4B.2

AN ANALYSIS OF, AND COMMUNICATING, LIFE CYCLE GREENHOUSE GAS EMISSIONS FROM OFFSHORE OIL AND GAS LEASING

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1.0 INTRODUCTION

Anthropogenic greenhouse gases (GHGs) emissions, and their subsequent accumulation in the atmosphere, are the primary contributor to climate change (IPCC 2023). The Bureau of Ocean Energy Management (BOEM), the Federal agency responsible for oil and natural gas leasing in Federal waters, has analyzed potential life cycle GHG emissions. This analysis is part of a larger planning process to evaluate environmental impacts to Outer Continental Shelf (OCS) resources from oil and natural gas development.

BOEM conducted life cycle GHG emissions analysis first in 2016 and most recently at the end of 2023, when the bureau completed its process to develop a schedule of lease sales for the 2024–2029 National OCS Oil and Gas Leasing Program (2024–2029 Program).

The methodology has remained largely similar over the years and relies on historical oil and natural gas consumption patterns, emission factors, economic projections, and production estimates. This approach examines emissions from oil and natural gas expected to be produced from the leases issued, as well as emissions that may result from a scenario in which the Federal government does not issue new leases on the OCS. In the latter case, other domestic and foreign sources of energy are used to meet energy demand. BOEM estimates emissions for three different oil and natural gas production volumes for both cases, for a total of six different scenarios. Additionally, the social cost of GHGs (SC-GHG), an estimate of the monetized damages associated with GHG emissions, is applied to the estimated GHG emissions.

There have been changes since BOEM first analyzed the full life cycle of GHG emissions in 2016, including changes in the energy marketplace, litigation, and legislation. In response to these changes, BOEM has made some minor adjustments to the methodology, which now includes estimates of foreign emissions.

Lastly, this complex and sometimes contradictory information must be communicated effectively to decisionmakers and the public. BOEM is seeking to move away from presenting only large data tables towards conveying the information in a more meaningful way.

2.0 METHODOLOGY

This analysis includes emissions from the three most common GHGs: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).

Some GHGs, such as fluorocarbons, have high global warming potential. However, these GHGs are not included in this analysis because they are used in very small quantities offshore (primarily in refrigeration and in circuit breakers) and are not deliberately released. Quantifying this class of GHGs is very difficult, and their contribution from the OCS relative to CO_2, CH_4, and N_2O emissions is very small despite their significantly higher warming potential. Furthermore, calculating these emissions would suggest the analysis has a greater degree of accuracy than is currently possible with the data available to BOEM.

This analysis focuses on emissions from domestic consumption of OCS oil and natural gas, along with the energy sources that may be utilized under a no leasing scenario (in which no new leases are issued between 2024 and 2029). The analysis covers all OCS operations, as well as onshore refining, processing, storage, distribution, and resource consumption. BOEM recently updated the analysis to include changes to overseas emissions resulting from the lowering of global prices as new OCS leasing generates oil. This analysis excludes emissions from fluctuations related to OCS operations, such as changes in oil and natural gas companies' office space, in vehicle fuel efficiency due to changing market conditions, and other secondary factors.

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BOEM uses global warming potentials—also known as carbon dioxide equivalent (CO_2e)—to provide a direct comparison between emissions with different potential to trap heat and different atmospheric lifespans (EPA 2016). For example, one metric ton of CH_4 has a similar impact as 25 metric tons of CO_2e following the Environmental Protection Agency's (EPA's) current approach (EPA 2023a). This analysis uses the 100-year warming potentials from the EPA and the most recent (both 20- and 100-year) warming potentials from the International Panel on Climate Change (IPCC 2023) (see **Table 2-1**).

Table 2-1. Global warming potential

Greenhouse Gas	EPA-100 Year	IPCC-100 Year	IPCC-20 Year
CO_2	1	1	1
CH_4	25	30	83
N_2O	298	273	273

Source: EPA 2023a, IPCC 2023

2.1 *EMISSIONS FROM EXPLORATION, DEVELOPMENT, PRODUCTION, AND TRANSPORT*

BOEM uses the Offshore Environmental Cost Model (OECM) to calculate the total GHG emissions associated with OCS oil and natural gas activity (Industrial Economics Inc. 2023b). OECM provides estimates for the GHG emissions of typical activities associated with OCS production (e.g., platform construction, and oil and natural gas well drilling), including potential oil spills occurring on the OCS. OECM uses economic inputs, oil production estimates, and expected offshore operations as the basis for its calculations.

