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Supplementary Information

Calculating Methane Emissions from Offshore Facilities Using Bottom-Up Methods

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Table S1. Estimated emissions from Type 1 platforms during normal operations. Emission factors taken from the EPA emission factor database [24,25]. Assuming an average wind speed in the Gulf of Mexico of 8 m s^{-1}.

Equipment	Description	Activity	EPA Emission factor	Emission (kg h^{-1})
Gas Outlet	Pipelines to shore	1	N/A	0
Oil/Condensate	Pipelines to refinery onshore	1	N/A	0
Separators	1 high pressure, 2 low pressure	3	969 kg separator^{-1} y^{-1}	0.3
Water Treatment	Water stored in the gravity base structure.	42.7 bbl h^{-1}	51 kg CH_4 Mbbl water^{-1}	2.2
Gas Flaring	Flaring gas to control emissions from loading operations and emergency releases. Destruction efficiency of 98%.	7.4 bbl h^{1}	5 g bbl^{-1}	0.04
Gas Venting	Vents from Chemical Injector pumps (CI) and dehydrators (D).	1 0.03 MMscf h^{-1}	CI 1519 kg pump^{-1} y^{-1} D 0.7 kg MMscf^{-1} NG	0.5 0.03
Pneumatic Controllers (PC)	Intermittent bleed	4.9 PC $well^{-1}$ 2.6 wells facility^{-1}	1,386 kg controller^{-1} y^{-1}	2.0
Fugitives		12	0.64 kg/h	7.7
Total				12.77

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Table S2. Estimated emissions from Type 2 facilities during normal operations. Emission factors taken from the EPA emission factor database.

Equipment	Description	Activity	Emission factor	Emission (kg h^{-1})
Gas Outlet	Pipelines transport gas back to shore	1	N/A	0
Oil/Condensate	Stored in atmospheric tanks inside the vessel hull, usually with vapor recovery. Shuttle/transportation tankers then offload and bring the oil to port.	1	N/A	0
Separators	High pressure separators, then condensate stabilization.	10	968.5 kg separator^{-1} y^{-1}	1.1
Hydrocarbon Storage Tanks	Oil tanks built into hull of vessel. Methane from flashing, working, and standing losses goes to vapor recovery.	0.26 Mbbl h^{-1} oil	188 kg CH_4 Mbbl^{-1} oil	48.9
Water Storage Tanks	Water treated and then discharged or reinjected. Methane from flashing, working, and standing losses goes to vapor recovery.	0.16 Mbbl h^{-1} water	51 kg CH_4 Mbbl water^{-1}	8.2
Gas Flaring	Flare efficiency is assumed to be 98%.		5 g bbl^{-1} liquid	0.3
Gas Venting	Vents from Chemical Injector pumps (CI) and dehydrators (D).	1 0.13 MMscf h^{-1} NG	CI 1519 kg^{-1} $pump^{-1}$ y^{-1} D 0.7 kg MMscf^{-1}	0.7 0.09
Pneumatic Controllers (PC)	Intermittent bleed.	4.9 PC well^{-1} 4 wells facility^{-1}	1,386 kg controller^{-1} y^{-1}	3.1
Compressors	Centrifugal. Dry gas seals. Assume similar to midstream compressors.	1	16,118 kg y^{-1}	1.8
Fugitives		13	1.8 kg h^{-1}	23.4
Total				87.6

Table S3. Data for platforms measured in the Gulf of Mexico [9,11,21] with observations removed for likely violated method assumptions, super emitters (> 100 kg CH_4 h^{-1}), or emissions less than 5.3 kg CH_4 h^{-1} [22]. "ID" - platform ID number. "C&P" - facility has both a compressor and power generator. Types include: MTLP – Mini Tension Leg Platform; TLP – Tension Leg Platform. "PFT" –prototypical facility type. "OP" - facility oil production. "GP" the gas production. Study 1 Yacovitch et al. (2020) all measurements made February 2018. Study 2 Ayasse et al. (2022) all measurements made October 2021. Study 3 Gorchov Negron et al. (2023) all measurements made August 2020. "Q" - measured emission. "Loss" - the percentage of produced gas lost.

