Gulf of Mexico GHG Analysis Updates for Lease Sale 261

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LIST OF ABBREVIATIONS AND ACRONYMS

AEO	Annual Energy Outlook
BOEM	Bureau of Ocean Energy Management
CH_4	methane
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
EIA	Energy Information Administration
EIS	environmental impact statement
GHG	greenhouse gas
GLEEM	Greenhouse Gas Life Cycle Energy Emissions Model
GOM	Gulf of Mexico
GOM Lease Sales 259 and 261 Supplemental EIS	*Gulf of Mexico OCS Oil and Gas Lease Sales 259 and 261: Final Supplemental Environmental Impact Statement*
Gulf of Mexico GHG Analysis Corrected Addendum	*Gulf of Mexico OCS Oil and Gas Leasing Greenhouse Gas Emissions and Social Cost Analysis: Addendum to the Gulf of Mexico Lease Sales 259 and 261 Supplemental EIS and Technical Report – Corrected*
IWG	Interagency Working Group on the Social Cost of Greenhouse Gases
MarketSim	Market Simulation Model
NEMS	National Energy Modeling System
N_2O	nitrous oxide
OCS	Outer Continental Shelf
OECM	Offshore Environmental Cost Model
SC-GHG	social cost of greenhouse gases
U.S.	United States
USEPA	U.S. Environmental Protection Agency

GULF OF MEXICO GHG ANALYSIS UPDATES FOR LEASE SALE 261

1 INTRODUCTION

The *Gulf of Mexico OCS Oil and Gas Leasing Greenhouse Gas Emissions and Social Cost Analysis: Addendum to the Gulf of Mexico Lease Sales 259 and 261 Supplemental EIS and Technical Report – Corrected* (Gulf of Mexico GHG Analysis Corrected Addendum (BOEM 2023b); supplements the greenhouse gas (GHG) results provided in the *Gulf of Mexico OCS Oil and Gas Lease Sales 259 and 261: Final Supplemental Environmental Impact Statement* (GOM Lease Sales 259 and 261 Supplemental EIS) (BOEM 2023a). For GOM Lease Sale 261, the Bureau of Ocean Energy Management (BOEM) conducted an update of its GHG analysis. Updated results are included in this document.

BOEM updated its analysis to include the most recent available information. Namely, this analysis updates BOEM's modeling to include certain provisions of the Inflation Reduction Act, which were modeled by the U.S. Energy Information Administration (EIA) in their 2023 Annual Energy Outlook (AEO) (EIA 2023). The EIA modeled certain provisions of the Inflation Reduction Act. However, given its complexity and uncertainty over select implementation details, not every Inflation Reduction Act provision could be modeled in the 2023 AEO release. This update is responsive to requests from stakeholders to evaluate the GHG emissions using a baseline that includes Inflation Reduction Act provisions.

2 UPDATES TO THE MODELS

BOEM has made several updates to the models that are used to estimate GHG emissions as part of the analysis. Since publication of the Gulf of Mexico GHG Analysis Corrected Addendum, BOEM has updated the

- modeling baseline in the Market Simulation Model (MarketSim) with new data from the EIA, including EIA's 2023 AEO, which incorporates provisions of the Inflation Reduction Act;
- upstream emissions factors in the Offshore Environmental Cost Model (OECM) using both internal and third-party data; and
- Greenhouse Gas Energy Emissions Model (GLEEM) with annual updates of data from the U.S. Environmental Protection Agency (USEPA) and EIA (updating from 2021 to 2022 data).

This information has been used to reanalyze the impacts and review the conclusions provided in the Gulf of Mexico GHG Analysis Corrected Addendum.

