APPENDIX TO

Beyond Expectations: Ocean Solutions to Prevent Climate Catastrophe

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APPENDIX A: Supplemental and Background Information

I. Glossary

- **Barrel of oil equivalent (boe)** – A barrel of oil equivalent (boe) is a unit describing the energy produced from burning one barrel, or 42 U.S. gallons, of crude oil. Both oil and gas production are expressed in boe to be comparable.

- **Business-as-usual (BAU)** – This scenario projects future offshore oil and gas production, and is derived from the International Energy Agency's New Policies Scenario (NPS).[1] The NPS incorporates the impact of existing energy policies and frameworks as well as an assessment of the results likely to stem from the implementation of announced policy commitments. As such, it provides an indication of the direction in which the energy system is heading, noting that this is not a forecast, as these policies and frameworks are certain to evolve in the future. The projections in the New Policies Scenario show significant progress in meeting global energy and environmental goals, with the power sector in the vanguard of the energy transition. However, a continued projected rise in global energy-related carbon dioxide (CO_2) emissions in this scenario is clearly out of step with the objectives of the Paris Agreement.

- **Carbon dioxide equivalent (CO_2e) -** A way to place gas emissions of various radiative forcing agents (methane, nitrous oxide, etc.) in the same context by accounting for their overall effect on climate. It describes, for a given mixture and amount of greenhouse gases, the amount of CO_2 that would have the same global climate warming ability when measured over a specified time period. This report uses the 100-year timescale.

- **2°C emissions gap** - The 2°C emissions gap is the difference between emissions expected if current trends and policies continue on a business-as-usual path, and emissions consistent with limiting average global temperature increase to 2 degree Celsius (relative to pre-industrial levels). Essentially, the gap represents the annual emissions reductions the world needs to achieve by 2050 to stay within the 2 degrees Celsius carbon budget.

- **High Level Panel for Sustainable Ocean Economy –** The High Level Panel is a global initiative launched in 2018 and consisting of 17 world leaders, with its Secretariat based at the World Resources Institute. The High Level Panel commissions research publications through a network of over 250 experts across 48 countries, on key ocean topics including climate change, marine tourism, ocean finance, and coastal resilience. Read more at: https://oceanpanel.org/.

- **International Energy Agency (IEA)** – The International Energy Agency was created in 1974 as an international body for energy, climate change, economics, and clean energy transition policy research. The IEA is made up of 31 member countries and 8 association countries that are already members of the OECD, and a Governing Board consisting of energy ministers from each member country. Read more at: https://www.iea.org/

[1] IEA (2018). World Energy Outlook Special Report: Offshore Energy Outlook 2018. Paris: IEA. 80p.

II. Background and Context in High Level Panel Ocean Solutions

This is a non-exhaustive description of the ocean-based solutions presented by the High Level Panel that have been achieved, or where global efforts are underway that hold promise.

Ocean-Based Renewable Energy

Replacing fossil-based power production with renewable sources like responsibly-sited offshore wind, and wave and tidal power is a vital mitigation strategy, with offshore wind holding the most potential for emissions reductions.[2] Most offshore wind installations are currently based in Europe, but Asia, and specifically China, is expected to significantly build out offshore wind in the coming years.[3] Costs per megawatt-hour are falling and expected to continue to drop as emerging technologies improve efficiency and lower maintenance costs.[4] Offshore wind is becoming cheaper and more competitive compared to fossil fuel energy generation.[5]

Ocean-Based Transport

About 90% of the world's goods are transported by sea.[6] Technical and operational interventions to improve efficiency, utilize batteries, shifting to low or zero carbon fuels, could all contribute to this reduction. The International Maritime Organization (IMO) will adopt a Greenhouse Gas Emissions Plan in 2023 with the goal to reduce emissions by 50% to 100% by 2050.[7] But they could be making more changes now to reduce emissions, such as by decreasing shipping speeds. Recent initiatives and proposals from the Global Maritime Forum, the International Chamber of Shipping, and the European Union aim to help meet the emissions reductions needed in the shipping sector.[8, 9, 10]

***Coastal and Marine Ecosystems*:**

Coastal ecosystems cover less than 2% of all ocean area, yet account for almost half of total natural marine carbon sequestration. Restoring and preventing the further degradation of these habitats, in addition to ending overexploitation of ocean biomass like fish, are important emissions mitigation options. Across the world, countries like Indonesia, Senegal, and the Philippines are exploring protections and restoration of these marine resources. International