2.2 *EMISSIONS FROM ONSHORE PROCESSING, STORAGE, DISTRIBUTION, AND CONSUMPTION*

Emissions from processing, storage, distribution, and consumption are calculated with the Greenhouse Gas Life Cycle Energy Emissions Model (GLEEM) (Wolvovsky 2023).

Once onshore, oil is processed into petroleum products for specific uses, such as jet fuel, kerosene, and motor gasoline at onshore refineries. To estimate these emissions, GLEEM uses a ratio of expected OCS production of crude inputs to refineries in 2022 to scale 2022 refinery emissions.

GLEEM takes the same approach for natural gas storage and transmission; the model uses a ratio of expected OCS production and natural gas processed in 2022 to scale the 2022 inventory of natural gas systems emissions.

To estimate fuel consumption, GLEEM assumes all oil and natural gas is consumed in domestic markets. Once again, the model uses 2022 data to estimate the types of petroleum products consumed in the U.S. and in what proportion. GLEEM then calculates expected emissions from fuel consumption using the matching emissions factors.

2.3 *EMISSIONS FROM NON-OCS ENERGY SOURCES*

To evaluate the difference between new OCS oil and natural gas leasing during the 2024–2029 Program and a no leasing scenario, BOEM uses the Market Simulation Model (MarketSim) (Industrial Economics, Inc. 2023a) to estimate the sources of energy used in absence of new leasing to meet energy demand. To determine energy substitutes, MarketSim relies on the Energy Information Administration's Annual Energy Outlook (AEO) data (EIA 2023). The AEO accounts for most current laws and policies, but there is usually a lag in incorporating new factors. Therefore, the current analysis also includes the impact from some of the provisions in the Inflation Reduction Act.

Using this data in OECM and GLEEM, BOEM estimates the GHG emissions that may be emitted from the other sources of energy that the U.S. could use in place of OCS oil and natural gas. These other sources of energy generally include other sources of oil and natural gas (such as production from state waters), onshore domestic production, and international imports. Coal, biofuels, nuclear, and renewable energy sources may also be used in lieu of OCS oil and natural gas, but in lesser amounts. In addition, BOEM's modeling indicates that there likely would be energy conservation, because higher energy prices reduce demand.

For the purposes of these GHG calculations, BOEM assumes nuclear, biofuels, solar, and wind sources have negligible GHG emissions at final consumption, either because the emissions are small by unit or because the volume of energy is less than 1% of the total 2024–2029 Program energy production (BOEM 2023b). Although coal is expected to substitute for a very small portion of OCS oil and natural gas (less than 1% of the energy in the 2024–2029 Program), it

is still evaluated because of its higher rate of GHG emissions per unit of energy.

2.4 *FOREIGN EMISSIONS*

For the 2024–2029 Program, BOEM added an analysis of changes to GHG emissions resulting from the effect on foreign markets of new OCS oil and natural gas leasing increasing oil supply and reducing oil prices in other countries. This particular analysis is the only secondary analysis BOEM currently is able to conduct, and it should be noted that the analysis is not as robust as the domestic analysis described above.

BOEM does not provide a quantitative estimate of the change in GHG emissions associated with the foreign oil refining due to lack of sufficient data on where oil refining would occur and appropriate emissions rates to apply to the refineries that would process the oil. Furthermore, BOEM also does not estimate any impacts from a change in foreign natural gas markets due to the lack of data to make these estimates.

BOEM simplified some assumptions made in emissions calculations to accommodate data gaps (BOEM 2023b). The most significant of these adjustments is the use of a "miscellaneous oil emissions factor" (EPA 2023a) in lieu of a suite of emissions factors.

2.5 *SOCIAL COST OF GREENHOUSE GASES*

The social cost of CO_2, CH_4, and N_2O—together referred to as the SC-GHGs—are estimates of the monetized damages associated with incremental increases in GHG emissions for each year. In February 2021, the Interagency Working Group on the Social Cost of Greenhouse Gases (IWG) published interim estimates under Executive Order 13990 (IWG 2021).

To calculate the total SC-GHG emissions, BOEM applies the IWG's annual SC-GHG estimates to the estimated annual emissions and then discounts the results back to a current value using the same discount rate as the SC-GHGs. Next, the values for each of the three GHGs are combined to derive the total SC-GHG. BOEM repeats this process for every stage in the life cycle for both new leasing and no new leasing scenarios. This calculation is completed for each set of IWG SC-GHG values using the discount rate and statistical damage assumptions for that set of SC-GHG values recommended by the IWG.