2.1 MarketSim Baseline Assumptions and the 2023 AEO

BOEM estimates GHG emissions and social costs associated with oil and natural gas leasing on the Outer Continental Shelf (OCS) (the Leasing scenario) and with potential energy market substitutes in the

absence of leasing (the No Leasing scenario). BOEM's MarketSim estimates that changes in baseline supply, demand, and prices of energy markets as they respond to the anticipated additional OCS production. BOEM uses the baseline energy forecast provided by the EIA. BOEM's previous GHG analysis for the GOM Lease Sales 259 and 261 Supplemental EIS used a MarketSim baseline derived from EIA's 2020 AEO. BOEM updated the baseline data to the AEO 2023, which provides EIA's most recent outlook on energy markets and includes certain provisions of the Inflation Reduction Act. As part of the baseline update, BOEM also updated certain elasticity values in MarketSim (refer to **Appendix A**). The elasticities are used in MarketSim to estimate changes in quantity demanded and supplied in response to changes in price and vice versa. The updated MarketSim baseline and the related elasticities lead to small but relevant changes in the estimated substitution patterns. The updated substitution rates are presented below in **Table 1**. A detailed description on substitution is provided in the MarketSim documentation (Industrial Economics Inc. 2021).

Table 1. Substitution of Other Energy Sources under the No Leasing Scenario.

Substitute Energy Source	Percentage of the Leasing Scenario's Forgone Production*
Onshore production	29
Onshore oil	9
Onshore gas	20
Production from existing State/Federal offshore leases	**
Imports	45
Oil imports	44
Gas imports	2
Coal	**
Electricity from sources other than coal, oil, and natural gas***	1
Other energy sources****	6
Reduced demand	17

Notes: The percentages in this table represent the percent of forgone production that is replaced by a specific energy source (or in the case of reduced demand, the percent of forgone production that is not replaced and represents reduced consumption) with the selection of the No Leasing scenario. The numbers can be interpreted as the percentage of Leasing scenario anticipated production that would be replaced by another source (e.g., 20% of the anticipated production if the Leasing scenario had occurred would be replaced by onshore natural gas production).

* Numbers may not sum due to rounding.

** These substitution rates are less than 0.5%.

*** Includes electricity from wind, solar, nuclear, and hydroelectric sources.

**** Includes primarily (roughly 80%) natural gas liquids, with the balance from biofuels, refinery processing gain, product stock withdrawal, liquids from coal, and "other" natural gas not captured elsewhere.

Substitution rates are used to estimate the different fuels that replace forgone OCS production in the No Leasing scenario. The most significant change in the substitutions for this GOM Lease Sale 261 analysis is an increase in the estimate of reduced demand, which was 13 percent in the original analysis and is now estimated to be 17 percent. This modeling suggests that a larger portion of forgone OCS production in the No Leasing scenario would not be replaced with other energy sources, thereby not resulting in any upstream, midstream, or downstream emissions.

2.2 Updates to the OECM's Upstream GHG Emission Factors

BOEM calculates upstream GHG emissions associated with both the Leasing scenario and the No Leasing scenario using the Offshore Environmental Cost Model (OECM). For detailed information, refer to the OECM documentation *Forecasting Environmental and Social Externalities Associated with Outer Continental Shelf (OCS) Oil and Gas Development – Volume 1: The 2018 Revised Offshore Environmental Cost Model (OECM)* (Industrial Economics Inc. 2018a) and *Volume 2: Supplemental Information to the 2018 Revised Offshore Environmental Cost Model (OECM)* (Industrial Economics Inc. 2018b). The OECM calculates the Leasing scenario's GHG emissions using BOEM's estimates of activity and production from Alternative A[1]. The OECM calculates the No Leasing scenario's GHG emissions using MarketSim's estimated rates of substitution by other energy sources in the absence of OCS leasing.

To estimate the GHG emissions, the OECM relies on many emission factors for specific portions of those activities and substitutions. Most of the OCS-related emission factors are derived from BOEM air emissions inventories. For this analysis, BOEM updated many of those emissions factors from the 2014 Inventory (Wilson et al. 2017)[2] to the most recently available 2017 Inventory (Wilson et al. 2019)[3]. For the No Leasing scenario, BOEM focused its update on the emissions factors associated with the substitute energy sources and activities that generate the most emissions. Due to the timing of the GOM Lease Sale 261 analysis (given the lease sale must be held by September 30 in accordance with the Inflation Reduction Act), BOEM prioritized the OECM emission factors based on their relative impact to the results. BOEM asked the contractor performing the updates to focus on those activity categories' emission factors that had the largest impact. **Appendix B** includes information on the updated emission factors and sources from those in the published 2018 OECM documentation. In addition to ongoing internal work, BOEM is continuing to work with its contractor to identify updated sources of air emissions factors. BOEM will update emissions factors that are not updated in this analysis as they become available for future analyses.