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[2] Estimated cumulative installed capacity for offshore wind will reach 2,000 GW by 2050, and tidal and wave cumulative installed capacity will reach 250 GW by 2050. *See* IRENA (2021) Offshore renewables: An action agenda for deployment. Abu Dhabi: International Renewable Energy Agency, 118p.
[3] Williams R, Zhao F, Lee J (2022) Global Offshore Wind Report 2022. Brussels: Global Wind Energy Council. 105p.
[4] Wiser R et al. (2021) Expert elicitation survey predicts 37% to 49% declines in wind energy costs by 2050. *Nature Energy* 6.5: 555-565.
[5] Jansen M et al. (2020) Offshore wind competitiveness in mature markets without subsidy. *Nature Energy* 5.8: 614-622.
[6] OECD (2022) Ocean shipping and shipbuilding.
[7] International Maritime Organization (2022) Greenhouse Gas Emissions. London: IMO.
[8] Global Marine Forum (2020) Poseidon Principles. Copenhagen: Global Marine Forum.
[9] International Chamber of Shipping (2022) Reducing Greenhouse Gas Emissions: A Guide to IMO Regulatory Compliance. London: ICS.
[10] European Commission (2022) Reducing emission from the shipping sector.

efforts like The Blue Carbon Initiative and the International Partnership for Blue Carbon are underway and hold promise.[11, 12]

***Fisheries, Aquaculture, and Dietary Shifts*:**

To reduce emissions from wild capture fisheries, aquaculture, and land-based agriculture, HLP suggests implementing policies that:

- Improve fish catch efficiency – this means rebuilding fish stocks so that more fish can be caught with less effort, which means burning less fuel
- Improve yields – this means improving storage and processing to use more of the fish that is caught which also means expending less fuel for every edible pound of fish caught
- Tax high-emission land-based food production
- Promote shifting diets to healthier and more climate-friendly ocean-based proteins using media and other behavior-change campaigns

Countries like The United States, Canada, Australia, and members of the European Union have implemented fisheries management policies and protections aimed at stopping overfishing and rebuilding fish stocks, which should improve catch efficiency over time as fish stocks recover, however, even these countries have a ways to go.[13, 14, 15, 16] Efforts to raise the profile of sustainable, ocean-based food include The Aquatic Blue Food Coalition and The Blue Food Assessment, which offers science-based recommendations for policy makers to drive solutions that encourage a shift to ocean-based foods.[17, 18]

Carbon Storage in the Seabed

More research is needed before this could be considered a safe and viable net emissions reduction solution, given the serious concerns around sequestration projects associated with offshore gas production and uncertainty over whether storage is truly durable.[19, 20] The HLP report describes direct injection of CO_2 from power plants into the seabed, lakes, containment vessels, and the deep ocean, as well as alkalinity addition and ocean fertilization to capture atmospheric CO_2, as potential options for emissions reductions. The report notes that proposals for carbon storage in the seabed should be measured against substantial risks to marine ecosystems, and that "to date, sub-seabed storage has been used only to facilitate the extraction