ID	Lat (°N)	Lon (°W)	Lease number	Distance (nm)	Depth (ft)	Store Tank	C&P	Type	PTF type	OP (bbl/h)	GP (kg/h)	Study	Q (kg/h)	Loss (%)
20043	28.97	90.00	00128	13	85	Y	N	Fixed	1	4	256	1	7.46	3
22486	29.15	89.90	N/A*	7	55	Y	N	Fixed	1	0	0	1	8.25	-
23103	29.14	91.17	G01359	5	15	N	N	Caisson	1	0	52	1	8.46	18
22630	28.93	90.47	G03236	10	60	N	N	Fixed	1	0	1819	1	10.85	1
20035	29.01	89.84	G31418	19	111	N	N	Fixed	1	53	8941	1	10.97	0.1
1531	29.56	93.42	G01240	14	42	N	N	Fixed	1	4	170	1	11.46	7
2006	28.96	90.02	00180	14	92	N	N	Fixed	1	3	176	1	14.01	9
717	29.13	91.18	G23740	5	12	N	N	Caisson	1	0	218	1	15.36	8
2275	29.34	92.99	00133	23	55	N	N	Fixed	1	4	150	1	17.05	12
10237	29.52	94.15	00346	10	41	N	N	Fixed	1	0	160	1	18.22	12
10500	29.13	94.55	G25937	17	58	N	N	Fixed	1	1	2074	1	25.01	1
31012	28.92	90.35	G05006	9	62	N	N	Fixed	1	0	61	1	35.06	61
21517	29.19	91.62	G06093	17	22	N	N	Fixed	1	16	261	2	46.55	19
1088	28.74	88.83	G01865	30	2850	Y	Y	MTLP	2	1	1247	1	5.83	1
21895	29.08	88.70	G23851	18	340	Y	Y	Fixed	2	2	6405	1	8.06	0.5
10082	29.18	94.52	G19931	15	54	N	Y	Fixed	2	28	2107	1	8.94	0.1
2574	28.12	90.53	G02445	0	391	Y	Y	Fixed	2	247	427	1	9.33	2
22593	28.91	89.51	N/A*	5	143	Y	Y	Fixed	2	0	0	1	12.43	-
21429	28.46	91.08	00830	62	130	Y	Y	Fixed	2	0	0	3	14.00	-
1899	27.30	90.14	G20084	175	4375	Y	Y	TLP	2	457	3754	3	15.00	0.4
1482	28.94	88.91	G28351	30	667	N	Y	Fixed	2	11	820	1	18.43	2
1279	28.09	90.74	G22762	60	447	N	Y	Fixed	2	4	117	1	21.36	20
1076	28.09	90.67	N/A*	65	460	Y	Y	Fixed	2	0	0	1	22.22	-
24129	28.10	90.20	G12136	66	775	Y	Y	Fixed	2	213	4403	1	37.57	1
24209	28.83	89.56	N/A*	6	252	Y	Y	Fixed	2	0	0	3	48.00	-
22380	28.89	89.06	G02177	7	300	Y	Y	Fixed	2	30	1303	1	49.36	4
24199	28.17	89.22	G07963	52	2933	Y	Y	TLP	2	852	18916	3	50.00	0.3
67	27.78	90.52	G05911	60	2590	Y	Y	Spar	2	49	1370	3	52.00	4
23848	28.78	89.24	G05052	13	467	Y	N	Fixed	2	0	0	1	57.95	-
251	27.69	90.28	G07049	86	3294	Y	Y	MTLP	2	58	2616	3	58.00	2
2103	29.38	91.75	G02625	7	13	N	Y	Fixed	2	24	392	3	63.00	17
20375	29.09	88.73	G01294	17	325	Y	Y	Fixed	2	8	179	1	64.29	39
2247	28.91	90.42	G24956	9	60	Y	Y	Fixed	2	26	2695	1	94.21	4

* facility not on active lease.

Table S4. Estimated emissions from Type 1 facilities during normal operations using emission factors that account for the long tail distribution. Emission factors taken from recent literature.

Equipment	**Description**	**Activity**	**Updated emission factors from measurement studies**	**Emission (kg h^{-1})**
Gas Outlet	Pipelines to shore	1		0
Oil/Condensate	Pipelines to refinery onshore	1		0
Separators	1 high pressure, 2 low pressure	3	969 kg separator^{-1} y^{-1}	0.3
Water Treatment	Water stored in the gravity base structure.	42.7 bbl h^{-1}	0.066 g CH_4 bbl^{-1} water[23]	-
Gas Flaring	Flaring gas to control emissions from loading operations and emergency releases. Destruction efficiency of 98%.	7.4 bbl h^{1}	5.4 g bbl^{-1} [23]	0.04
Gas Venting	Vents from Chemical Injector pumps (CI) and dehydrators (D).	1 0.03 MMscf h^{-1}	CI 1577 kg pump^{-1} y^{-1} [30] D 5.1 kg CH_4 MMscf^{-1} NG [30]	0.52 0.15
Pneumatic Controllers (PC)	Intermittent bleed	4.9 PC well^{-1} 2.6 wells facility^{-1}	4643 kg controller^{-1} y^{-1}[30]	6.8
Fugitives		12	0.64 kg/h	7.7
Total				15.5

Table S5. Estimated emissions from Type 2 facilities during normal operations using emission factors that account for the long tail distribution. Emission factors taken from recent literature.

Equipment	Description	Activity	Updated emission factors	Emission (kg h^{-1})
Gas Outlet	Pipelines transport gas back to shore	1	N/A	0
Oil/Condensate	Stored in atmospheric tanks inside the vessel hull, usually with vapor recovery. Shuttle/transportation tankers then offload and bring the oil to port.	1	N/A	0
Separators	High pressure separators, then condensate stabilization.	10	968.5 kg separator^{-1} y^{-1}	1.1
Hydrocarbon Storage Tanks	Oil tanks built into hull of vessel. Methane from flashing, working, and standing losses goes to vapor recovery.	0.26 Mbbl h^{-1} oil	0.36 kg CH_4 bbl^{-1} oil [23]	93.6
Water Storage Tanks	Water treated and then discharged or reinjected. Methane from flashing, working, and standing losses goes to vapor recovery.	0.16 Mbbl h^{-1} water	0.066 g CH_4 bbl^{-1} water [23]	0.01
Gas Flaring	Flare efficiency is assumed to be 98%.		5.4 g bbl^{-1} [23]	0.32
Gas Venting	Vents from Chemical Injector pumps (CI) and dehydrators (D).	1	CI 1577 kg pump^{-1} y^{-1} [30]	0.52
		0.13 MMscf h^{-1} NG	D 5.1 kg CH_4 $MMscf^{-1}$ NG [30]	0.66
Pneumatic Controllers (PC)	Intermittent bleed.	4.9 PC well^{-1} 4 wells facility^{-1}	4643 kg controller^{-1} y^{-1} [30]	10.4
Compressors	Centrifugal. Dry gas seals. Assume similar to midstream compressors.	1	58.3 kg CH_4 y^{-1} [23]	6.7
Fugitives		13	1.8 kg h^{-1}	23.4
Total				136.7