2.3 Updates to GLEEM and the Midstream and Downstream Inputs

The 2023 version of GLEEM includes changes compared to the previous 2022 version of GLEEM. BOEM updated values from the EIA for the national fossil fuel production and consumption patterns, non-combusted fuels, and processing gain. The updated values from the USEPA include emissions from refineries, natural gas systems, and coal processing. The 2023 version also added a new category of consumed fuels, i.e., petroleum coke. BOEM has adjusted the conversion rates used for changing volumes of coal and natural gas to units of energy to be consistent with MarketSim.

[1] Just like with the previous analysis, BOEM used the mid-activity production scenario that was used for the *Gulf of Mexico OCS Oil and Gas Lease Sales: 2017-2022; Gulf of Mexico Lease Sales 249, 250, 251, 252, 253, 254, 256, 257, 259, and 261 – Final Multisale Environmental Impact Statement* for modeling market response, GHG emissions, and social costs. However, this analysis assumes a start date of 2024 for the scenario (BOEM 2017).

[2] https://www.boem.gov/environment/environmental-studies/2014-gulfwide-emission-inventory.

[3] https://www.boem.gov/environment/environmental-studies/ocs-emissions-inventory-2017.

3 UPDATED ESTIMATES

The updates to the models result in new estimates of GHG emissions for the evaluated alternatives. This is due to the changes in substitution rates, upstream emissions factors, and midstream and downstream data used in GLEEM. **Table 2** presents the updated GHG emissions for the domestic upstream, midstream and downstream, and full lifecycle.

Table 2. Domestic Production and Consumption Life Cycle GHG Emissions (in thousands of metric tons).

	Upstream				Midstream and Downstream				Life Cycle			
	CO_2e	CO_2	CH_4	N_2O	CO_2e	CO_2	CH_4	N_2O	CO_2e	CO_2	CH_4	N_2O
Leasing	**8,327**	6,913	53	*	**362,181**	356,208	213	2	**370,508**	363,121	266	2
No Leasing	**40,430**	26,931	536	*	**295,780**	291,932	130	2	**336,210**	318,863	666	2
Difference	**(32,102)**	(20,018)	(483)	*	**66,401**	64,276	83	0	**34,299**	44,258	(400)	0

Note: For ease of comparison, BOEM provides combined totals of all three GHG emissions in CO_2 equivalent, or CO_2e. CH_4 and N_2O are converted to CO_2e using USEPA current Global Warming Potentials (USEPA 2021b) of 25 and 298, respectively. Values are rounded to nearest 1,000 metric tons.

* Values are between -0.5 and 0.5.

3.1 Updates to Upstream GHG Emissions

As a result of updates to the baseline, AEO-derived elasticities, and updates to emission factors, the upstream GHG emissions for both the Leasing and No Leasing scenarios are lower than those used for the Gulf of Mexico GHG Analysis Corrected Addendum (BOEM 2023b). However, upstream GHG emissions for the Leasing scenario have decreased more than those from the No Leasing scenario. This increases the difference between upstream emissions from the Leasing and No Leasing scenarios. As seen in **Table 2**, the Leasing scenario now results in 32.1 million metric tons CO_2e less than the upstream emissions associate with the No Leasing scenario (whereas the GOM Lease Sale 259 analysis estimated the difference to be 23.7 million metric tons, CO_2e).

3.2 Updates to Midstream and Downstream GHG Emissions

The updated midstream and downstream GHG emissions shown in **Table 2** result from changes in MarketSim energy market substitutions and the GLEEM updates mentioned earlier. As a result of these changes, the midstream and downstream GHG emissions in the revised analysis are slightly higher, by half a percent, under the Leasing scenario, while the No Leasing scenario shows an emissions reduction of about 5 percent. However, in part because of the increase in reduced demand as a result of the updated MarketSim, the two scenarios now show a larger difference in midstream and downstream emissions between the alternatives. The incremental midstream and downstream GHG emissions attributable to the Leasing scenario are larger (66.4 million metric tons, CO_2e) than the GOM Lease Sale 259 estimate (50.5 million metric tons, CO_2e).

