	**71**
Total Reported to GEI[a]		**1,407**	**65**	**2,614**	**99**	**2,205**	**108**	**1,397**	**71**

a – Sum of major and minor complexes does not equal total number of complexes reported to the GEI because certain complexes could not be categorized. Section 3.1.2.2 discusses the categorization approach.

Table 6. Complex-Level Vent and Leak EFs (mt/yr) Calculated from BOEM GEI Data

Pollutant/Facility Subcategory	2005 Complex EF (mt/yr)	2008 Complex EF (mt/yr)	2011 Complex EF (mt/yr)	2014 Complex EF (mt/yr)
CH_4				
Gas / Major	91	256	123	113
Oil / Major	183	285	265	252
Gas / Minor	39	12	13	35
Oil / Minor	66	14	12	30

Pollutant/Facility Subcategory	2005 Complex EF (mt/yr)	2008 Complex EF (mt/yr)	2011 Complex EF (mt/yr)	2014 Complex EF (mt/yr)
CO_2				
Gas / Major	0.8	2.9	2.2	1.4
Oil / Major	2.2	3.2	4.2	4.4
Gas / Minor	0.1	0.1	0.4	0.7
Oil / Minor	0.5	0.2	0.2	0.4

Table 7. Complex-Level Flaring EFs (mt/yr) Calculated from BOEM GEI Data

Pollutant/Facility Subcategory	2005 Complex EF (mt/yr)	2008 Complex EF (mt/yr)	2011 Complex EF (mt/yr)	2014 Complex EF (mt/yr)
CH_4				
Gas / Major	<0.005	0.01	0.01	0.01
Oil / Major	0.35	0.44	0.43	0.37
Gas / Minor	<0.005	0.01	<0.005	<0.005
Oil / Minor	0.14	0.02	0.02	0.12
CO_2				
Gas / Major	1[a]	17	10	13
Oil / Major	11[a]	415	725	342
Gas / Minor	4[a]	6	1	2
Oil / Minor	1[a]	22	15	114

a – Flaring CO_2 EFs are noticeably low in this year because the 2005 GEI estimated emissions from flare pilot gas only.

3.2 BOEM Platform Database

This section summarizes the scope and available data from the BOEM Platform Database[14] and provides considerations for using the data in updating the methodology for the 2020 GHGI.

3.2.1 Scope and Available Data

The BOEM Platform Database provides information on all offshore facilities in GOM federal waters. The information includes complex and structure IDs, lease IDs, Area/Block IDs, install dates, removal dates, the structure water depth, and a major/minor structure designation.[15] There are 7,070 structures and 6,164 complexes in the database; the earliest install date is 1947 and the earliest removal date is 1973. EPA accessed the BOEM Platform Database in May 2019 to conduct the analyses presented in this memo. A similar BOEM dataset is available for facilities in the Pacific, and this information is discussed further in Section 3.6.2.

3.2.2 Considerations for Use in GHGI Updates

EPA evaluated the BOEM Platform Database for consideration in determining the number of active offshore complexes in GOM federal waters, including major versus minor subcategorization (refer to Section 3.1.2.2), in each year of the time series.

An important consideration when determining the number of "active" offshore complexes, versus the number of "existing" offshore complexes, is the removal date. Based on current DOI/Bureau of Safety and Environmental Enforcement (BSEE) regulations, structures must be removed as soon as possible, but no later than 5 years after ceasing production (30 CFR 250.1703(c)). As a result, there can be a period of inactivity (no emissions) while an offshore complex exists but is awaiting or undergoing removal. Because EFs are developed for active (emitting) complexes, EPA aims to exclude inactive complexes from activity data estimates over the time series.

[14] https://www.data.boem.gov/Platform/PlatformStructures/Default.aspx

[15] A major structure is defined as containing at least 6 completions or containing more than 2 pieces of production equipment.

To ensure correct interpretation of the BOEM Platform Database, EPA queried the BOEM Platform Database by various approaches to develop a reasonable assumption for expected decommissioning time (i.e., duration of inactivity before recorded removal date). EPA considered decommissioning time periods ranging from two to four years and found that assuming a three-year decommissioning period produced the most reasonable activity estimates (based on comparing calculated activity from the BOEM Platform Database and GEI reported activity). In other words, EPA plans to consider that a structure or complex is active in year N only if its removal date is three or more years after year N.

3.3 BOEM OGOR-A Production Dataset

This section summarizes the scope and available data from the BOEM OGOR-A dataset and provides considerations for using the data in updating the methodology for the 2020 GHGI.

3.3.1 Scope and Available Data

BOEM publishes the Oil and Gas Operations Reports – Part A (OGOR-A), that present annual oil and gas production information for each oil and gas lease in GOM federal waters. Two methods to download OGOR-A data are available, and the information in each varies. The complete OGOR-A dataset, which includes production from year 1947 to the present, provides data for each lease ID over this time period.[16] The Area/Block IDs associated with each lease ID are also available, but this information is only available to be downloaded for individual years from 1996 to the present.[17] The GOM federal waters oil and gas production available in OGOR-A is from the offshore facilities whose emissions are estimated in the BOEM GEI. A similar BOEM dataset is available for facilities in the Pacific, and this information is discussed further in Section 3.6.2.

3.3.2 Considerations for Use in GHGI Updates

EPA is considering using this dataset to assign production type and calculate annual production from all GOM federal water complexes over the time series, as described below.

3.3.2.1 Production Type Assignment

EPA is considering using production at the lease-level, Area/Block-level, and Area-level to assign GOM federal water complexes as oil or gas production type (see Section 3.1.2.3). EPA used the complete OGOR-A dataset to analyze lease-level production and the separate individual year OGOR-A downloads to analyze Area/Block-level and Area-level production. EPA applied the existing GHGI methodology to designate each lease, Area/Block, and Area as gas- or oil-production; entities with a GOR greater than 100 mcf/bbl are classified as gas-producing, and entities with a GOR less than 100 mcf/bbl as oil-producing.

These production type assignments can then be used in two ways: (1) Matched to the IDs of the offshore complexes in the BOEM GEI data in order to calculate EFs specific to oil and gas complexes (as detailed in Section 3.1.2.3); and (2) Classify the production type fractions of total active GOM federal water complex counts determined from the BOEM Platform Database (see Section 3.2) over the GHGI time series. Figure 4 presents the estimated percentages of active GOM federal water oil versus gas complexes over the GHGI time series.

3.3.2.2 Annual Production

EPA used the complete OGOR-A dataset to determine oil and gas production from oil facilities versus gas facilities over the time series. While OGOR-A production data are reported separately for offshore production from gas wells versus oil wells, EPA used the existing GHGI convention to define each lease with a GOR greater than 100 mcf/bbl as gas-producing, and otherwise defined each lease as oil-producing. The resulting production from oil facilities and gas facilities over the GHGI time series is presented in Figure 5. EPA is considering using the ratio

[16] See "Production Data" at https://www.data.boem.gov/Main/RawData.aspx.
[17] https://www.data.boem.gov/Main/OGOR-A.aspx

between GOM OCS production and GOM state waters production[18] to estimate offshore production emissions in GOM state waters (see discussion in Section 4.2).

3.4 OGOR-B Flaring and Venting Volumes Dataset

This section summarizes the scope and available data from the BOEM OGOR-B dataset and provides considerations for using the data in updating the methodology for the 2020 GHGI.

3.4.1 Scope and Available Data

BOEM publishes Oil and Gas Operations Reports – Part B (OGOR-B) that presents lease disposition data, including codes indicating disposal types of flared or vented gas. OGOR-B data are specific to leases in GOM federal waters. As discussed in Section 2.2, in the current GHGI, CO_2 emissions from all offshore flaring activities have been calculated using OGOR-B activity data provided by MMS staff, because the OGOR-B data were not previously publicly available. OGOR-B data are now available online,[19] with limitations: the total combined volume of gas vented and flared is available for all years from 1996 through present, but the separate volumes of gas vented and gas flared have only been available since 2011 (when BOEM expanded reporting requirements).

The publicly available OGOR-B dataset also specifies the volumes of vented and flared gas by well production type (gas versus oil), which may facilitate EPA estimating flaring CO_2 emissions separately for natural gas and petroleum systems. Note, while gas and oil wells are not likely defined in the same manner as the GHGI convention (using a GOR threshold of 100 mcf/bbl), this production type designation still likely offers an improvement on the current methodology which does not separate flaring emissions between natural gas and petroleum systems.

To assess agreement between the current GHGI basis and the newly available OGOR-B dataset, EPA compared the total volume of gas vented and flared for overlapping years between the publicly available OGOR-B data and data previously provided by MMS staff (years 1996–2008); EPA found that the volumes are very similar, within ±2% in each year—providing support for retaining current GHGI data in early time series years. The fraction of gas that is flared is not available for overlapping years across the two datasets and therefore could not be directly compared; the data provided by MMS staff are available for 1990–2008, while the publicly available OGOR-B data provide this from 2011 and forward.

The volumes of flared gas used in the current GHGI (as provided by MMS staff) and the volumes of flared gas reported in the publicly available OGOR-B data are compared in Table 8.

Table 8. Comparison of Flared Gas Volumes for Offshore Production Facilities Between Current GHGI and OGOR-B

	Flared & Vented Gas (MMcf)	% Gas Flared	Flared & Vented Gas (MMcf)	% Gas Flared	% of Flared & Vented Gas: from Oil Wells / from Gas Wells	Gas Flared (MMcf)	% of Flared Gas: from Oil Wells / from Gas Wells
1990	13,610	28%	- [b]	- [b]	- [b]	- [b]	- [b]
1991	13,017	28%	- [b]	- [b]	- [b]	- [b]	- [b]
1992	11,193	24%	- [b]	- [b]	- [b]	- [b]	- [b]
1993	11,230	24%	- [b]	- [b]	- [b]	- [b]	- [b]
1994	11,516	24%	- [b]	- [b]	- [b]	- [b]	- [b]
1995	12,537	26%	- [b]	- [b]	- [b]	- [b]	- [b]
1996	14,343	28%	14,630	- [c]	65% / 35%	- [c]	- [c]

[18] GOM State waters production is available in separate data sources, as discussed in Section 3.6.1.
[19] https://www.data.boem.gov/Main/OGOR-B.aspx

	Flared & Vented Gas (MMcf)	% Gas Flared	Flared & Vented Gas (MMcf)	% Gas Flared	% of Flared & Vented Gas: from Oil Wells / from Gas Wells	Gas Flared (MMcf)	% of Flared Gas: from Oil Wells / from Gas Wells
1997	15,440	33%	15,749	- [c]	61% / 39%	- [c]	- [c]
1998	16,280	32%	16,497	- [c]	61% / 39%	- [c]	- [c]
1999	14,057	28%	14,057	- [c]	53% / 47%	- [c]	- [c]
2000	12,975	26%	12,992	- [c]	50% / 50%	- [c]	- [c]
2001	13,038	26%	13,060	- [c]	53% / 47%	- [c]	- [c]
2002	12,456	28%	12,470	- [c]	57% / 43%	- [c]	- [c]
2003	10,704	24%	10,704	- [c]	54% / 46%	- [c]	- [c]
2004	10,485	26%	10,423	- [c]	61% / 39%	- [c]	- [c]
2005	9,941	30%	9,895	- [c]	58% / 42%	- [c]	- [c]
2006	8,418	29%	8,433	- [c]	57% / 43%	- [c]	- [c]
2007	8,586	31%	8,474	- [c]	60% / 40%	- [c]	- [c]
2008	11,747	51%	11,871	- [c]	65% / 35%	- [c]	- [c]
2009	- [a]	- [a]	10,396	- [c]	68% / 32%	- [c]	- [c]
2010	- [a]	- [a]	13,009	- [c]	75% / 25%	- [c]	- [c]
2011	- [a]	- [a]	11,182	63%	70% / 30%	7,023	80% / *20%*
2012	- [a]	- [a]	10,646	66%	75% / 25%	7,021	*85% / 15%*
2013	- [a]	- [a]	9,866	56%	73% / 27%	5,555	87% / *13%*
2014	- [a]	- [a]	10,468	56%	75% / 25%	5,899	86% / *14%*
2015	- [a]	- [a]	10,334	63%	81% / 19%	6,528	*91% / 9%*
2016	- [a]	- [a]	9,640	67%	84% / 16%	6,471	*93% / 7%*
2017	- [a]	- [a]	10,177	64%	83% / 17%	6,501	*94% / 6%*

a – Data from MMS staff were provided for 1990-2008. Year 2008 data are used as surrogate for years 2009 forward in the current GHGI.

b – OGOR-B does not provide data prior to 1996.

b – OGOR-B does not provide separate vented and flared gas volumes prior to 2011.