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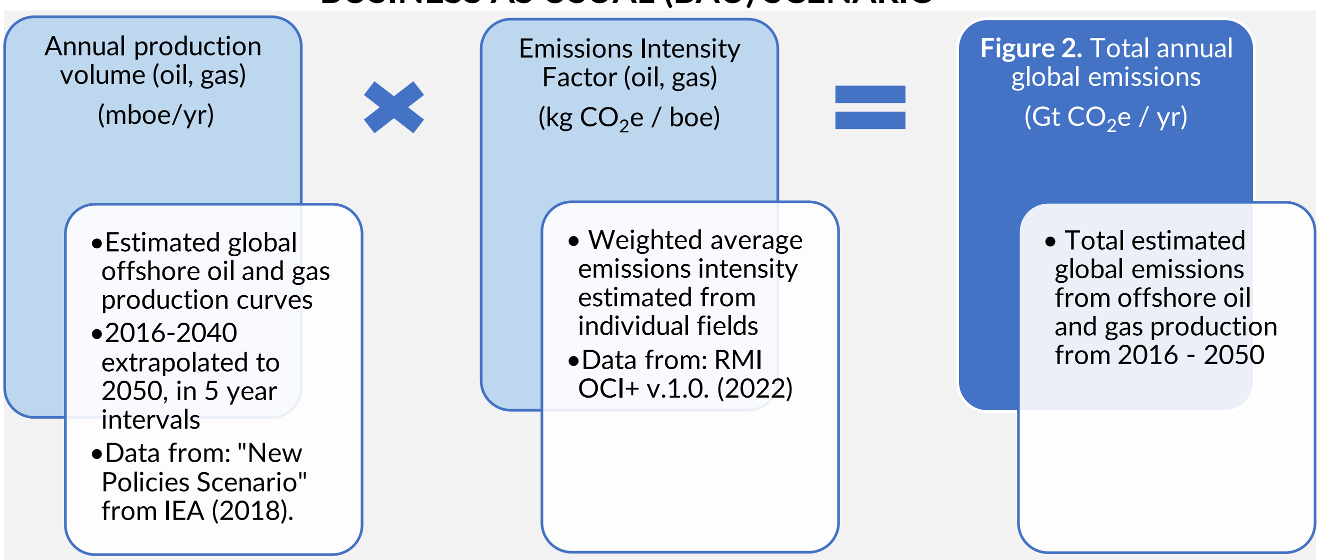
[11] The Blue Carbon Initiative (2019) Mitigating Climate Change Through Coastal Ecosystem Management. Conservation International.
[12] International Partnership for Blue Carbon (2022) About the Partnership. IPBC.
[13] Oceana (2022) The Magnuson-Stevens Act: World's Leading Fisheries Management under threat.
[14] Oceana (April 14 2022) Oceana Canada Celebrates Government Release of Regulations that Give Canada the legal Backing to Rebuild Depleted Fisheries.
[15] Australian Fisheries Management Authority (2022) AFMA and economics. Australian Government.
[16] Oceana (2021) Common Fisheries Policy: Mission Not Yet Accomplished. Birdlife International, ClientEarth, FishSec, Oceana, OurFish, Seas At Risk, WWF, 16p.
[17] Environmental Defense Fund (2022) The Aquatic Blue Food Coalition.
[18] Blue Food Assessment (2022) The Blue Food Assessment. Stanford: Standard Center for Ocean Solutions & Center on Food Security and the Environment.
[19] Monastersky R (2013) "Seabed scars raise questions over carbon-storage plan." *Nature* 504.7480: 339-340.
[20] Lichtschlag A, Haeckel M, Olierook D et al. (2021) Impact of CO2 leakage from sub-seabed carbon dioxide storage on sediment and porewater geochemistry. *International Journal of Greenhouse Gas Control* 109: 103352.

of natural gas from the Norwegian coast. Thus, the net flux of carbon has been from the seafloor to the atmosphere, not the other way around."

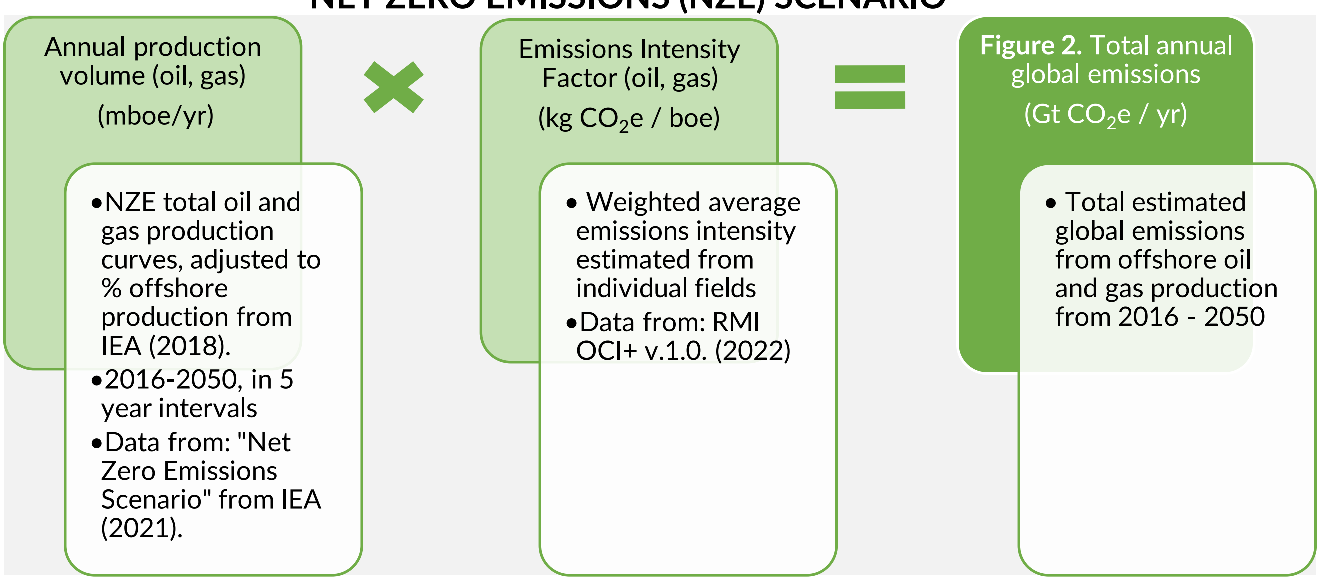
APPENDIX B: Offshore Oil and Gas Emissions Methodology