3.3 Updates to Full Domestic Life Cycle GHG Emissions

The full domestic life cycle GHG emissions (refer to **Table 2**) reflect the combined upstream, midstream, and downstream emissions. The total life cycle emissions' estimates have shifted slightly for both the

Leasing and No Leasing scenarios, increasing the difference between the two alternatives. The domestic life cycle GHG emissions for the Leasing scenario result in 34.3 million metric tons, CO_2e more emissions than the No Leasing scenario (compared to a difference of 26.8 million metric tons, CO_2e).

3.4 Updates to Foreign GHG Emissions

The model updates also impacted the foreign emissions analysis. Over the 40-year period of anticipated production, the updated MarketSim baseline suggests that foreign oil consumption will increase by 173.9 million barrels under the Leasing scenario, which is slightly higher than what was originally estimated (173.5 million barrels) in the Gulf of Mexico GHG Analysis Corrected Addendum (BOEM 2023b). In addition, to the slightly higher foreign oil consumption, the updates to the GLEEM emission calculation (the increase in the percentage of processing gain and the decrease in portion of non-combustion use) applied to this foreign oil consumption resulted in an increase in the downstream GHG emissions for foreign oil consumption attributable to the Leasing scenario.

Table 3 presents the updated estimates. Together, these changes result in slightly higher foreign GHG emissions for the Leasing scenario (67.5 million metric tons, CO_2e) from the previous estimates (66.8 million metric tons, CO_2e) in the Gulf of Mexico GHG Analysis Corrected Addendum (BOEM 2023b).

Table 3. Change in Foreign Oil Consumption GHG Emissions under the Leasing Scenario (in thousands of metric tons).

CO_2e	CO_2	CH_4	N_2O
67,484	67,265	3	1

Notes: Accounts for crude oil and petroleum product consumption only. Values rounded to nearest thousand metric tons.

3.5 Updated GHG Emissions Targets and Carbon Budgets

Table 4 shows the updated analysis in the context of United States GHG emissions targets and carbon budgets. The percent of U.S. targets are lower in 2025 and 2030 given the later start year of this analysis and the fact that production is not anticipated to begin until after 2025. However, given that emissions increased, the percentage of U.S. targets will be greater in later years. The No Leasing columns show the expected emissions from the substitute sources of energy, which would replace OCS oil and gas from the Leasing scenario and the portion of the targets they represent.

Table 4. Comparison Between the Gulf of Mexico Leasing and No Leasing Scenarios and U.S. Emissions Target Reductions (CO_2e, in thousands of metric tons).

Target Year	Leasing CO_2e	Leasing Percent of U.S. Targets	No Leasing CO_2e	No Leasing Percent of U.S. Targets
2025	93	0.002% to 0.002%	*	*
2030	12,111	0.363% to 0.378%	11,084	0.332% to 0.346%
2050	7,453	**	6,838	**

* Signifies no anticipated emissions in reference year. Percentages represent the amount of the U.S. targets that are estimated to be consumed by new leasing on the OCS or substitutions.

** Percentage of the 2050 targets consumed by OCS production, or its substitutes, is blank because by 2050 an equal amount of emissions would have to be removed from the atmosphere to achieve the net-zero emissions target. However, if the amount of emissions removed in 2050 is in fact less than the amount emitted, then any amount of emissions will exceed the U.S. target for 2050, up to 7,453 metric tons in amount.

3.6 Updated Estimates of the Social Cost of GHG Emissions

The updates to the social costs from GHG emissions largely follow the GHG emissions in terms of the differences from the previous analysis. However, two updates not tied to the GHG emissions estimates also influenced the increase in the social costs estimates.

The first change was to the gross domestic price deflator value used to inflate the annual social costs per metric ton of GHG emissions (SC-GHG) values to the appropriate dollar-year. BOEM continues to use the SC-GHG values published by the Interagency Working Group on the Social Cost of Greenhouse Gases (IWG) in their technical report *Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990 in 2021* for this analysis (IWG 2021). BOEM updated the SC-GHG estimates to inflate the IWG's published estimates to the appropriate dollar-year using the gross domestic product deflator. BOEM used the Bureau of Economic Analysis' 2022 gross domestic product price deflator, as released on March 30, 2023, to derive a 2020 (the IWG base year) to 2022 inflation rate of 11.8 percent (BEA 2023).