3.4.2 Considerations for Use in GHGI Updates

EPA is considering two options (referred to as Option A and Option B) to combine the current GHGI (based on historical MMS data) and OGOR-B datasets to calculate offshore flaring emissions in the updated GHGI. The current GHGI assigns all offshore flaring emissions to natural gas systems, and the OGOR-B data would allow for a portion of the flaring emissions to be attributed to offshore oil production within petroleum systems.

Under Option A, the current GHGI data would generally be used for years 1990-2008 and OGOR-B data would be used for subsequent years. Combining the current GHGI and OGOR-B datasets for Option A would require two assumptions to estimate separate natural gas and petroleum offshore flaring emissions over the time series. First, for years 1990 through 2010 (when the percent of flared gas from gas versus oil complexes is not available), EPA is considering applying the year 2011 values (80% of flared gas is from oil complexes and 20% of flared gas is from gas complexes). Second, the volume of flared gas is not directly available for years 2009 and 2010; EPA is considering linearly interpolating between the 2008 and 2011 volumes.

Under Option B, the current GHGI data generally would be used for years 1990-1995, the current GHGI data (% of gas flared) combined with the OGOR-B data (flared and vented gas volume, % flared gas from oil and gas wells) would both be used for years 1996-2008, and OGOR-B data would be used for years 2009 forward. Combining the current GHGI and OGOR-B datasets for Option B would require three assumptions to estimate separate oil and gas offshore flaring emissions over the time series. First, for years prior to 2011, Option B would rest on the assumption that the percent of flared and vented gas from oil complexes (and gas complexes) is equivalent to the percent of flared gas from oil complexes (and gas complexes). Second, for years 1990-1995, the percent of flared

gas from oil versus gas complexes is not available; EPA is considering applying the 1996 values (65% of flared gas is from oil complexes and 35% of flared gas is from gas complexes) to prior time series years. Lastly, the percent of gas flared is not available for 2009 and 2010; EPA is considering linearly interpolating between the 2008 value (51% of flared and vented gas is flared) and 2011 value (63% of flared and vented gas is flared).

The flared gas volumes that result for Option A and Option B are compared in Figure 6. For the emissions estimates shown in this memo, Option A is applied to calculate flaring emissions.

OGOR-B data are specific to GOM offshore facilities in federal waters, therefore EPA is considering other approaches to estimate offshore flaring emissions for GOM state waters, Pacific, and Alaska regions (see Sections 4.2 and 4.3).

The current GHGI includes flaring CH_4 emissions within the EFs shown in Table 1. In order to calculate CH_4 and N_2O flaring emissions in the same manner as calculating CO_2 emissions discussed here (using flared gas volumes as the activity basis), new flaring CH_4 and N_2O EFs would be needed to apply to the flared gas volumes. EPA is considering applying a CH_4 EF of 0.057 kg/MMBtu and an N_2O EF of 0.00091 kg/MMBtu, which are used in the BOEM GEI calculations. These EFs would then be adjusted each year using the natural gas heat content, as discussed in Section 2.2.

3.5 GHGRP

This section summarizes the scope and available data from EPA's GHGRP dataset and provides considerations for using the data in updating the methodology for the 2020 GHGI.

3.5.1 Scope and Available Data

Offshore petroleum and natural gas production facilities (referred to as "offshore production facilities" in this memo) are defined in the GHGRP as: *Any platform structure, affixed temporarily or permanently to offshore submerged lands, that houses equipment to extract hydrocarbons from the ocean or lake floor and that processes and/or transfers such hydrocarbons to storage, transport vessels, or onshore. In addition, offshore production includes secondary platform structures connected to the platform structure via walkways, storage tanks associated with the platform structure and floating production and storage offloading equipment (FPSO). This source category does not include reporting of emissions from offshore drilling and exploration that is not conducted on production platforms.* "Offshore" is defined as: *Seaward of the terrestrial borders of the United States, including waters subject to the ebb and flow of the tide, as well as adjacent bays, lakes or other normally standing waters, and extending to the outer boundaries of the jurisdiction and control of the United States under the Outer Continental Shelf Lands Act.*

GHGRP subpart W requires offshore production facilities meeting the reporting threshold (25,000 mt CO_2e) to report CO_2, CH_4, and N_2O emissions from equipment leaks, vented emission, and flare emission source types as identified in the BOEM GEI data collection and emissions estimation study. Offshore production facilities under BOEM jurisdiction report the same annual emissions as calculated and reported in the BOEM GEI; offshore production facilities that are not under BOEM jurisdiction must use the monitoring and calculation methods used in the most recent BOEM GEI publication.

The BOEM GEI study is updated and published triennially (to coincide with the EPA and state agency onshore criteria pollutant inventory process). For any calendar year that does not overlap with the most recent published BOEM GEI study and/or methods, GHGRP reporters must employ the most recently published study estimates or methods, then adjust emissions based on the operating time for the facility relative to operating time in the previous reporting or calculation period.

For fuel combustion emissions, GHGRP offshore production facilities report CO_2, CH_4, and N_2O emissions using methodologies specified in subpart C.

In addition to emissions data, GHGRP offshore production facilities annually report production volumes beginning in RY2015, specifically: (1) total quantity of gas handled at the offshore facility in the calendar year, in thousand standard cubic feet (mscf), including production volumes and volumes transferred via pipeline from another location; and (2) total quantity of oil and condensate handled at the offshore facility in the calendar year, in barrels (bbl), including production volumes and volumes transferred via pipeline from another location.

Table 9 provides an overview of the GHGRP offshore production and emissions reported for RY2011 through RY2017.

Table 9. GHGRP Offshore Emissions and Production Reporting Overview

Data	2011	2012	2013	2014	2015	2016	2017
# Facilities	101	108	109	129	133	137	141
Gas production (Bscf)	NR	NR	NR	NR	1,355	1,344	1,650
Oil/condensate production (MMbbl)	NR	NR	NR	NR	506	563	615
Subpart W Vent and Leak Emissions							
CH_4 (mt)	69,306	62,818	59,205	69,921	69,269	71,917	61,248
CO_2 (mt)	919	1,691	4,239	904	21,678	55,147	52,688
N_2O (mt)	0	0	0	0	0	0	0
Subpart W Flare Emissions							
CH_4 (mt)	731	893	517	683	937	1,106	723
CO_2 (mt)	485,890	467,999	370,561	371,907	459,434	457,617	355,880
N_2O (mt)	8	7	6	10	12	11	6
Subpart C Emissions							
CH_4 (mt)	80	87	87	94	99	98	99

NR – Not publicly reported in Envirofacts.

3.5.2 Considerations for Use in GHGI Updates

Due to the reporting threshold, GHGRP data generally reflect less than 10 percent of all U.S. offshore production facilities, though coverage varies by region. Emission factors and assumptions based on GHGRP reporters may not be representative of offshore production facilities that do not report to GHGRP.

Most GHGRP reported activity is centered in the GOM, with reporters also located in the Pacific (off the coast of California) and Cook Inlet regions (southern Alaska).

Most of the offshore facilities reporting in RY2017 are located in federal waters. All reporting facilities in the Pacific are in federal waters, and most (if not all) of the reporting facilities in the GOM are in federal waters; while all reporting facilities in Alaska are located in state waters. While the GHGRP dataset coverage overlaps that of the BOEM GEI (GOM federal waters), the GHGRP provides a unique source of emissions characterization data for the Pacific and Alaska regions.

EPA calculated year-specific EFs on a per-facility basis and on a production basis using available GHGRP data, including three levels subcategorization: (1) region (GOM, Pacific, Alaska); (2) production type (gas, oil); and (3) emission type (vent/leak (including engine exhaust CH_4), and flare). To group GHGRP reporters by production type, EPA applied the standard GHGI approach of assignment by calculating the production GOR in a given year and assigning facilities with a GOR greater than 100 mcf/bbl as gas and otherwise as oil. Production data are not available for RY2011 through 2014, so the RY2015 oil versus gas assignment for a facility was used for all prior

years. Table 10 and Table 11 show the production-based EFs calculated from GHGRP data for each region. Note, all offshore GHGRP facilities in the Pacific region were categorized as oil facilities.

Table 10. Year-specific EFs Calculated from GHGRP Data for Offshore Oil Facilities

Region/Emission Type/Pollutant	2015	2016	2017
GOM			
Vent and Leak EFs (mt/MMbbl)			
CH_4	123	120	90
CO_2	1.6	1.6	1.9
Flare EFs (mt/MMbbl)			
CH_4	1.7	1.6	0.7
CO_2	818	709	472
N_2O	0.02	0.02	0.01
Pacific			
Vent and Leak EFs (mt/MMbbl)			
CH_4	421	283	309
CO_2	124	3.0	3.1
Flare EFs (mt/MMbbl)			
CH_4	0.7	0.6	0.8
CO_2	1,188	623	821
N_2O	0.01	0.01	0.01
Alaska			
Vent and Leak EFs (mt/MMbbl)			
CH_4	461	468	598
CO_2	4.6	4.4	4.0
Flare EFs (mt/MMbbl)			
CH_4	8.2	6.4	3.0
CO_2	7,647	6,004	5,919
N_2O	0.1	0.1	0.1

Table 11. Year-specific EFs Calculated from GHGRP Data for Offshore Gas Facilities

Region/Emission Type/Pollutant	2015	2016	2017
GOM			
Vent and Leak EFs (mt/Bcf)			
CH_4	9.2	4.5	4.0
CO_2	40	126	64
Flare EFs (mt/Bcf)			
CH_4	0.1	0.5	0.3
CO_2	29	82	57
N_2O	0.0002	0.0003	0.0002
Alaska			
Vent and Leak EFs (mt/Bcf)			
CH_4	20	34	25
CO_2	0.10	0.01	0.00
Flare EFs (mt/Bcf)			
CH_4	0.16	0.16	0.004
CO_2	208	150	177
N_2O	0.0	0.0	0.0

In Section 4, EPA discusses updates under consideration for the 2020 GHGI that use the EFs presented in the tables above. In Section 5, EPA requests stakeholder feedback on use of this dataset in the GHGI and other considerations.

3.6 Other Activity Data

The above sections discuss the extensive data available mainly for offshore facilities in GOM federal waters. This section discusses the activity data available for the other offshore production regions, including GOM state waters, and federal and state waters in the Pacific and Alaska. EPA reviewed available activity data on the basis of both offshore facility counts and production volumes.

3.6.1 GOM State Waters Activity Data

Offshore production in GOM state waters occurs in coastal areas off the states of Alabama, Louisiana, and Texas. The Oil and Gas Board of Alabama (AL OGB) provides a list of all wells for the state, including offshore.[20] A map of offshore facilities off of Louisiana is available from the Louisiana Department of Wildlife and Fisheries,[21] and detailed well data are available through the Department of Natural Resources' online database - Strategic Online Natural Resource Information System (SONRIS).[22] The Texas General Lands Office provides GIS files for offshore facilities.[23] These datasets may allow EPA to estimate the number of currently operating offshore facilities in GOM state waters, but it does not appear possible to develop such facility counts over the entire GHGI time series.