3.0 RESULTS

This analysis estimates the life cycle oil and natural gas SC-GHGs on leases that could be issued during the 2024–2029 Program. However, because the analysis was completed before the final decision was made on the number of leases included in the 2024–2029 Program, the analysis was based on a five-lease sale program. The final program specifies three lease sales in the Gulf of Mexico. **Table 3-1** presents the analysis for the five-lease sale scenario.

Table 3-1. Estimated domestic life cycle emissions from the leases in the 2024–2029 Program and the substitute energy sources in millions of metric tons of CO_2e and billions of dollars

Analysis	CO_2e-100 (EPA)			CO_2e-100 (IPCC)			CO_2e-20 (IPCC)			$ SC-GHG[1]		
	High	Mid	Low	High	Mid	Low	High	Mid	Low	High	Mid	Low
Five Lease Sales	1,497	964	234	1,500	966	234	1,528	983	239	70	45	11
No Lease Sales	1,496	967	232	1,510	976	234	1,663	1,074	258	70	46	11
Increment	**1**	**(3)**	**2**	**(10)**	**(10)**	**-**	**(135)**	**(91)**	**(19)**	**-**	**(1)**	**-**
Foreign Change[2]	383	246	58	781	332	58	841	357	62	17	11	3

Notes: [1]SC-GHGs is for the 3% discount rate. [2]Foreign emissions only include production and consumption and use a modified methodology and so cannot be added to the domestic emissions or social cost.

3.1 *LIFE CYCLE NET EMISSIONS*

The results in **Table 3-1** are both highly uncertain and likely very conservative. As such, BOEM presents the estimated numbers because they provide for agency and public review of a "worst-case" level of emissions and corresponding social cost. If progress is made towards reducing overall use of fossil fuels by replacing them with lower-emitting sources of energy, then other sources of energy for OCS oil and natural gas production will shift to lower-emitting fuels. This shift would result in lower estimated emissions than those presented in **Table 3-1**. This shift would impact estimates throughout all four lines in the table.

Overall, BOEM's GHG modeling analysis shows the following:

• Emissions from the extraction of other energy sources are estimated to be higher, in support of the domestic market, than offshore emissions associated with OCS leasing, despite including a reduction in consumption. This result stems from a projected increase in tankering to import oil and the consideration that oil extraction would take place in countries with less stringent air quality emissions regulations and higher GHG intensity per unit of oil than the OCS.

• Processing and consumption emissions from other sources of energy are estimated to be lower than those associated with OCS leasing for both oil and natural gas.

• Total emissions and social costs from other energy sources are similar to OCS leasing overall for the domestic analysis.

For a more in-depth description and data, see BOEM's economic analysis (BOEM 2023b).

Overall, the difference between emissions under the leasing versus no leasing scenarios is quite small. It is particularly important to note this result and to recognize that a change in assumptions used by any of the models and data entered could alter the outcome of which scenario is estimated to have higher GHG emissions.

In addition to estimating changes in domestic emissions from OCS production, BOEM's analysis also considers changes in GHG emissions from foreign oil production and consumption. As new OCS leasing could lower the global price of oil, BOEM estimates emissions associated with resulting changes in foreign oil production and consumption.

As a result of lower prices from new OCS oil leasing, BOEM anticipates decreased foreign oil production and increased foreign oil consumption.

BOEM's current analysis shows that new OCS leasing likely would result in greater foreign emissions, and thus greater social costs, from global GHG emissions than emissions from other sources of energy that would occur without new OCS leasing.

At the global scale, BOEM anticipates a decrease in GHG emissions with new leasing because changes in overseas markets are anticipated to outweigh the smaller domestic shifts.

3.2 *COMPARISON AGAINST GHG EMISSIONS REDUCTION TARGETS*

Another way to conceptualize carbon emissions from new OCS oil and natural gas development is in comparison to emission reduction targets established by the U.S.

The Paris Agreement, to which the U.S. is a party, aims to keep the global average temperature to "well below 2° C above pre-industrial levels" (United Nations Framework Convention on Climate Change 2015). The agreement requires countries to set short-term goals to help stabilize atmospheric GHG concentrations at a level that would limit anthropogenic interference with the climate system to keep the global average temperature increase to within 2°C, and preferably to within 1.5°C. These intermediate goals, which are on the pathway to global net-zero emissions, are referred to as Nationally Determined Contributions (NDCs).

The U.S. set its NDCs using emissions from a base year of 2005. In 2005, net emissions were 6,680,300,000 metric tons of CO_2e (EPA 2023b). The U.S. achieved its 2020 goal to reduce its net GHG emissions by 17% below 2005 levels, in part due to the coronavirus pandemic. Currently, the U.S. has established NDCs for 2025 and 2030, each with a two-percentage point range, 26% to 28% and 50% to 52%, respectively (The White House 2021). There is an additional goal of net-zero emissions by 2050 (U.S. Department of State and U.S. Executive Office of the President 2021); this target is outside of the Paris Agreement framework.