The second change was updating the assumed start year for the analysis from 2022 to 2024. The emissions are now monetized using the SC-GHGs 2 years ahead of the same activity's year of emissions in the previous analysis. Thus, the SC-GHG applied to the annual emissions estimates are slightly higher since the SC-GHG dollar values increase every year.

Table 5 shows the social cost of the GHG emissions expected from domestic production and consumption in the lifecycle analysis for the Leasing and No Leasing scenarios, respectively. **Table 6** calculates the social cost of GHG emissions resulting from increased foreign consumption of oil under the Leasing scenario.

Table 5. Incremental Change in Domestic Production and Consumption Life Cycle Social Cost of GHG Emissions (2022 $, billions)

Discount Rate	Statistical Damages	Leasing	No Leasing	Incremental
5.00%	Average	4.64	4.34	0.30
3.00%	Average	18.37	16.85	1.52
2.50%	Average	28.04	25.60	2.43
3.00%	95th Percentile	55.98	51.09	4.90

Notes: Values are rounded to nearest $10 million. A positive value is a cost. A negative value is a benefit. Incremental SC-GHG represents the difference between the Leasing scenario and No Leasing scenario. A positive incremental value suggests costs are lower under the No Leasing scenario and higher under the Leasing scenario.

Table 6. Change in Social Cost of GHG Emissions from the Shift in Foreign Oil Consumption Associated with the Leasing Scenario (2022 $, billions)

Discount Rate	Statistical Damages	Incremental Value of SC-GHG from Leasing Relative to No Leasing
5.00%	Average	0.79
3.00%	Average	3.22
2.50%	Average	4.95
3.00%	95th Percentile	9.84

Notes: Values are rounded to nearest $10 million. Values presented are incremental costs of the Leasing scenario's GHG emissions from an increase in foreign oil consumption relative to the No Leasing scenario.

4 UNCERTAINTY OF GHG EMISSIONS ANALYSIS

The modeling updates described above represent aspects of uncertainty within BOEM's analyses. While BOEM has updated this analysis with the most recent available information, there are still many areas of uncertainty. One key area is the estimates of anticipated production and resulting activities. In particular, the forecast of oil compared to natural gas is important. Forgone OCS oil is replaced largely by imported oil. Thus, OCS oil has a lower upstream emissions factor than its substitutes due to the higher estimated GHG emissions per barrel of imported oil. However, forgone OCS natural gas has a very high substitution rate for reduced demand relative to OCS oil, meaning a larger percentage of forgone natural gas is not replaced by substitute energy sources, resulting in no emissions. As BOEM analyzes future lease sales, the ratio of anticipated oil to natural gas production can play a major role in the ultimate life cycle GHG emissions associated with the Leasing and No Leasing scenarios.

5 SUMMARY

While the estimates of incremental domestic full life cycle GHG emissions and foreign GHG emissions for the Leasing scenario have slightly increased compared to the Gulf of Mexico GHG Analysis Corrected Addendum, the conclusions remain the same. The Leasing scenario is expected to result in a higher estimate of lifecycle GHG emissions compared to the No Leasing scenario. BOEM recognizes that there are many uncertainties, such as the proportions of anticipated OCS oil versus natural gas production,

emissions factors, baseline, elasticities, and trends in U.S. energy consumption, which could ultimately impact the conclusions of the analysis. BOEM's updated analysis uses the most recent and best available information for informing leasing decisions.

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A UPDATES TO MARKETSIM

Several updates have been made in MarketSim, and these updates are not reflected in the current documentation published on BOEM's website but are described herein. These updates were made as a result of the 2023 AEO being incorporated into MarketSim's baseline. The EIA provided BOEM with three price cases (i.e., low, reference, and high) of the constrained National Energy Modeling System (NEMS) run of their 2023 AEO. BOEM used the reference case to update the energy market baseline in MarketSim. The constrained run of NEMS is a modified version of the NEMS used in the published 2023 AEO. This constrained run includes an assumption of no new OCS leasing starting in 2023. Removing the EIA's production expectation from new OCS leasing allows investigating alternative new OCS leasing scenarios within the EIA's broad energy market projection using MarketSim.