EPA also reviewed the production data available for GOM state waters. Each state provides both oil and gas production online, in various forms. The AL OGB considers all offshore production to be from gas wells (based on the aforementioned offshore wells data, wherein all offshore data are labeled as "gas"). [24] The Louisiana Department of Natural Resources and the Texas Railroad Commission report oil and gas production from gas wells and oil wells separately. [25,26] Note, while gas and oil wells in these datasets may not be defined in the same manner as the GHGI convention (using a GOR threshold of 100 mcf/bbl), this production type designation offers an improvement versus assigning all production (and hence emissions) to either natural gas or petroleum systems, or making other assumptions to distinguish between natural gas and petroleum systems production. Limited offshore gas production data for these states are also available from EIA; however, the data are of insufficient detail to fully assess GOM state waters oil production.[27] Each of the state agency datasets provide production data over most of the GHGI time series.

Figure 7 and Figure 8 present the offshore oil and gas production data for GOM state waters. EPA is considering applying the relationship between emissions and production for complexes in the OCS of the GOM to estimate emissions for complexes in state waters of the GOM (see Section 4.2 for further discussion).

3.6.2 Pacific Federal and State Waters Activity Data

Offshore production occurs in federal and state waters off the coast of California (Pacific region). The California State Lands Commission provides information on state water facility counts. There are nine offshore production facilities in state waters; four offshore oil facilities and five artificial islands.[28] Federal waters facilities are under

[20] https://www.gsa.state.al.us/ogb/wells
[21] http://ldwf.maps.arcgis.com/apps/webappviewer/index.html?id=a71d6758535042dd969114fb6a356888
[22] http://www.sonris.com/
[23] http://www.glo.texas.gov/land/land-management/gis/
[24] https://www.gsa.state.al.us/ogb/production
[25] http://www.dnr.louisiana.gov/index.cfm?md=pagebuilder&tmp=home&pid=206
[26] http://webapps.rrc.state.tx.us/PDQ/generalReportAction.do
[27] http://www.eia.gov/dnav/ng/ng_prod_sum_a_epg0_fgw_mmcf_a.htm
[28] https://www.slc.ca.gov/Info/Oil_Gas.html

BOEM jurisdiction, and there are 23 active offshore facilities in federal waters of the Pacific based on the BOEM Pacific Platform Database (analogous to the BOEM Platform Database covering GOM activity discussed in Section 3.2).[29] Each of the active federal water facilities was installed prior to 1990 and consists of a single, major structure; there is one federal water facility that was removed in 1994.

Pacific region state waters production data are available from annual reports published by the State Oil and Gas Supervisor in the California Department of Conservation[30] and Pacific region federal waters production data are available from BOEM[31] and EIA.[32,33] For Pacific region federal waters production, EPA is considering using EIA data for 1990–1995 and BOEM data for all subsequent years. EPA is also considering assigning all Pacific federal waters and state waters production to oil facilities (Petroleum Systems segment); data are not available for all years to distinguish between gas and oil facility production, and for the years when this can be determined gas facilities account for a small percent of gas production (from 0%–10%). Figure 9 shows the offshore oil production data for the Pacific region. EPA is considering an approach to estimate emissions for the Pacific region that relies on production data in conjunction with GHGRP-based EFs (see Section 4.3 for further discussion).

3.6.3 Alaska State Waters Activity Data

At this time, offshore production occurs only in state waters off the coast of Alaska, as noted in Section 1.2. There are two state waters offshore production regions—the Cook Inlet in the south and Beaufort Sea in the north. The Alaska Oil and Gas Conservation Commission (AOGCC) provides information on state water offshore well counts and production.[34,35]

Figure 10 shows the offshore oil and gas production data for Alaska. The AOGCC dataset includes onshore and offshore; EPA estimated the offshore production by summing the production for the API well IDs that are noted as being offshore within the AOGCC well dataset. EPA is considering an approach to estimate offshore production emissions for Alaska that uses production volumes as the activity data component in conjunction with GHGRP-based EFs (see Section 4.3 for further discussion).

4 Updates Under Consideration for the GHGI

The subsections below discuss updates under consideration for EFs and activity data in the 2020 GHGI, organized by region, and summarized in Table 12.

Table 12. Approaches under Consideration for 2020 GHGI Updates, by Offshore Region

Region	Memo Section	EF Basis Under Consideration	Activity Data Basis Under Consideration
GOM federal waters	4.1	BOEM GEI, complex-level EFs	BOEM Platform Database
GOM state waters	4.2	GOM federal waters production-based EFs	State-specific offshore production data
Pacific federal and state (California) waters	4.3	GHGRP (facilities in Pacific region), production-based EFs	California state and BOEM and/or EIA federal offshore production data
Alaska state waters	4.3	GHGRP (facilities in Alaska region), production-based EFs	Alaska state offshore production data

[29] https://www.data.boem.gov/Main/PacificPlatform.aspx
[30] https://www.conservation.ca.gov/dog/pubs_stats/annual_reports/Pages/annual_reports.aspx
[31] https://www.data.boem.gov/Main/PacificProduction.aspx
[32] http://www.eia.gov/dnav/ng/ng_prod_sum_a_epg0_fgw_mmcf_a.htm
[33] http://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbbl_a.htm
[34] http://aogweb.state.ak.us/DataMiner3/Forms/WellList.aspx
[35] http://aogweb.state.ak.us/DataMiner3/Forms/Production.aspx

There is a particular consideration for GHGI updates to offshore production emissions in state waters that applies across regions. EPA understands near-shore offshore production might include minimal offshore processing operations, with the production stream piped or shipped to centralized onshore facilities where most of the production segment processing occurs. However, EPA identified very limited data characterizing emissions and activity for such operations that likely fall within state waters. As described further within this section, EPA is therefore considering developing region-specific, *production-based* EFs from facilities in federal waters and/or reporting to GHGRP (which likely have higher per-facility emissions than facilities in state waters or not reporting to GHGRP),and applying such EFs to production in state waters. This effectively estimates emissions from state waters operations by scaling based on production relative to that in federal waters and/or from GHGRP facilities (refer to Figure 1 for production volumes by region in year 2014). EPA considered an alternative of using a complex-level EF developed from these facilities but believes such an approach might overestimate emissions from state water operations; additionally, state water production data are readily available, while state water active complex counts are not.

EPA seeks stakeholder feedback on these preliminary approaches and the particular state waters consideration noted above; refer to Section 5 for specific questions.

4.1 Offshore Production in GOM Federal Waters

This section summarizes a preliminary approach for estimating emissions (EFs multiplied by activity data) from offshore production in GOM Federal waters.

4.1.1 EFs

EPA is considering applying year-specific, complex-level EFs developed from the BOEM GEI dataset (see Table 6) to estimate vent and leak emissions (including engine exhaust CH_4) over the GHGI time series for major complexes, rather than applying the 2011 BOEM GEI EFs to all time series years as in the current GHGI (refer to Section 2). EPA is specifically considering an approach for major complexes where the BOEM GEI-based EFs for a particular year would generally be used for the Inventory years on either side of the BOEM GEI year that provides the EF, as follows:

- EFs calculated from the 2005 BOEM GEI would be applied to year 2005 only (due to the hurricane season impact, discussed in Section 3.1.1);
- EFs calculated from the 2008 BOEM GEI would be applied to 1990 through 2004 and 2006 through 2009;
- EFs calculated from the 2011 BOEM GEI would be applied to 2010 through 2012; and
- EFs calculated from the 2014 BOEM GEI would be applied to 2013 through 2017.
- When the 2017 BOEM GEI data are available, EFs would be calculated and applied to years 2016 through 2018.

For minor complexes, EPA is considering applying the 2014 (or more recent) BOEM GEI minor complex EFs (see Table 6) to estimate vent and leak emissions (including engine exhaust CH_4) over the GHGI time series. This consideration is due to changes in BOEM GEI reporting requirements over time; as discussed in Section 3.1.1, the 2014 GEI is the first year in which emissions from minor source structures are fully accounted for in the GEI. As is the case for major complexes, when the 2017 BOEM GEI data are available, EFs would be calculated and applied to years 2016 through 2018.

EPA considered two options to estimate flaring emissions from complexes in GOM Federal waters. The first option would maintain the current GHGI approach, wherein EFs on the basis of kg/MMBtu (along with year-specific heat content) would be applied to OGOR-B flared gas volumes over the time series—see Sections 2.2 and 3.4.2. While the current GHGI only estimates flaring CO_2 emissions using this EF approach, EPA would also estimate flaring CH_4 and N_2O emissions under this option. The second option would use BOEM GEI-based flaring EFs (as shown in Table

7). Major complex flaring EFs would be applied as discussed in the prior paragraph, and minor complex flaring EFs would be applied in the same manner as major complex flaring EFs (based on EPA analysis, the GEI reporting requirement changes discussed in the above paragraph did not significantly impact minor source flaring emissions). For purposes of estimating emissions discussed in the remainder of this memo, EPA applied the first option discussed above, primarily because OGOR-B flared gas volume data are available for each time series year, whereas GEI EFs can only be calculated for GEI publication years.

4.1.2 Activity Data

EPA is considering an updated approach to estimate active GOM federal waters complex counts that would pair with BOEM GEI EFs discussed in Section 4.1.1. As discussed in Section 2.1, the current GHGI activity data relies on an MMS dataset that has not been updated since 2010, and EPA has recently identified opportunities to improve subcategorization of EFs and thus applicable activity data, based on stakeholder feedback. EPA is considering using the BOEM Platform Database (discussed in Section 3.2) to count total active complexes, subcategorized by major versus minor complexes over the time series; details of this approach are discussed in Section 3.2.2. EPA is considering then using the BOEM OGOR-A Production Dataset to further subcategorize complexes as gas versus oil production; details of this approach are discussed in Section 3.3.2.3. Figure 11 presents the resulting complex counts over the time series, compared to the facility counts in the 2019 GHGI.

EPA is considering two approaches to calculate offshore flaring emissions. The first, discussed above, would use BOEM GEI EFs and the same AD as discussed in the above paragraph. The second would estimate offshore flared gas volumes over the time series (such approach would be used with EFs from the second option for estimating flaring emissions discussed in Section 4.1.1), by relying on both the historical activity data provided by MMS staff (used in the current GHGI) and publicly available OGOR-B data. Details of this approach are discussed in Section 3.4.2, including considerations for two options to estimate the flared gas volumes (see Option A and Option B).

4.1.3 Emissions

Figure 12 and Figure 13 show the total CH_4 emissions and CO_2 emissions, respectively, for the updates under consideration for GOM federal water offshore production facilities, compared to the 2019 GHGI emissions (which also solely represent GOM federal water emissions). The updates under consideration for the 2020 GHGI for GOM federal water offshore facilities would result in a 2% increase in GOM federal water offshore production CH_4 emissions for petroleum systems in year 2017 and an average increase of 44% over the 1990-2017 time series (with most of the increase occurring over the 1990-2009 time frame). The updates under consideration would result in a 91% decrease in GOM federal water offshore production CH_4 emissions for natural gas systems in year 2017 and an average decrease of 29% over the 1990-2017 time series. Total CH_4 GOM federal water offshore production emissions would decrease by 39% for year 2017 and increase by 11% on average over the 1990-2017 time series for the updates under consideration compared to the 2019 GHGI.

The two approaches to estimate flaring emissions from GOM federal water production result in very different estimates, with the approach that relies on BOEM GEI EFs generally leading to much higher CO_2 emissions. Using the OGOR-B flaring volumes Option A approach under consideration (consistent with the current GHGI approach), GOM federal waters offshore production total CO_2 emissions would increase by 6% for year 2017 and the annual average over the 1990-2017 time series would not change. Using the BOEM GEI flaring EFs approach, GOM federal waters offshore production total CO_2 emissions would decrease by 18% for year 2017 and increase by 72% on average over the 1990-2017 time series.

4.2 Offshore Production in GOM State Waters

As explained in the introduction to Section 4, EPA understands near-shore offshore production might include minimal offshore processing operations, with the production stream piped or shipped to centralized onshore facilities where most of the production segment processing operations occur. However, EPA identified very

limited data characterizing emissions and activity for such operations that likely compose some fraction of activity within state waters. EPA is therefore considering estimating emissions from offshore production in GOM state waters using production-based EFs developed from GOM federal water data, in conjunction with state-specific offshore oil and gas production.