III. GHG Emissions Analysis Overview

BUSINESS AS USUAL (BAU) SCENARIO



NET ZERO EMISSIONS (NZE) SCENARIO



2050 EMISSIONS MITIGATION POTENTIAL (Report Figure 2)

Total annual global emissions under BAU in 2050 (Gt CO_2e / yr) − Total annual global emissions under NZE in 2050 (Gt CO_2e / yr) = **Total emissions mitigation potential in 2050** (Gt CO_2e / yr)

IV. Scenarios Included in Analysis

All offshore oil and gas production scenarios are based on analysis from the International Energy Agency's World Energy Model. The **Business-as-Usual (BAU) scenario** in this report is derived directly from the International Energy Agency's (IEA) "New Policies Scenario" (NPS) from the 2018 Offshore Energy Outlook report.[21] Throughout this appendix and the main report, data and projections from this scenario are referred to as BAU. According to the IEA:

> "The New Policies Scenario incorporates the impact of existing energy policies and frameworks as well as an assessment of the results likely to stem from the implementation of announced policy commitments. As such, it provides an indication of the direction in which the energy system is heading (noting that this is not a forecast, as these policies and frameworks are certain to evolve in the future). The projections in the New Policies Scenario show significant progress in meeting global energy and environmental goals, with the power sector in the vanguard of the energy transition. However, a continued projected rise in global energy-related carbon dioxide (CO_2) emissions in this scenario is clearly out of step with the objectives of the Paris Agreement."[22]

The **Net Zero Emissions (NZE) scenario** in this report is modified from the scenario in IEA's Net Zero by 2050 report as a global pathway to net-zero emissions in the energy sector by 2050.[23] See Section V "Estimating Offshore Oil and Gas Production" below for more details. According to the IEA:

> "This is a normative IEA scenario that shows a narrow but achievable pathway for the global energy sector to achieve net zero CO_2 emissions by 2050, with advanced economies reaching net zero emissions in advance of others. This scenario also meets key energy-related United Nations Sustainable Development Goals (SDGs), in particular by achieving universal energy access by 2030 and major improvements in air quality. The NZE does not rely on emissions reductions from outside the energy sector to achieve its goals, but assumes that non-energy emissions will be reduced in the same proportion as energy emissions. It is consistent with limiting the global temperature rise to 1.5°C without a temperature overshoot (with a 50% probability)."[24]

In summary, the key difference between the two scenarios is the exploration and development of <u>new</u> offshore oil and gas fields driven by different demand conditions.

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[21] IEA (2018). World Energy Outlook Special Report: Offshore Energy Outlook 2018. Paris: IEA. 80p.
[22] *Id* at page 14.
[23] IEA (2021). Net Zero by 2050: A Roadmap for the Global Energy Sector.
[24] *Id* at page 6.

In the NPS, global demand continues to increase and new fields are developed. This will encourage continued investment in existing fields to maintain production (as per NZE), but sufficiently strong demand/price signals could also encourage further investment in existing fields to recover every last drop (e.g., enhanced recovery techniques for resources that are now economically viable). The degree to which this plays out is highly dependent on price changes.

In the NZE, global demand for oil and gas declines and no new fields are developed. To meet the demand levels modelled in the NZE with existing fields, operators must continue to invest to maintain production – reducing average reservoir depletion rates from ~8% per annum to ~4% per annum. For more information on the technical data and assumptions included in the model, see [IEA (2021) World Energy Model Documentation].[25]

V. Estimating Projected Offshore Oil and Gas Production

All historical and projected offshore oil and gas production data for the BAU and NZE scenarios are derived from IEA's World Energy Model. IEA reports and projects offshore oil production in daily production volumes (million barrels of oil per day, Mbo/d). Annual offshore gas production is reported as billion cubic meters (bcm), which was converted to million barrels of oil equivalent (Mboe) using a conversion factor of 5.88.[26]

For the BAU scenario, we used offshore oil and gas production curves from the New Policies Scenario in the IEA (2018) Offshore Energy Outlook report (*see* Supp Table 1).[27] Since IEA projections of crude oil and gas production volume only extend out to 2040, we extrapolated the 2045 and 2050 production volumes based on the preceding 5-year growth trajectory:

$$Volume_{x[oil,gas]} = \left(\frac{V_{x-5} - V_{x-10}}{V_{x-10} + 1}\right) \times V_{x-5}$$

$Volume_x$ or V_x — Total production volume of either offshore oil (Mbo/day) or gas (bcm) in year x (2045 or 2050)

Supplemental Table 1. Offshore oil and gas production curves under the BAU scenario (i.e., the "New Policies Scenario" (NPS) from IEA). *See* p66 of IEA (2018) Offshore Energy Outlook.