Table 3-2 compares the estimated emissions from the target year to the established reduction targets and shows the percentage of the target that is expected to be consumed under leasing and no leasing scenarios. The percentages in **Table 3-2** likely show a worst-case scenario, as there is the potential for carbon capture and storage to allow for higher emissions than the targets while still achieving the NDCs. With the net-zero emissions target, all GHG emissions would have to be offset by 2050 by removal of an equal amount of GHGs from the atmosphere. Note that the emissions for both leasing and no leasing scenarios in **Table 3-2** include emissions that would occur outside of the U.S., but BOEM is currently unable to isolate just the emissions subject to the targets. Instead, these values represent the emissions that result from supplying the U.S. energy demand.

Table 3-2. GHG emissions from new OCS leases (in thousands of metric tons for years with reduction targets)

Analysis	2025 Target*			2030 Target*			2050 Target
	CO_2e	Low %	High %	CO_2e	Low %	High %	CO_2e
Five Lease Sales	25	0.01	0.010	6,992	0.209	0.218	29,583
No Lease Sales	0	0	0.001	6,286	0.188	0.196	30,116

* U.S. NDC commitment under the Paris Agreement.

4.0 *RESULTS COMPARED TO PAST ANALYSES*

BOEM has conducted this analysis for many previous projects, such as for (most notably) the last national oil and gas program (BOEM 2016), for individual OCS lease sales, and in support of other Federal agencies. Over time and after the passing of the Inflation Reduction Act, BOEM has seen the models reflect an increase of lower-emitting energy sources replacing oil and natural gas under the no leasing scenario. Although these changes have occurred, they have not radically altered net emissions, showing only marginal changes in the difference between new leasing and no new leasing.

A myriad of factors influences the results, but the most notable is the ratio between oil and natural gas in the proposed leasing. Because Gulf of Mexico oil is partially replaced by oil from other—usually more carbon-intense—production streams (BOEM 2023a), while natural gas is expected to be replaced at a higher rate by fuels emitting lower GHGs. As a result, there is a larger drop in emissions when this analysis is conducted on possible leases with a higher proportion of natural gas.

5.0 COMMUNICATION

A difficult, but nonetheless important, challenge is communicating the results to both decisionmakers and the public.

This challenge is compounded by legal mechanics, such as the process of implementing the National Environmental Policy Act (NEPA). This analysis was initially undertaken to support NEPA analysis, which is intended to be a concise explanation of the environmental impacts of a Federal decision. A complex NEPA analysis is expected to be covered in a document with a maximum of 300 pages. In this framework, an explanation of climate change, GHG emissions, and the SC-GHGs would be allocated about four pages (about half the length of this paper), despite the fact that this issue is a critical overarching environmental concern.

BOEM has spent more than decade shifting its NEPA approach to maximize the use of maps and graphics to make better use of limited page space and better engage the audience. Tables can be problematic because they use numbers, which can be difficult for audiences not familiar with the subject matter to understand the key points (Heath and Star 2022). Tables also can run multiple pages. However, replacing tables with graphic visual can have shortcomings for certain situations, such as when bar and pie charts are not the best use of space compared to a table due to the volume of data generated.

For this analysis, the data was simplified to three small tables. This analysis needed to be published before BOEM had time to develop and use a new approach for communicating the data to the public, but there are three ideas currently being advanced.

The first idea is to compare the emissions reduction difference to something directly in people's daily lives. For example, we could give people an idea of how much of a year they would have to cut oil and natural gas products to balance the same percent reduction of GHG emissions in their life, as would occur by not leasing. Another example could be to tell the reader that, if the overall emissions in 2030 fit into a one-gallon jug, then the emissions from the 2024–2029 Program would be on the scale of a teaspoon.

The second idea is to show the number of states that would need to shut down household energy use to reduce GHG emissions to balance the new development.

The third idea would be to develop a map showing the amount of forest that would need to be newly protected to remove an equivalent amount of GHGs from the atmosphere as either leasing scenario, or the no leasing scenario. See **Figure 5-1** for examples of some of these ideas.