4.2.1 EFs

EPA is considering developing production-based EFs for each year of the time series from the GOM federal waters data. EPA would calculate EFs by dividing the GOM federal waters emissions by the GOM federal waters production in each year. The production basis would also be unique for oil complexes and gas complex emissions; oil production would be used in the numerator for oil complexes and gas production would be used in the numerator for gas complexes. Separate EFs for vent and leak emissions and flaring emissions would also be developed from the GOM federal waters data set. For flaring emissions, this approach would apply to either of the options EPA is considering in Section 4.1.

4.2.2 Activity Data

EPA is considering using annual state-specific offshore production (discussed in Section 3.6.1) paired with the EFs discussed in Section 4.2.1 to calculate emissions.

4.2.3 Emissions

Figure 14 and Figure 15 show the GOM state waters total CH_4 emissions and CO_2 emissions, respectively, for the 2020 GHGI updates under consideration.

4.3 Offshore Production in Pacific and Alaska Regions

As explained in the introduction to Section 4, EPA understands there are limitations to the available data for the offshore Pacific and Alaska regions to characterize all offshore production emissions in these regions. However, EPA is considering using reported GHGRP data (refer to Section 3.5) to calculate production-based EFs, to be used in conjunction with region-specific offshore oil and gas production.

4.3.1 EFs

EPA is considering applying the GHGRP production-based EFs shown in Table 10 and Table 11 to estimate emissions from facilities in the Pacific and Alaska regions, respectively. The GHGRP RY2015 EFs would be applied to all prior years in the GHGI time series.

4.3.2 Activity Data

EPA is considering using year-specific, region-specific offshore production (discussed in Sections 3.6.2 and 3.6.3) to pair with the EFs discussed in Section 4.3.1 to estimate emissions over the time series.

4.3.3 Emissions

Figure 16 and Figure 17 show the total CH_4 emissions and CO_2 emissions, respectively, for the 2020 GHGI updates under consideration for the Pacific and Alaska regions.

4.4 Emissions Summary

Figure 18 and Figure 19 show the total offshore production CH_4 emissions and CO_2 emissions, respectively, for the updates under consideration for the 2020 GHGI for each of the production regions, compared to the 2019 GHGI emissions. Flaring CO_2 emissions for the updates under consideration included in Figure 19 are based on the approach that uses OGOR-B flaring volumes for the GOM.

For the updates under consideration for the 2020 GHGI, GOM federal waters offshore facilities account for a majority of the offshore production emissions in both petroleum systems (offshore oil facilities) and natural gas systems (offshore gas facilities). In year 2017, GOM federal waters offshore facilities account for 91% of offshore

production CH_4 emissions and 74% of offshore production CO_2 emissions for petroleum systems, and 69% of offshore production CH_4 emissions and 64% of offshore production CO_2 emissions for natural gas systems. In addition, for year 2017, GOM state waters offshore gas facilities contribute 28% of offshore production CH_4 emissions and 26% of offshore production CO_2 emissions for natural gas systems, while Alaska region offshore oil facilities contribute 23% of offshore production CO_2 emissions for petroleum systems. Pacific region offshore facilities generally contribute minimal emissions. Table 13 presents the offshore production CH_4 emissions and CO_2 emissions for each region in year 2017 for the updates under consideration for the 2020 GHGI and the 2019 GHGI.

Compared to the 2019 GHGI, petroleum systems offshore production CH_4 emissions increase overall for the updates under consideration for the 2020 GHGI, while natural gas systems offshore production CH_4 emissions decrease overall for the updates under consideration for the 2020 GHGI. Compared to the 2019 GHGI, offshore production CO_2 emissions increase overall for the updates under consideration for the 2020 GHGI. Petroleum systems offshore production flaring CO_2 emissions also constitute approximately 90% of the total flaring CO_2 emissions for the updates under consideration for the 2020 GHGI, whereas the 2019 GHGI assigned all offshore production flaring CO_2 emissions to natural gas systems. Table 14 shows the percent change between the 2019 GHGI and the updates under consideration for the 2020 GHGI, for year 2017 and on average over the 1990-2017 time series.

Offshore production N_2O emissions are not presented in this memo, but EPA would calculate offshore production flaring N_2O emissions for the updates under consideration for the 2020 GHGI in the same manner that offshore production flaring CO_2 and CH_4 emissions are calculated for each region. Offshore production flaring N_2O emissions will have a minimal contribution to the natural gas and petroleum systems emissions estimates, and would account for approximately 0.5% of total offshore production flaring emissions (on a CO_2 equivalent basis) for the updates under consideration for the 2020 GHGI.

Table 13. Offshore Production Year 2017 CH_4 and CO_2 Emissions (mt), by Region, for the Updates Under Consideration for the 2020 GHGI and the 2019 GHGI

Emissions Category	Region	2020 GHGI Update (Year 2017)	2019 GHGI (Year 2017)
CH_4			
Petroleum systems	GOM Federal Waters	191,431	187,604
	GOM State Waters	1,252	NE
	Alaska	12,164	NE
	Pacific	5,052	NE
	Total	**209,899**	**187,604**
Natural gas systems	GOM Federal Waters	13,845	150,565
	GOM State Waters	5,658	NE
	Alaska	501	NE
	Pacific	n/a	n/a
	Total	**20,005**	**150,565**
CO_2			
Petroleum systems	GOM Federal Waters	380,723	8,340
	GOM State Waters	2,491	NE
	Alaska	119,963	NE
	Pacific	13,440	NE
	Total	**516,617**	**8,340**

Emissions Category	Region	2020 GHGI Update (Year 2017)	2019 GHGI (Year 2017)
Natural gas systems	GOM Federal Waters	24,179	372,116
	GOM State Waters	9,881	NE
	Alaska	3,483	NE
	Pacific	n/a	n/a
	Total	**37,543**	**372,116**

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

Table 14. Percent Change Due to Recalculations in CH_4 and CO_2 Emissions Between the 2019 GHGI and the Updates Under Consideration for the 2020 GHGI

Emissions Category	Year 2017 Change from 2017 Estimate in Previous GHGI	1990-2017 Time Series Average Annual Change from Previous GHGI
CH_4		
Petroleum systems	12%	69%
Natural gas systems	-87%	-16%
Total	**-32%**	**31%**
CO_2		
Petroleum systems*	6,094%	7,106%
Natural gas systems	-90%	-71%
Total	**46%**	**184%**

* In the previous GHGI, all CO_2 emissions from flaring were reported under Natural Gas Systems.

5 Requests for Stakeholder Feedback

General

1. EPA seeks stakeholder feedback on the proposed approach of calculating vent and leak EFs that include emissions from all equipment at an offshore facility (except for flares), versus calculating emission source-specific EFs. For consideration, Section 3.1.1 documents the emission sources included in the BOEM GEI-based complex-level vent and leak EFs.
2. The 2020 GHGI updates under consideration show a noticeable decrease in CH_4 emissions over the time series (see Figure 18). EPA seeks feedback on the trend, including information on changes in offshore production practices over time that may have contributed to the trend.

Region-specific Approaches Under Consideration

3. ***GOM Federal Waters***: EPA seeks feedback on the datasets and approach under consideration to estimate offshore production emissions in GOM federal waters using BOEM GEI data. This includes feedback on the following:
    a. The approach to develop complex-level EFs from BOEM GEI data for each subcategory (i.e., oil and gas complexes, major and minor complexes).
    b. The approach for applying the BOEM GEI EFs over the time series, including applying BOEM GEI 2008 EFs to all prior years (except for 2005).
        i. Applying the 2005 GEI EFs to prior years of the time series was not considered due to the hurricane season impact (see Section 3.1.1).
    c. The approach to estimate complex counts over the time series using the BOEM Platform Database and OGOR-A data.

4. ***GOM Federal Waters Flaring:*** EPA seeks feedback on the two approaches under consideration to estimate offshore production flaring emissions in GOM federal waters; applying GEI-based EFs (as shown in Table 7) versus OGOR-B based flaring volumes.
    a. If OGOR-B flaring volume data are used in the update, two options are presented in Section 3.4.2. Option A is used to estimate emissions for this memo, but EPA seeks feedback on the assumptions applied for each option and which option is most appropriate to apply, or whether a different methodology should be applied.
    b. Regarding flaring volumes, EPA notes some discrepancies between GEI and OGOR-B flaring volumes. The GEI flaring volumes (used to calculate the GEI-based EFs) are higher than OGOR-B flaring volumes in certain years but lower in other years, see the following table. EPA seeks stakeholder feedback on these discrepancies.

Year	BOEM GEI Flared Gas Volumes (Bcf)	OGOR-B Flared Gas Volumes (Bcf)
2000	2.5	3.4
2005	5.1	3.0
2008	7.0	6.0
2011	10.0	7.0
2014	5.1	5.9

5. ***GOM State Waters, Pacific, and Alaska Regions***: EPA seeks feedback on the datasets and approaches under consideration to estimate offshore production emissions in these regions, specifically:
    a. GOM state waters emissions estimates relying on GOM federal waters production-based EFs.
    b. How to characterize operations and emissions from offshore production in GOM state waters. As discussed in Section 4, EPA understands near-shore offshore production might include minimal offshore processing operations, with the production stream piped or shipped to centralized onshore facilities where most of the production segment processing occurs. However, EPA identified very limited data characterizing emissions and activity for such operations that likely fall within state waters.
    c. Pacific federal and state waters emission estimates relying on GHGRP production-based EFs.
    d. Alaska state waters emission estimates relying on GHGRP production-based EFs.
    e. Whether data are available for EPA to consider an approach wherein facility counts, rather than production volumes, could be used as the activity basis for emissions estimates in these regions.

Other Considerations

6. EPA seeks stakeholder feedback on the potential utility of using DrillingInfo DI Desktop well-level data to estimate oil and gas production in each offshore production region for each year of the time series (under a scenario wherein production-based EFs were used in GHGI updates). The use of this data source would provide benefits including: (1) consistency with the data source for onshore production volumes underlying current GHGI estimates; (2) data processing efficiency compared to the current approach under consideration that involves mining various individual state datasets. If stakeholder feedback supports such an approach, EPA would develop draft methodologies, compare results to current state dataset-based estimates, and share results with stakeholders for additional consideration.
7. EPA seeks feedback on how to track and estimate emissions from anomalous leak events occurring in offshore producing regions, for example the Cook Inlet underwater gas pipeline rupture that occurred in late 2016/early 2017 and released natural gas for multiple months.
8. EPA seeks stakeholder information on other available or upcoming data related to offshore oil and gas emissions. For example, EPA is aware of a number of measurement studies in the Gulf of Mexico. EPA seeks stakeholder information on how information from these studies may be used to assess or update the GHG Inventory estimates.