Beyond the energy market baseline, MarketSim uses detailed elasticities in calculating the energy price, demand, and supply shifts from that baseline in response to anticipated OCS oil and natural gas production. Several of MarketSim's elasticities are derived from AEO data. Some of those elasticities have been updated based on the 2023 AEO data provided to BOEM by EIA.

These updated elasticities are not reflected in the MarketSim documentation currently published on BOEM's website (Industrial Economics Inc. 2021). The updated 2023 MarketSim documentation will be published in or around September 2023, so BOEM is providing this appendix as an interim documentation of those changes not currently reflected in the published documentation. For this analysis, BOEM updated six of MarketSim's supply elasticities from Table 5 in the 2021 model documentation. The updated supply elasticities are shown in **Table A-1**. None of the demand or cross-price elasticities were updated. BOEM uses the low, reference, and high price cases of the constrained NEMS to derive the six updated elasticities. For cases in which the AEO 2023 data yielded elasticity values that were unrealistically high or low, the elasticity values in MarketSim were left unchanged[4].

Table A-1. Updated MarketSim Default Supply Elasticities.

Fuel	Source	Supply-Elasticity
Oil	Alaska Onshore	0.45
Oil	Alaska Offshore	0.70
Natural Gas	Imports pipeline	1.13
Natural Gas	Alaska Onshore	1.93
Natural Gas	Alaska Offshore	1.93
Coal	Imports	1.00

Note: The elasticities from Table 5 in the MarketSim documentation are updated for those elasticities in the table above.

Source: EIA (2023) Annual Energy Outlook 2023: Special constrained NEMS runs of the low oil price, reference, and high oil price 2023 AEO cases by EIA for BOEM.

[4] BOEM worked with the MarketSim contractor, Industrial Economics, Inc., to evaluate and update the elasticity values that rely on the AEO.

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B UPSTREAM AIR EMISSIONS UPDATES

The GHG emissions factors for many categories of activity modeled by the OECM have been updated from those values in the current published documentation. They were updated as part of a current contract and in response to public comments. However, the full updated documentation related to all the work performed by the contractor will not be available before the publication of the updated GHG analysis results ahead of GOM Lease Sale 261. So, BOEM has prepared this appendix, which shows those emission factors that have been updated to new values for the GOM Lease Sale 261 analysis.

These updated emissions factors in the Gulf of Mexico were calculated based on the 2017 emissions inventory (Wilson et al. 2019)[5]. This dataset is the most recent BOEM inventory that includes both facility and vessel information. The emissions factors were calculated by dividing the total emissions across all activity (e.g., emissions from laying pipelines and operating caissons) by the amount of activity for each emissions source. The emission factors calculated for the Gulf of Mexico are assumed for the Pacific and Atlantic planning areas as well.

Beyond the updates to the OCS-related emissions factors, BOEM contracted Industrial Economics, Inc. to update many of the onshore and overseas emission factors used for onshore and overseas substitute sources of energy under the No Leasing scenario. These updated emission factors reflect the technologies used by these emissions sources and, for U.S. emissions sources, emissions controls or limits required under Federal and State regulations. To the extent that emissions vary geographically (e.g., differences in emissions factors for onshore oil produced in different states), the emissions factors also reflect available information on the spatial distribution of activity. These emissions factors were derived from a variety of sources, which are disclosed below in **Table B-1**.

[5] https://espis.boem.gov/final%20reports/BOEM_2019-072.pdf.

Table B-1. Updated OECM GHG Emission Factors.