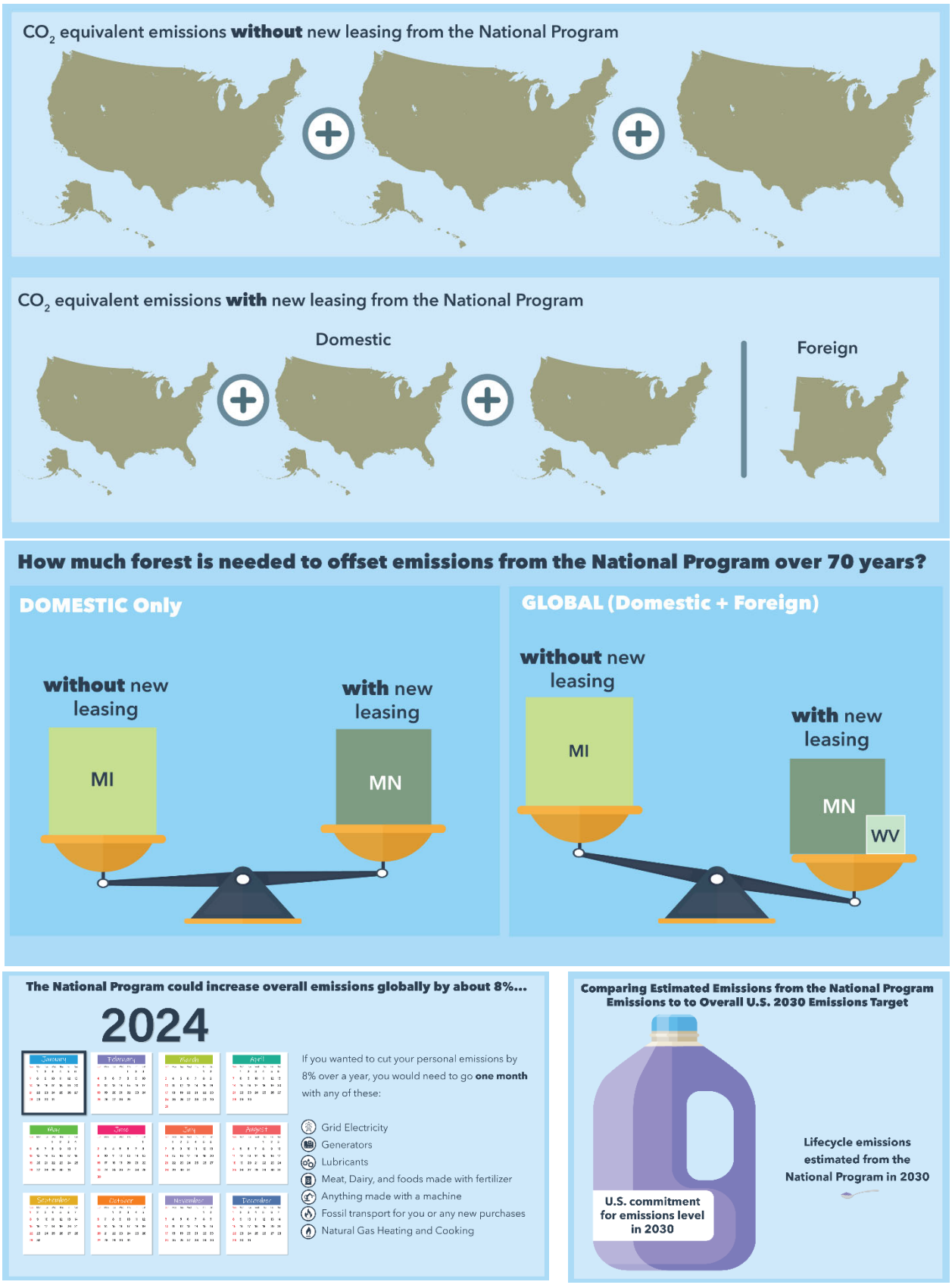

Figure 5-1: Draft ideas on how to present greenhouse gas emission information to decisionmakers and the public in a way that they will understand the information that is important to them.

These are comparisons that people can relate to and can appeal to the audience on an emotional level, which achieves two goals. First, the audience can grasp, at least somewhat, the meaning behind the tables. Secondly, the emotional "connection" prompts the reader to take a position (Heath and Starr 2022). That connection is important as it ensures that a decisionmaker understands the consequences of their decision.

6.0 CONCLUSION

Overall, BOEM expects lower global emissions from new OCS oil and natural gas leasing globally but neutral or even higher emissions domestically. This anticipated outcome may make it harder for the U.S. to meet our climate targets but would shift the world closer to addressing the global climate crisis.

It should be noted that future changes in climate or other policies, supply and demand, legislation, litigation, shifting economic circumstances, or technological advances could substantially affect the assumptions and results of this analysis.

Lastly, BOEM is undertaking new, and hopefully better, ways to communicate this information to both decisionmakers, as well as the public.

7.0 REFERENCES

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