Appendix A – Memo Figures

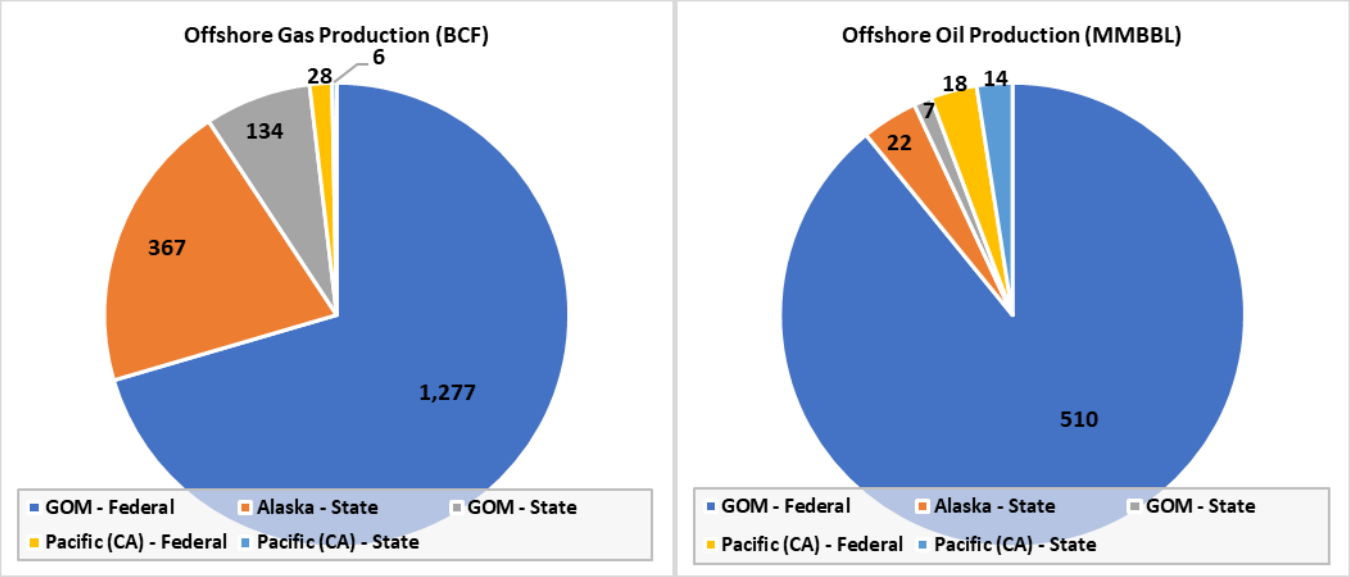

Figure 1. Overview of U.S. Offshore Gas Production (BCF) and Oil Production (MMBBL), Year 2014

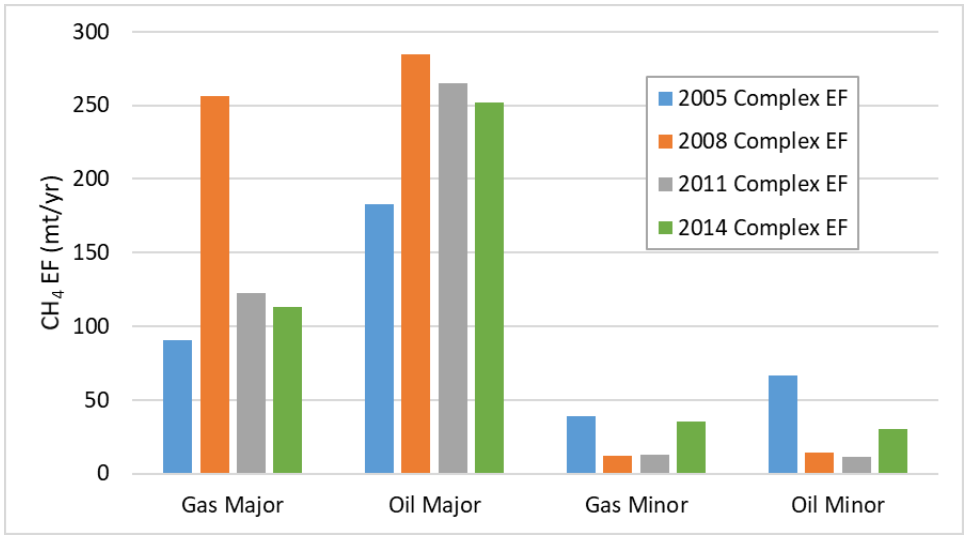

Figure 2. Complex-Level Vent and Leak CH_4 EFs (mt/yr) Calculated from BOEM GEI Data

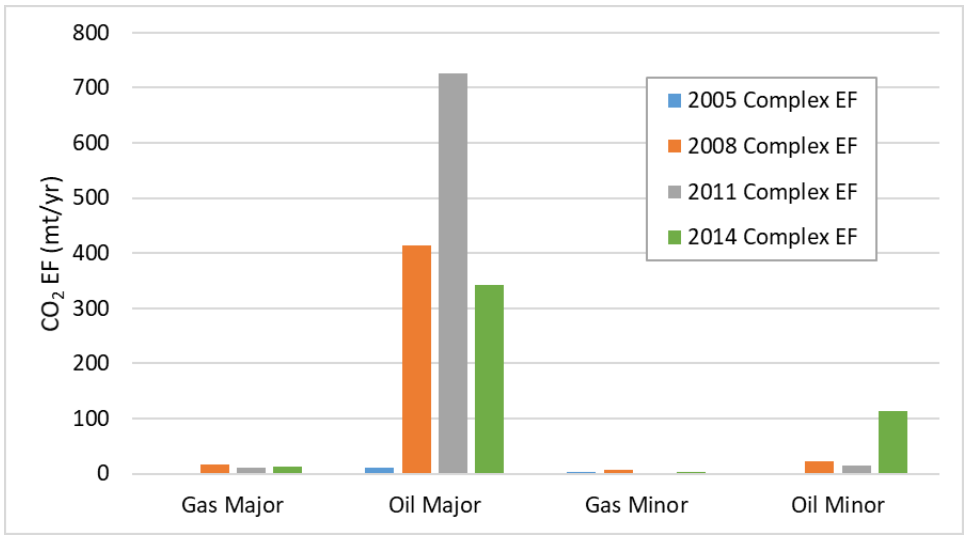

Figure 3. Complex-Level Flaring CO_2 EFs (mt/yr) Calculated from BOEM GEI Data

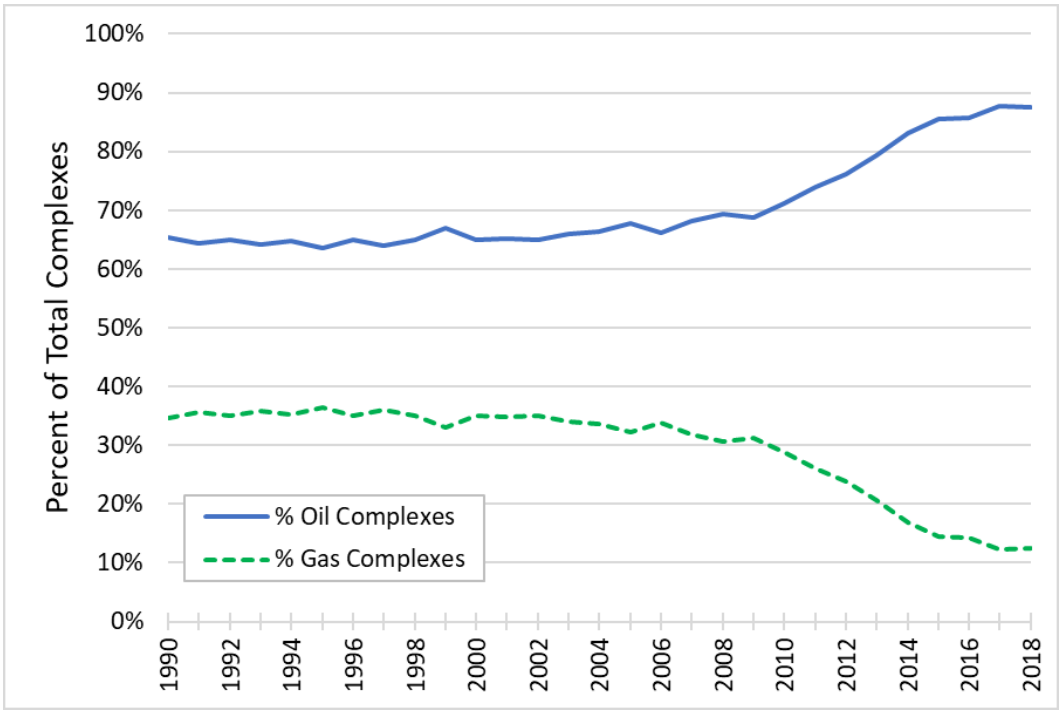

Figure 4. Production Type of Active GOM Federal Water Complexes Over the GHGI Time Series