Emission Source (Units)	Depth Range	Region	CO_2	CH_4	N_2O	Source #
Caisson Production (tons/caisson/year)	All depths	All planning areas	60.15029	17.56665	0.00000	1
Development/Production Wells (tons/well)	All depths	All, except for Alaska planning areas	3,347.34868	0.01974	0.17105	2
Drilling Exploration/ Delineation Wells (tons/well)	All depths	All, except for Alaska planning areas	3,347.34868	0.01974	0.17105	2
Helicopters (tons/platform/year)	All depths	All planning areas	50.80333	0.00098	0.00196	2
Oil Tanker/Cruising - Alaska (tons/million bbl per mile)	N/A	Alaska planning areas and overseas	0.56653	0.00178	0.00003	3
Oil Tanker/Cruising - Lower 48 States (tons/million bbl per mile)	N/A	Atlantic, Gulf of Mexico, and Pacific	1.46847	0.00215	0.00007	3
Oil Tanker/Export Cruising (tons/million bbl per mile)	N/A	All planning areas and overseas	0.56653	0.00178	0.00003	3
Oil Tanker/Export Loading (tons/million bbl)	N/A	All planning areas and overseas	585.61491	1.93011	0.02338	3
Oil Tanker/Loading - Alaska (tons/million bbl)	N/A	Alaska planning areas and overseas	585.61491	1.93011	0.02338	3
Oil Tanker/Loading - Lower 48 States (tons/million bbl per mile)	N/A	Atlantic, Gulf of Mexico, and Pacific	341.99732	1.92634	0.01376	3
Oil Tanker/Unloading - Alaska (tons/million bbl)	N/A	Alaska planning areas	585.61491	1.14261	0.02338	3
Oil Tanker/Unloading - Lower 48 States (tons/million bbl)	N/A	Atlantic, Gulf of Mexico, and Pacific	341.99732	1.13884	0.01376	3
Onshore Coal Production (tons/million short tons)	N/A	Onshore (all areas)	35,595.57085	3,248.46016	0.72580	4
Onshore Gas Production (Conventional) (tons/billion cubic feet)	N/A	Onshore (all areas)	1,174.16262	190.60113	0.00131	5
Onshore Gas Production (unconventional) (tons/billion cubic feet)	N/A	Onshore (all areas)	2,360.31226	74.65348	0.00275	5
Onshore Oil Production (tons/million bbl)	N/A	Onshore (all areas)	11,841.21034	1,059.08919	0.22348	6
Overseas Oil Production (pipeline) (tons/million bbl)	N/A	Overseas	75,103.59348	1,331.14305	0.46633	7
Overseas Oil Production (Tanker) (tons/million bbl)	N/A	Overseas	43,620.99327	773.14253	0.27085	7
Overseas Oil Tanker/Export Unloading (tons/million bbl)	N/A	Overseas	585.61491	1.14261	0.02338	8
Pipe-laying Vessels (tons/mile)	All depths	All planning areas	1,619.76271	0.00848	0.07627	2
Platform Production (tons/platform/year)	All depths	Atlantic, Gulf of Mexico, and Pacific	6,699.56360	180.87573	0.11546	2
Support Vessels (tons/platform/year)	All depths	All planning areas	1,850.81004	0.00753	0.11213	2
Survey Vessels (tons/(platforms + caissons)/year)	All depths	All planning areas	226.00586	0.00084	0.01255	2

bbl = barrel.

Note: The above emission factors update several of the published GHG emission factors that are found in Table 5 of Volume 1 of the OECM (Industrial Economics Inc. 2018).

Sources:
1: (Wilson et al. 2019) Calculations based on 2017 Inventory Study Tables 6-1 and 6-11.
2: (Wilson et al. 2019) 2017 Inventory Study Tables 6-2 and 6-12.
3: (SC&A, Inc. 2023b)
4: (Argonne National Laboratory 2022)
5: (Littlefield et al. 2019) Used data from Appendix F: Full Inventory Results
6: (SC&A, Inc. 2023a)
7: (SC&A, Inc. 2023c) prepared under subcontract to Industrial Economics, Inc. for BOEM, July 18, 2023.
8: Assumed same as Alaska tankers.

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SC&A, Inc. 2023a. Calculation of onshore oil emission factors. Includes WESTAR/WRAP 2014 emission inventory compilation for Western Regional Air Partnership (WRAP) Oil and Gas Work Group (OGWG) spreadsheet from October 2018. Arlington (VA): SC&A, Inc. p. 185.

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SC&A, Inc. 2023c. Overseas oil emission factors. Arlington (VA): SC&A, Inc. p. 2.

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BOEM
Bureau of Ocean Energy Management

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