YEAR	2000	2015	2016	2025	2030	2035	2040	2045*	2050*
Oil Production (Mbo/d)									
World	**75**	**92**	**92**	**98**	**99**	**100**	**102**	**104**	**106**
Onshore	50	65	65	70	71	72	73	74	75
Offshore	25	27	27	28	28	28	29	30	31
Shallow water	*23*	*21*	*21*	*20*	*19*	*19*	*19*	*19*	*19*
Deep water	*2*	*6*	*6*	*8*	*9*	*9*	*10*	*11*	*12*

[25] IEA (October 2021). World Energy Model Documentation.
[26] BP (2022) Approximate conversion factors from the Statistical Review of World Energy.
[27] *See* p66 of IEA (2018), Offshore Energy Outlook.

Offshore % of Total	33%	29%	29%	29%	28%	28%	28%	29%	29%
Natural Gas Production (bcm)									
World	**2,506**	**3,592**	**3,621**	**4,174**	**4,546**	**4,950**	**5,306**	**5,688**	**6,097**
Onshore	1,848	2,596	2,597	2,945	3,123	3,352	3,574	3,811	4,063
Offshore	658	996	1,024	1,229	1,423	1,598	1,732	1,877	2,035
Offshore converted (Mboe/d)	10.8	16.4	16.8	20.2	23.4	26.3	28.5	30.9	33.4
Shallow water	*633*	*913*	*934*	*1,009*	*1,118*	*1,209*	*1,271*	*1,336*	*1,405*
Deep water	*25*	*83*	*90*	*220*	*304*	*389*	*461*	*546*	*647*
Offshore % of Total	26%	28%	28%	29%	31%	32%	33%	33%	33%

** Future production only projected to 2040; volumes extrapolated based on growth rate from previous 5 years.*

Offshore oil and gas production volumes under the NZE scenario are derived from the IEA (2021) Net Zero by 2050 report.[28] IEA (2021) only reports total oil and gas production volumes between 2010 and 2050 for this scenario and does not distinguish between onshore and offshore sources. Because there are no other data points available to determine the onshore versus offshore split in the NZE scenario, we aligned assumptions from the other IEA scenarios. To estimate the volume of offshore oil and gas, we calculated the average percent of total fuel production that is offshore in each year between the IEA (2018) NPS and SDS scenarios. The total NZE oil and gas production curves were then adjusted to reflect only offshore production based on this offshore percentage split (*see* Supp Table 2). In reality, as demand and production decline over time in the NZE scenario, oil and gas assets will be broadly phased out in order of cost (i.e., most expensive first) — this depends on many factors and detailed cost breakdown analysis is beyond the scope of this report.

Supplemental Table 2. Offshore oil and gas production curves under the NZE scenario from IEA (2021). Total oil and gas (onshore and offshore) adjusted based on the average offshore percentage split found in the IEA (2018) NPS and SDS scenarios. *See* Figure 3.3, p102 of IEA (2021) Net Zero by 2050.

YEAR	**2015**	**2016**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Oil Production (Mboe/day)								
Total oil	94.5	94.7	86.3	71.7	56.1	42.6	31.6	24.1
*Offshore % of Total (Avg)**	29%	29%	29%	28%	28%	28%	29%	30%
Offshore oil	27.7	27.8	24.8	20.3	15.5	12.0	9.1	7.2
Gas production (bcm)								
Total gas	3,573	3,619	4,290	3,718	2,834	2,143	1,898	1,746
*Offshore % of Total (Avg)**	28%	28%	29%	31%	32%	33%	33%	34%
Offshore gas	990	1,023	1,265	1,163	914	700	628	586