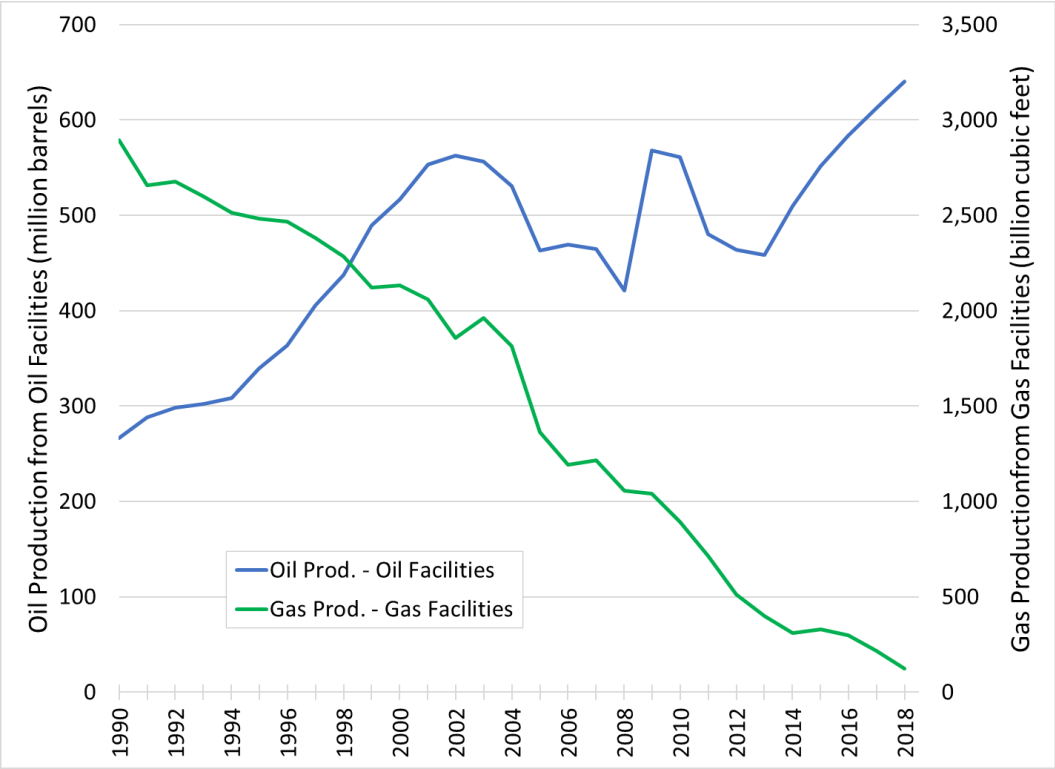

Figure 5. GOM OCS Oil and Gas Production

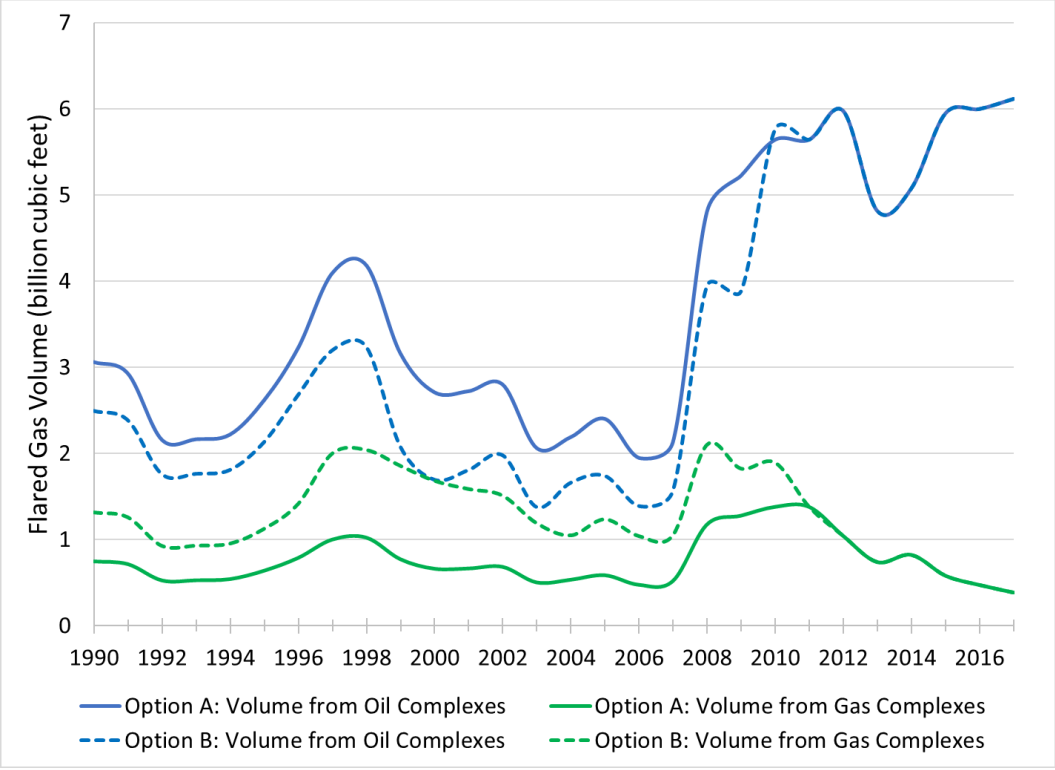

Figure 6. Comparison of Flared Gas Volumes for Option A and Option B

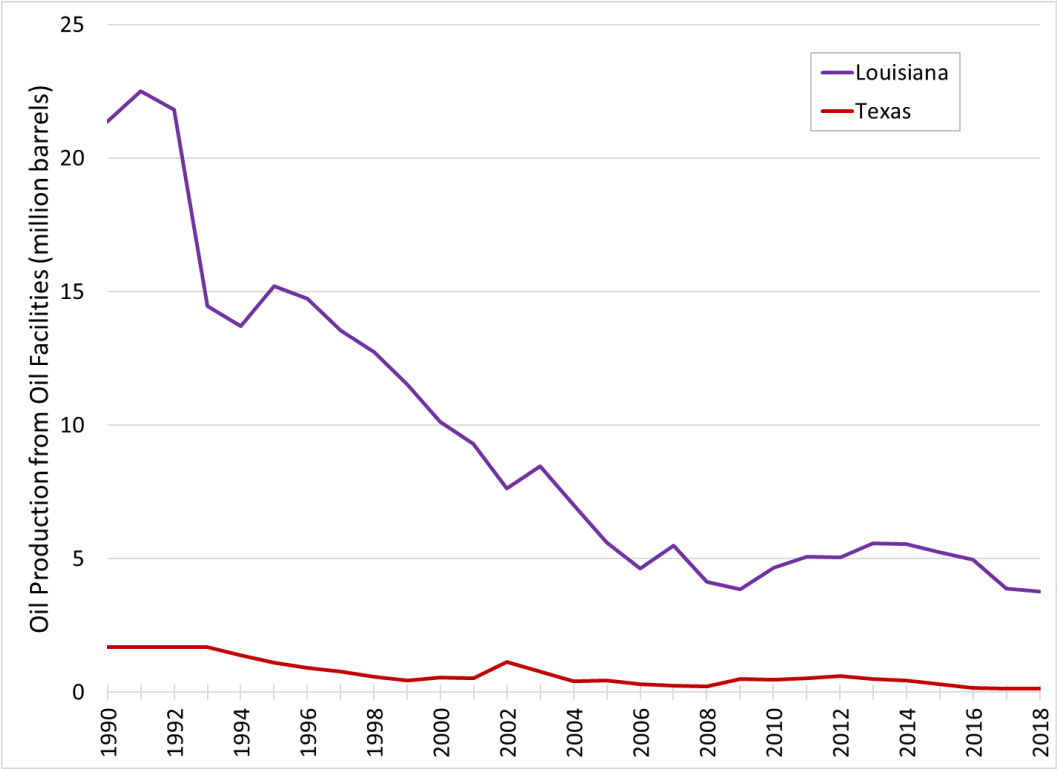

Figure 7. Offshore Oil Production from Oil Facilities in GOM State Waters

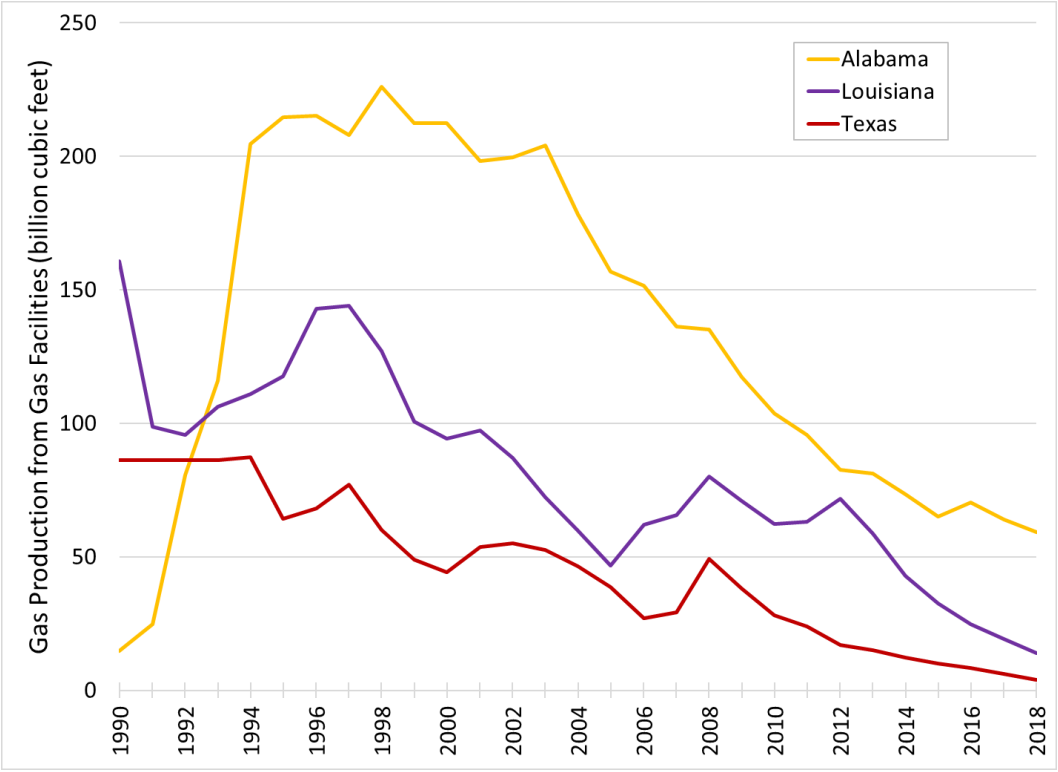

Figure 8. Offshore Gas Production from Gas Facilities in GOM State Waters

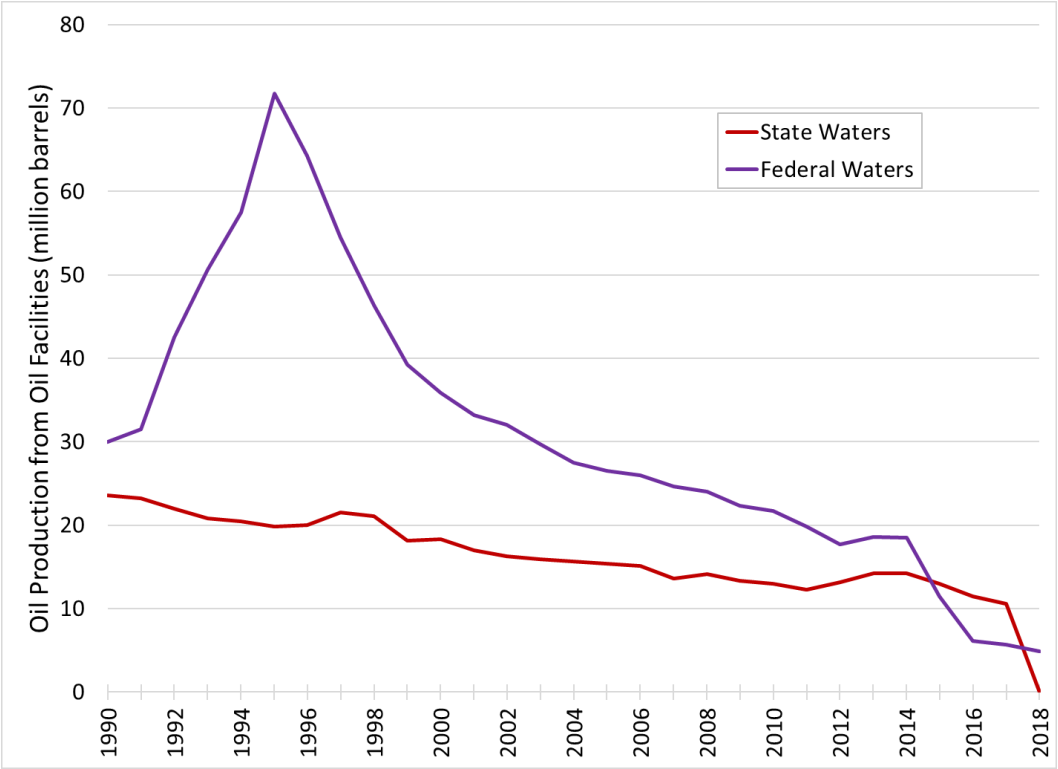

Figure 9. Pacific Federal and State Waters Oil Production from Oil Facilities

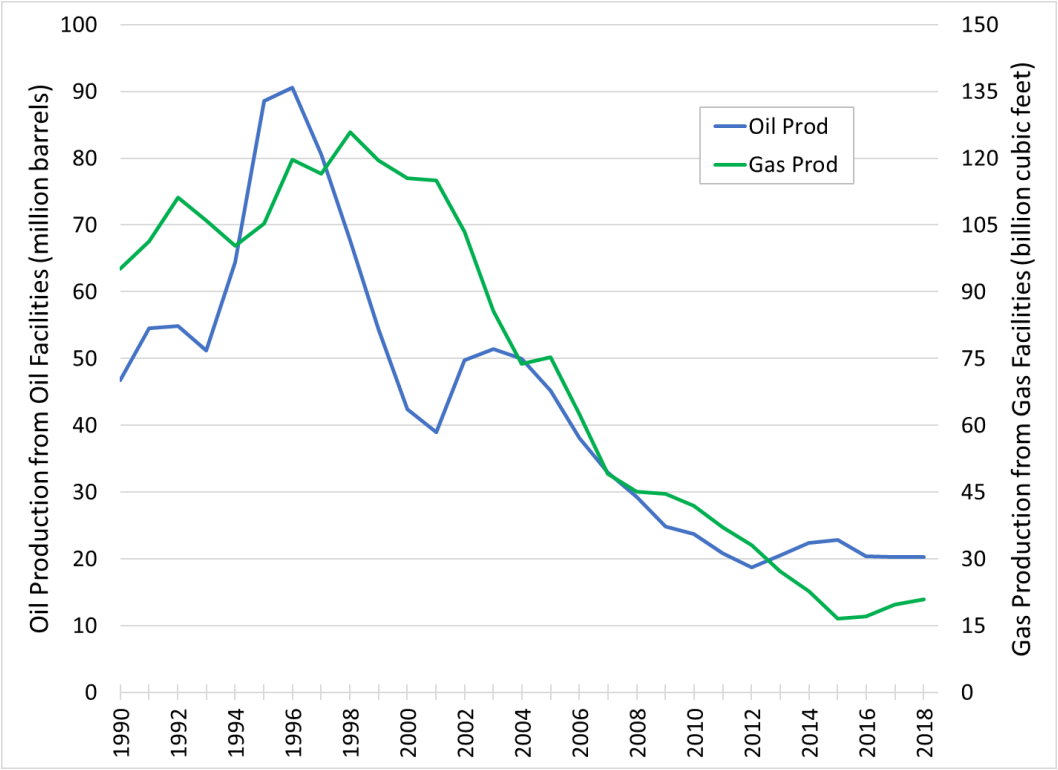

Figure 10. Alaska State Waters Production

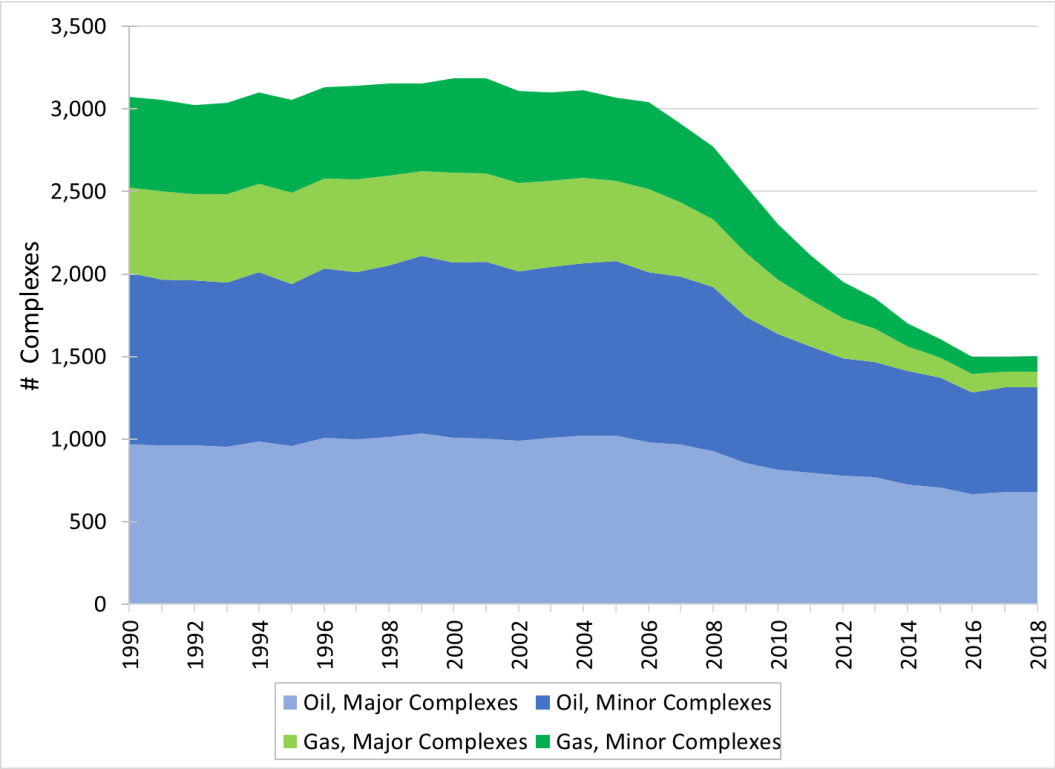

Figure 11. GOM Federal Water Oil and Gas Complex Counts for the 2020 GHGI Updates Under Consideration

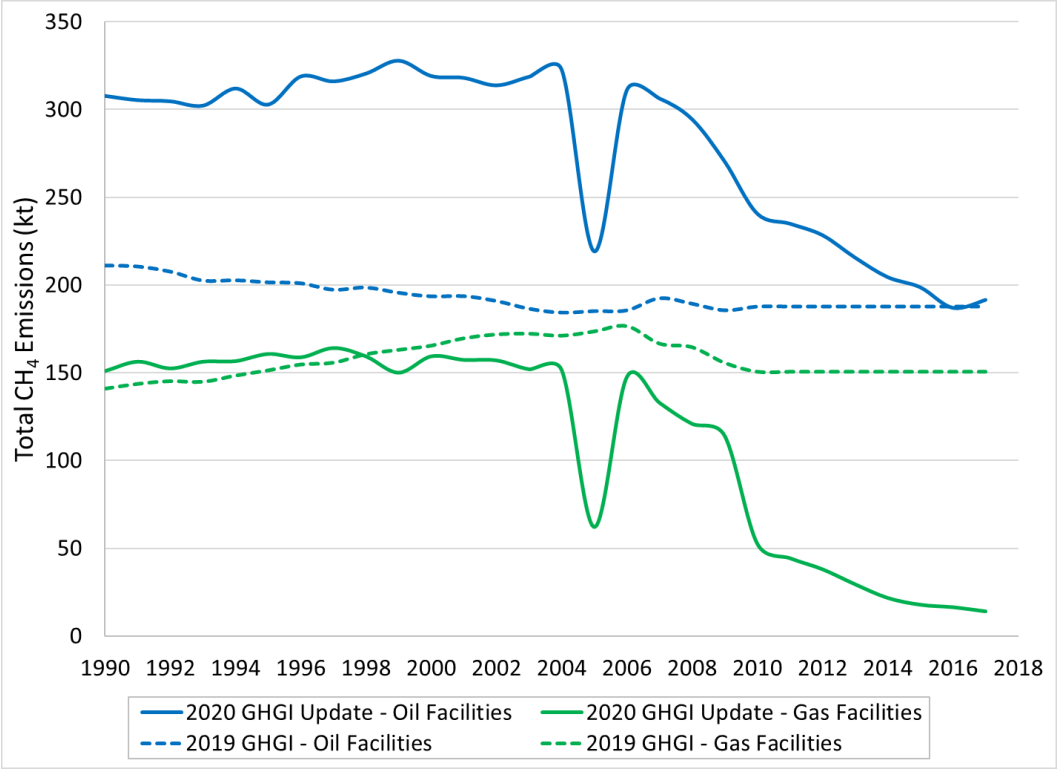

Figure 12. GOM Federal Waters Offshore Production CH_4 Emissions by Production Type (Oil and Gas Facilities) for 2020 GHGI Updates Under Consideration Compared to 2019 GHGI Emissions

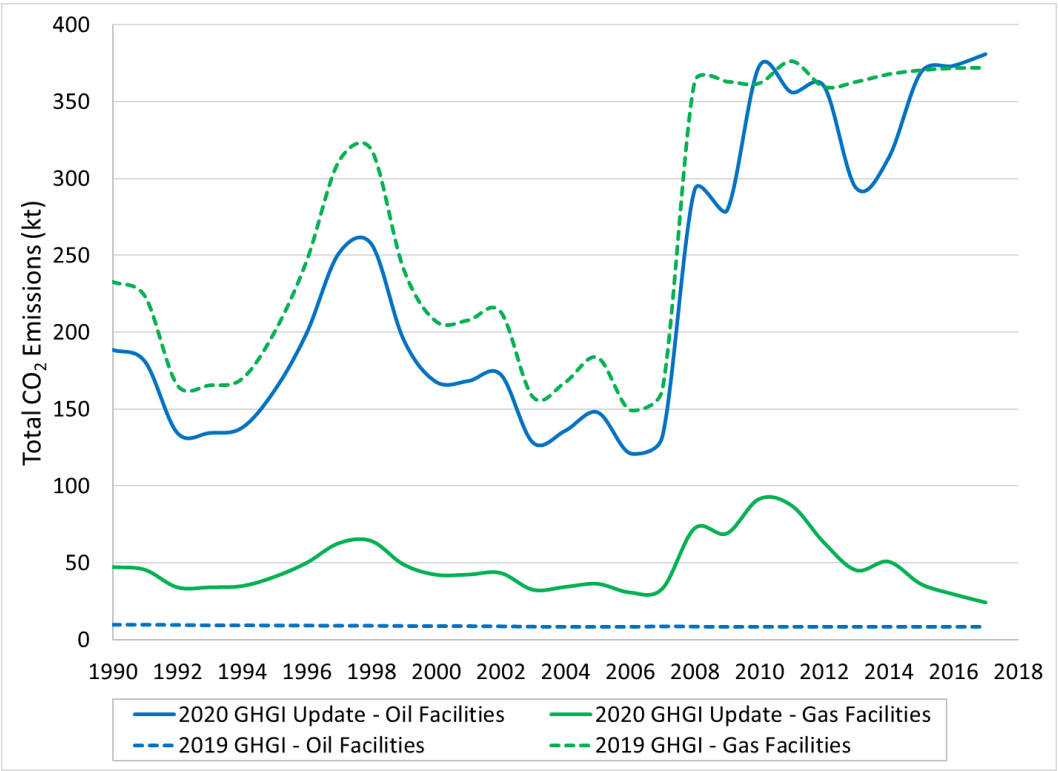

Figure 13. GOM Federal Waters Offshore Production CO_2 Emissions by Production Type (Oil and Gas Facilities) for 2020 GHGI Updates Under Consideration Compared to 2019 GHGI Emissions

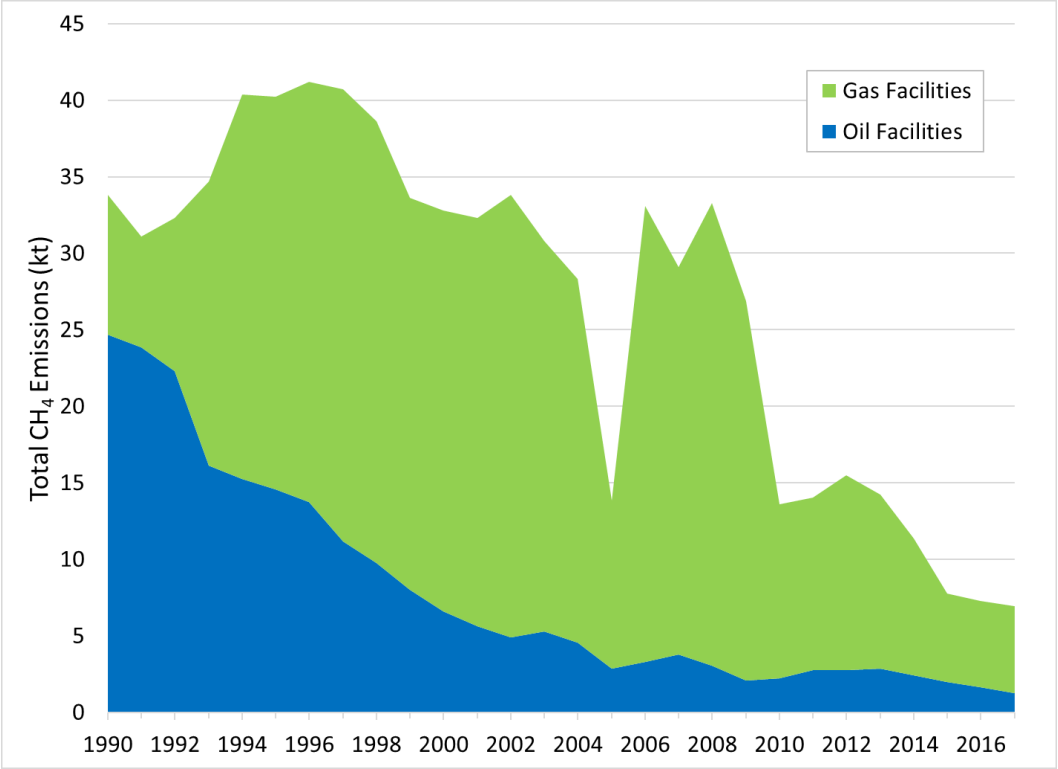

Figure 14. GOM State Waters Offshore Production CH_4 Emissions for 2020 GHGI Updates Under Consideration

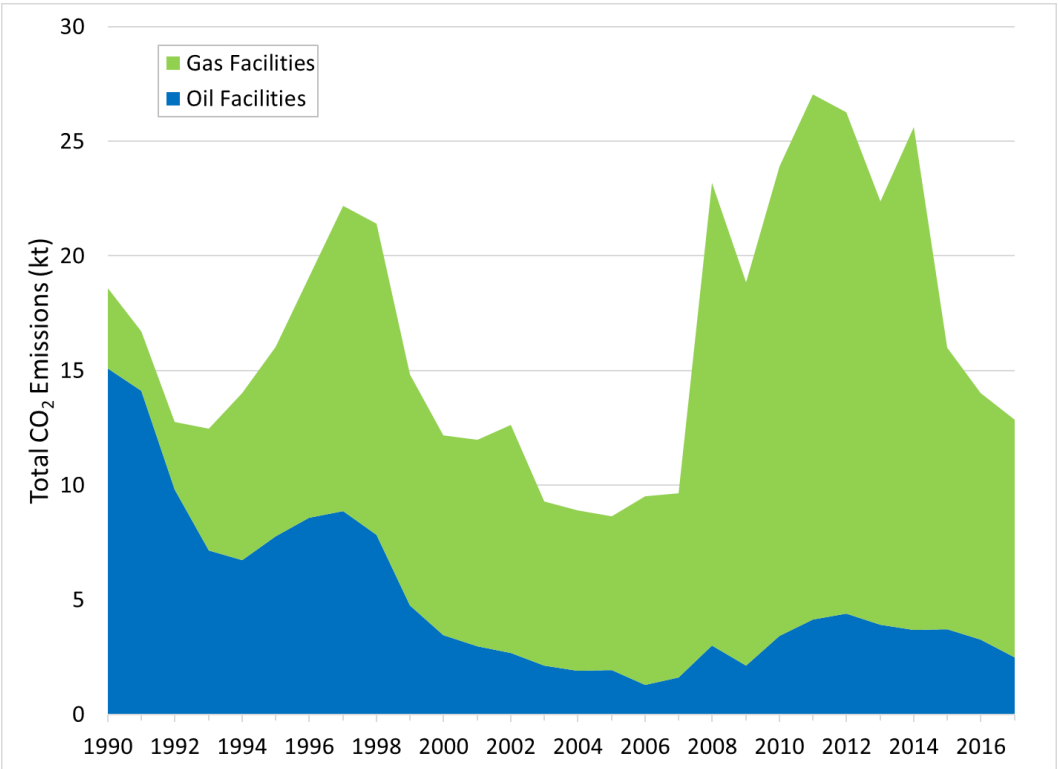

Figure 15. GOM State Waters Offshore Production CO_2 Emissions for 2020 GHGI Updates Under Consideration