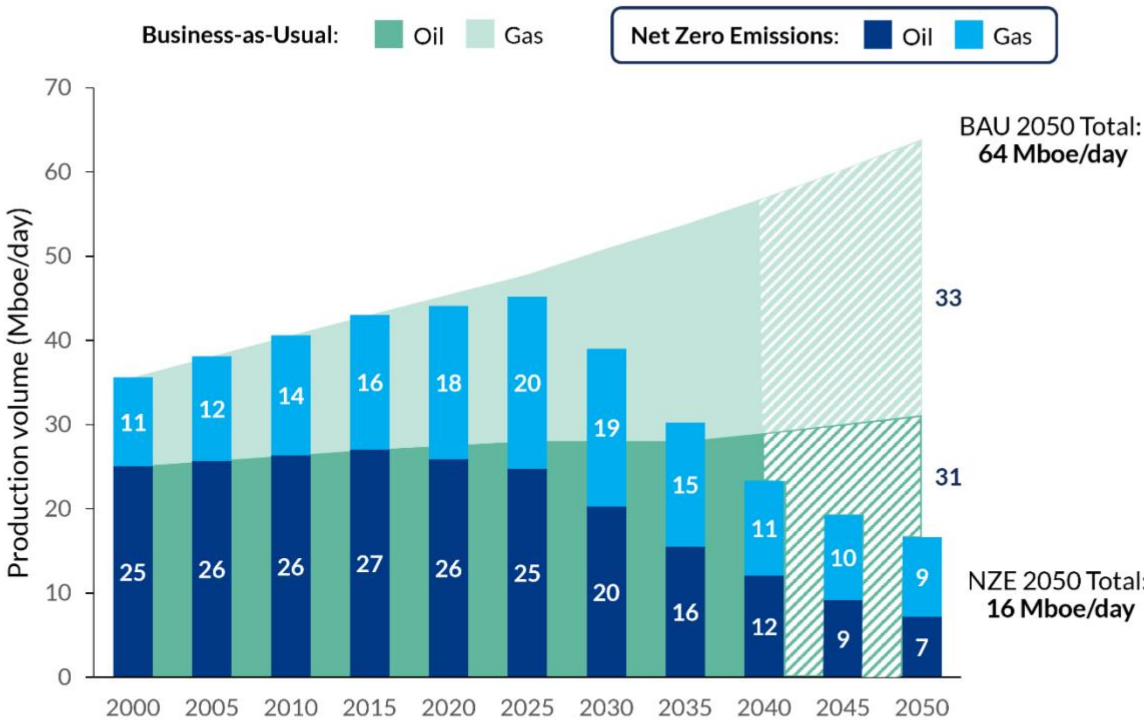
[28] Raw data for download at: IEA (May 2021). Net Zero by 2050 Scenario, Figures and data by chapter.

Offshore gas converted (Mboe/d)	16.3	16.8	20.8	19.1	15.0	11.5	10.3	9.6

** Offshore percent of total oil or gas production is the average of the breakdown from the BAU/NPS projections and the SDS projections. SDS data not presented here but is available in the IEA (2018) report.*

Under BAU, daily production volume of offshore oil and gas increased from 44 Mboe/day in 2016 to 64 Mboe/day by 2050 (*see* Supp Figure 1). Under the NZE scenario, offshore oil and gas production eventually decreases from 44 Mboe/day to 16 Mboe/day by 2050 (*see* Supp Figure 1). By 2050, the energy policies modelled for NZE leads to 48 Mboe/day less production of offshore oil and gas.

Supplemental Figure 1. Comparison of change in offshore oil and gas production volumes from 2000 to 2050 in the business-as-usual scenario vs. the Net Zero Emissions scenario. Striped wedges indicate 2050 trajectory not provided by the IEA; volumes between 2040 to 2050 are extrapolated using growth rate of the previous 5 years.



VI. Estimating Projected Global Emissions from Scenarios

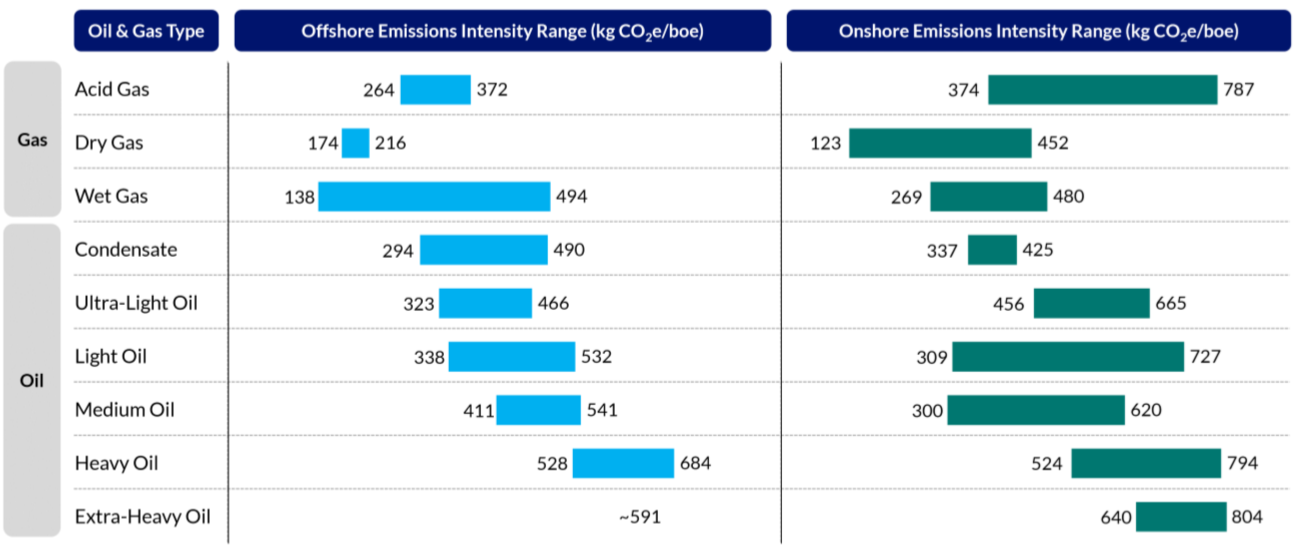
Emission factors used to estimate the total greenhouse gas emissions for both scenarios were calculated using field-level data from the RMI Oil Climate Index plus gas (OCI+) model.[29] OCI+ quantifies and compares life-cycle greenhouse gas emissions intensities from global oil and gas assets on a field-by-field basis, from upstream production, midstream refining, and downstream transport and end uses of the fuel (*see* Supp Table 3). Upstream processes include both offshore and onshore operations required to produce and transport crude fuels to the