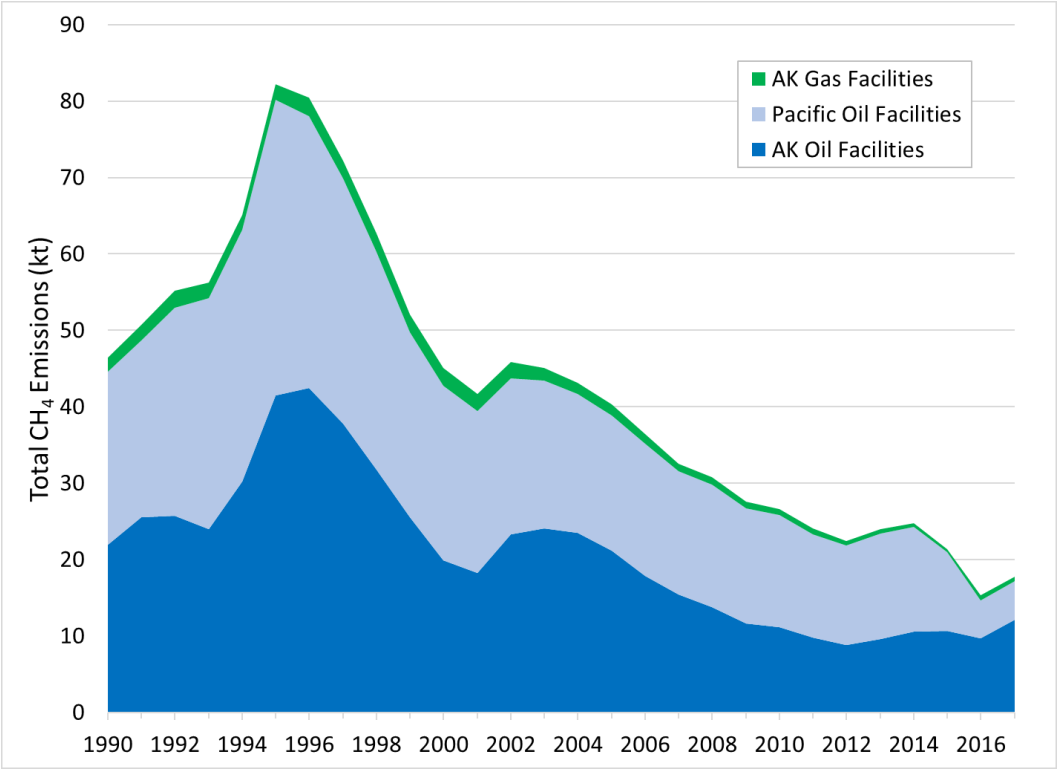

Figure 16. Pacific and Alaska Region Offshore Production CH_4 Emissions for 2020 GHGI Updates Under Consideration

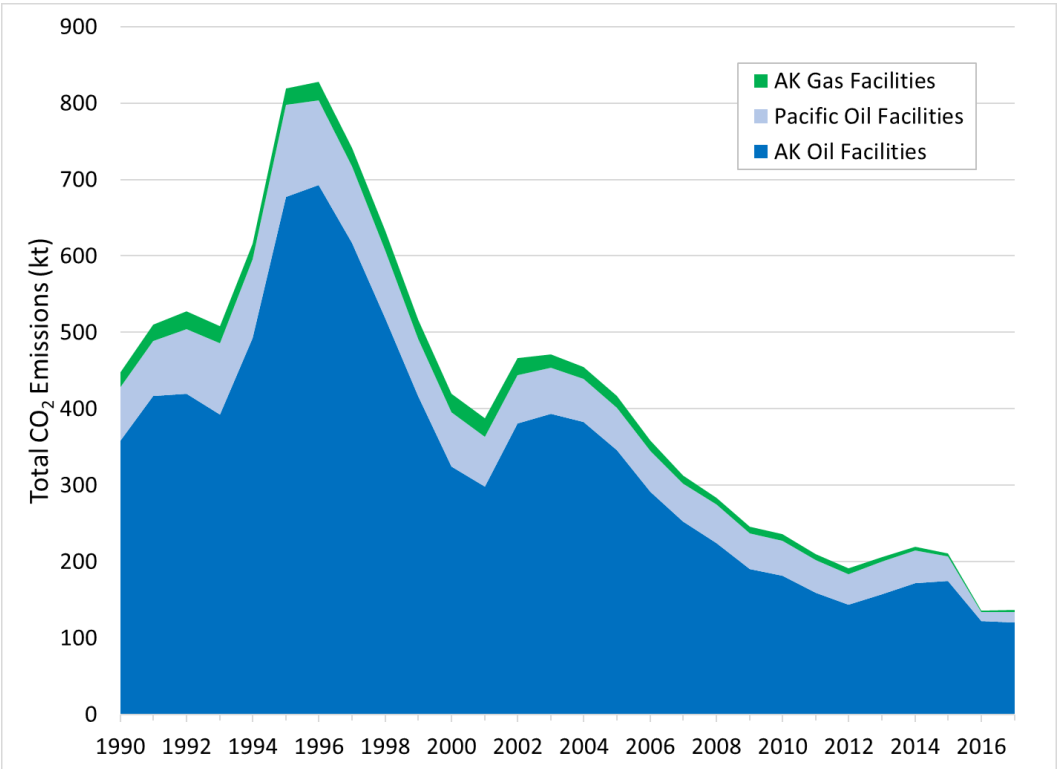

Figure 17. Pacific and Alaska Region Offshore Production CO_2 Emissions for 2020 GHGI Updates Under Consideration

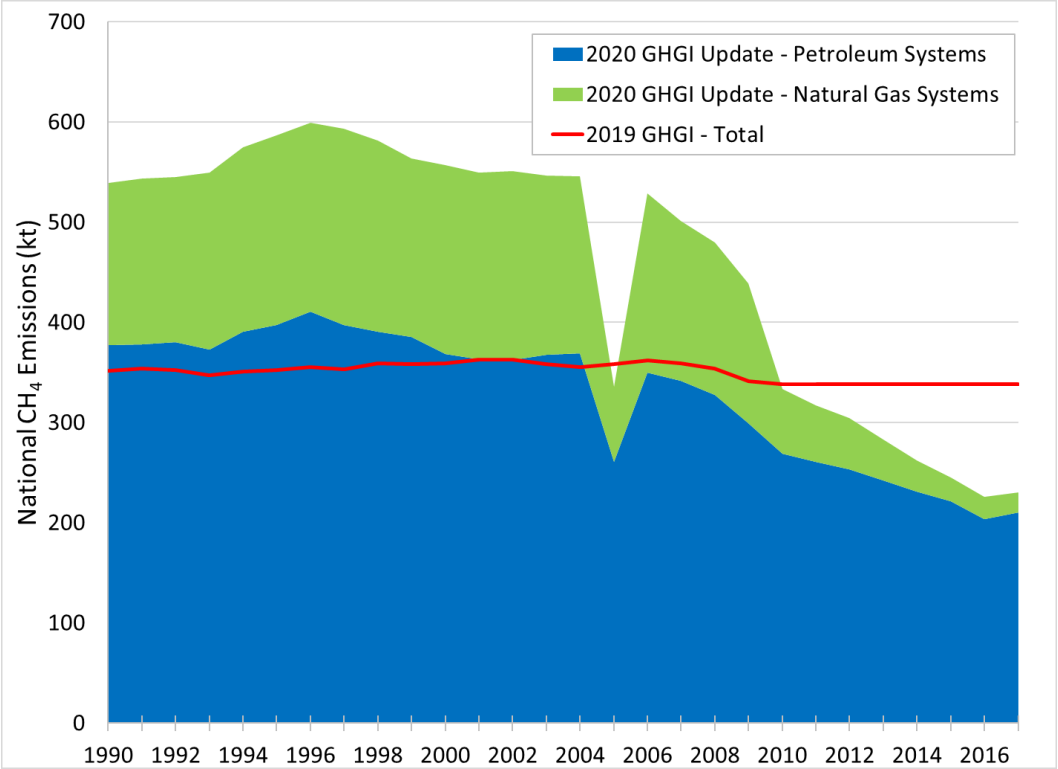

Figure 18. Offshore Production Total CH_4 Emissions For Updates Under Consideration for the 2020 GHGI Compared to 2019 GHGI Emissions

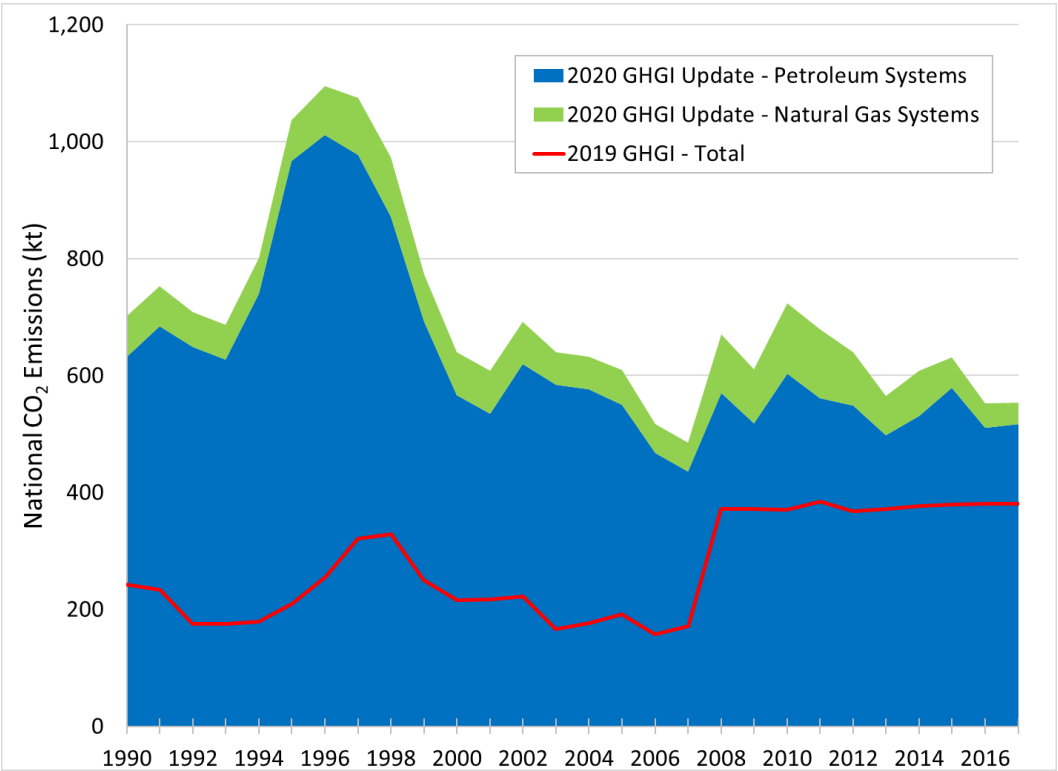

Figure 19. Offshore Production Total CO_2 Emissions For Updates Under Consideration for the 2020 GHGI Compared to 2019 GHGI Emissions