[29] RMI (2022) Oil Climate Index plus gas v.1.0. Methodology.

refinery gate. The midstream stage includes all activities related to crude oil/gas refineries. Downstream emissions encompass consumer-end emissions, notably from the transport of petroleum products to end-users, and the burning of those petroleum products in different consumer contexts. Emissions at all stages include both direct and indirect sources, such as emissions in the electricity and materials used for refining or transport. This model used the global warming potential (GWP) for methane (CH_4) of 34 times greater than CO_2 on a 100-year timescale.[30]

The data available from OCI+ covers approximately 50% of the world's oil and gas fields, with 87 offshore oil fields and 48 offshore gas fields included in the dataset. Note that the emissions intensities of fuels produced offshore is different from those produced onshore (see Supp Figure 2). For each individual field, we multiplied the emissions intensity per barrel by the total quantity of oil and gas produced for each of those fields. Field-level emissions were then summed across all offshore oil and gas to get total emissions.

Supplemental Figure 2. GHG emissions intensity ranges for offshore and onshore oil and gas, by fuel type. GHG emissions in kg CO_2e per boe.



[30] The Global Warming Potential is based on the cumulative radiative forcing over a time horizon of 100 years, including climate-carbon feedbacks. Note that the IPCC is discussing whether to increase the methane GWP in AR6. If this change is operationalized, it will be updated in future OCI$^+$ versions. *See* Table 8.7 in IPCC (2013) Chapter 8: Anthropogenic and Natural Radiative Forcing. *In:* Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, p714.

Supplemental Table 3. Lifecycle emission sources included in RMI OCI+ model for this analysis, and the average emissions intensity across each stage for oil and gas.

Lifecycle Stage	Emission Source	Average Emissions Intensity (oil *n* = 87, gas *n* = 48)
Upstream (industry)	Exploration	Oil = 48 kg CO_2e / boe Gas = 40 kg CO_2e / boe
	Drilling and development	
	Crude production and extraction	
	Surface processing	
	Maintenance	
	Waste disposal	
	Crude transport	
	Other small sources	
	Offsite emissions credit/debit	
Midstream (industry)	Electricity	Oil = 28 kg CO_2e / boe Gas = 3 kg CO_2e / boe
	Heat	
	Steam	
	Hydrogen via steam methane reforming	
	Hydrogen via catalytic naphtha reforming	
	Other emissions	
Downstream (consumer)	Transport of petroleum products to consumers	Oil = 422 kg CO_2e / boe Gas = 181 kg CO_2e / boe
	Transport of liquified natural gas to consumers	
	Transport of pipeline gas to consumers	
	Gasoline for cars	
	Jet fuel for planes	
	Diesel for trucks and engines	
	Fuel oil for boilers	
	Petroleum coke for power	
	Liquid heavy ends for ships	
	Natural gas liquids	
	Liquefied petroleum gases	
	Petrochemical feedstocks	
	Natural gas	
Methane	Upstream	Oil = 23 kg CO_2e/boe Gas = 19 kg CO_2e/boe
	Midstream	*NA*
	Downstream	Oil = 2 kg CO_2e/boe Gas = 20 kg CO_2e/boe

Total offshore emissions intensities were then calculated separately for each fuel type (oil vs. gas). To get the weighted average emissions intensity of each type of offshore fuel, total offshore oil or total offshore gas emissions across the summed individual fields were divided by total offshore oil or total offshore gas production (*see* equation below). This results in a weighted average emissions intensity of 498 kg CO_2e/boe for offshore oil and 223 kg CO_2e/boe for offshore gas (*see* Supp Table 4).

$$EF_{oil,gas} = \sum_{i=1}^{n} \left(\frac{Emissions_i}{Volume_i} \right)$$

$EF_{oil,gas}$	Total lifecycle emissions intensity of either offshore oil or gas in kg CO_2e per one barrel of oil equivalent (boe).
i	Individual field.
n	Total number of fields included in dataset. $n = 86$ for offshore oil, $n = 48$ for offshore gas.
$Emissions_i$	Total emissions estimated for individual field i, including upstream, midstream, downstream, and methane, in Mt CO_2e/yr.
$Volume_i$	Total oil or gas production volume in 2020 for individual field i, in barrels of oil equivalent (boe).

Supplemental Table 4. Emissions intensity factors for offshore oil and gas, calculated as the weighted average of available individual field-level emission estimates. Includes upstream, midstream, downstream, and methane emission.

Offshore Fuel Type	Average Total Emissions Intensity (kg CO_2e / boe)
Oil	498
Gas	223

Because the OCI+ only provides data on ~50% of global oil and gas production, the average emissions intensity values were applied as the emissions factor to the IEA's BAU and NZE estimates for global offshore oil and gas production to calculate total global offshore oil and gas emissions in each scenario. Finally, we calculated the difference in total projected annual emissions in 2050 between BAU and NZE to get the emission mitigation potential of 6.3 Gt CO_2e/yr.

VII. Emissions Estimates in Climate Goal Context

We calculated the percent contribution of the emission mitigation potential from the NZE scenario to annual GHG emissions reductions needed to stay under a 2°C change relative to pre-industrial levels.[31] Emission gap values are prepared by the United Nations Environmental Programme (UNEP) to estimate the emission levels permissible for the world to progress on a

[31] *See* Table ES-2, p10 from Hoegh-Guldberg O et al. (2019) The Ocean as a Solution to Climate Change: Five Opportunities for Action. Washington DC: World Resources Institute.

pathway to achieve the goals of the Paris Agreement.[32] We used emission gap values from 2018 that the original HLP analysis reported on in order to demonstrate a comparable range of mitigation potential from all ocean-based solutions. The offshore oil and gas NZE was also added to the five existing HLP ocean-based solutions and was compared to the 2°C gap in 2050 to generate the percentage of the emissions gap mitigated by ocean-based solutions.

Supplemental Table 5. Annual GHG emissions reductions needed by the given target year to stay under a 1.5°C or 2°C warming pathway, relative to pre-industrial levels.

Target Year	**Emissions Gap (Gt CO_2e/yr)**	
	1.5°C pathway	2°C pathway
2030	30	19
2050	56	47

VIII. Top Offshore Oil and Gas Producing Countries

Data for the top offshore oil and gas producing countries are based on 2017 estimates from Rystad Energy field-level data (*see* Supp Table 6).[33] Production figures are rounded and percentage estimates are based on a total of 43.8 Mboe/day offshore oil and gas production .[34] Note that we did not have direct access to oil and gas production data from Rystad Energy because data access in Rystad's U-Cube platform must be purchased.

Supplemental Table 6. Estimates of offshore oil and gas production by country in 2017, in descending order for production volume, and percent of total offshore production. Figure 3 in report text.

Country	**Oil Production (Mboe/day)**	**Gas Production (Mboe/day)**	**Total (Mboe/day)**	**% of Total Offshore Production**
Other	*7.8*	*4.09*	*11.89*	*26%*
Saudi Arabia	3.9	0.9	4.8	10%
Norway	2	2.1	4.1	9%
Qatar	1.4	2.5	3.9	8%
Iran	1.5	1.8	3.3	7%
Brazil	2.4	0.3	2.7	6%
US	1.9	0.5	2.4	5%
Mexico	1.8	0.3	2.1	5%
United Arab Emirates	1.7	0.3	2	4%
United Kingdom	1	0.7	1.7	4%
Angola	1.6	0	1.6	3%
TOTAL	27	16.8	43.8	-

[32] UNEP (2018) The Emissions Gap Report 2018. Nairobi: United Nations.
[33] Ivanova M & Westwood D (Jan 13, 2017) Top 10 Offshore Producing Countries in 2017. *In*: Offshore Magazine.
[34] IEA (2018) Offshore Energy Outlook: Special Report.