ve methane

Entity emissions from combustion, venting, flaring, and fugitive methane

Richard Heede
Climate Accountability Institute
18-Oct-20

Saudi Aramco, Saudi Arabia

Saudi Aramco, Saudi Arabia

	CE	CF	CG	CH	CI	CJ	CK	CL	CM	CN	CO	CP	CQ	CR	CS	CT	CU	CV	CW	CX	CY	CZ	DA	DB	DC	DD	DE	DF	DG	DH	DI	DJ	DK	DL	DM	DN	DO	DP	DQ
					1930s							1930s			1940s										1950s											1960s				
	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964
													0.0	0.1	0.2	0.2	0.2	0.2	0.3	0.8	2	3	5	6	7	10	11	11	13	13	13	13	14	15	17	19	21	24	26
																													0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0004	0.0033	0.2	0.2
	-	-	-	-	-								0	0	0	0	0	0	0	1	2	3	5	6	7	10	11	11	13	13	13	13	14	15	17	19	21	24	26
	-	-	-	-	-								0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	-	-	-	-	-								0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	-	-	-	-	-								-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0
	-	-	-	-	-								-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0
	-	-	-	-	-								-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0
	-	-	-	-	-								0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	-	-	-	-	-								0	0	0	0	0	0	0	1	2	3	5	7	8	11	11	12	13	13	14	14	14	15	17	20	22	25	27
	-	-	-	-	-								0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	-	-	-	-	-								-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0
	-	-	-	-	-								-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-								0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	-	-	-	-	-								0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	-	-	-	-	-								-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0
	-	-	-	-	-								-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-								0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	-	-	-	-	-								0	0	0	0	0	0	0	1	2	4	6	7	8	11	12	12	14	14	14	14	15	16	18	21	23	26	28
	3,606	3,891	3,906	4,195	3,855	3,441	3,104	3,276	3,565	3,759	4,141	4,430	4,188	4,364	4,760	4,884	4,914	5,097	5,068	4,254	4,536	5,104	5,383	5,199	5,976	6,475	6,577	6,742	6,834	7,490	7,977	8,318	8,538	8,857	9,345	9,366	9,699	10,248	10,781
	984	1,062	1,066	1,145	1,052	939	847	894	973	1,026	1,130	1,209	1,143	1,191	1,299	1,333	1,341	1,391	1,383	1,161	1,238	1,393	1,469	1,419	1,631	1,767	1,795	1,840	1,865	2,044	2,177	2,270	2,330	2,417	2,550	2,556	2,647	2,797	2,942
	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.02%	0.05%	0.07%	0.10%	0.13%	0.13%	0.16%	0.17%	0.17%	0.19%	0.18%	0.17%	0.16%	0.16%	0.17%	0.19%	0.21%	0.23%	0.24%	0.25%
	21.2	23.0	22.8	24.4	22.3	19.9	17.9	18.8	20.4	21.0	23.3	24.8	23.4	24.8	26.2	27.0	27.0	27.4	26.9	23.5	24.7	27.6	29.2	28.1	30.4	32.2	32.7	33.1	33.1	35.9	38.4	39.7	40.9	42.7	44.6	44.3	45.1	47.1	49.4
	-	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09%	0.10%	0.10%

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Saudi Aramco, Saudi Arabia

	DR	DS	DT	DU	DV	DW	DX	DY	DZ	EA	EB	EC	ED	EE	EF	EG	EH	EI	EJ	EK	EL	EM	EN	EO	EP	EQ	ER	ES	ET	EU	EV	EW	EX	EY	EZ	FA	FB	FC	FD
1																																								
2																																								
3																																								
4																																								
5																																								
6																																								
7																																								
8																																								
9																																								
10	1960s					1970s										1980s										1990s						1990s							
11	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
12																																								
13																																								
14																																								
15	30	36	39	43	46	53	67	84	265	679	567	1,159	1,252	1,128	1,296	1,359	1,365	916	638	581	455	677	588	726	716	921	1,169	1,192	1,154	1,158	1,158	1,172	1,155	1,189	1,086	1,163	1,135	1,046	1,242
16	0.2	0.2	0.2	0.4	0.5	0.4	0.5	0.5	2	7	6	7	8	18	21	24	30	23	22	33	38	48	40	48	58	61	64	70	70	77	79	81	83	86	86	94	104	114	127
17																																								
18	30	36	39	43	46	54	67	85	267	686	573	1,167	1,261	1,146	1,317	1,383	1,396	939	660	614	493	725	627	774	774	981	1,233	1,262	1,224	1,236	1,237	1,253	1,238	1,275	1,173	1,257	1,239	1,161	1,370
19																																								
20	0	0	0	0	0	0	0	0	1	3	2	4	5	4	5	5	5	4	2	2	2	3	2	3	3	4	4	5	4	4	4	4	4	5	4	4	4	4	5
21	0	1	1	1	1	1	1	1	4	11	9	18	20	18	21	22	22	15	10	9	7	11	9	12	11	15	19	19	18	18	18	19	18	19	17	19	18	17	20
22	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	1	1	2	2	3	2	3	3	3	4	4	4	4	5	5	5	5	5	5	6	7	7
23	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	3	3	3	4
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	1	1	1	1	1	1	1	2	5	14	12	24	26	24	28	29	30	20	15	14	12	18	15	19	19	24	29	30	29	30	30	30	30	31	29	31	32	31	36
26																																								
27																																								
28																																								
29	31	37	40	44	47	55	68	86	273	700	585	1,190	1,286	1,170	1,345	1,412	1,425	959	675	629	506	742	643	793	793	1,005	1,262	1,291	1,253	1,265	1,267	1,283	1,269	1,306	1,202	1,288	1,270	1,191	1,405
30																																								
31																																								
32																																								
33	0	0	0	0	0	0	0	0	1	1	1	2	2	2	2	3	3	2	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2
34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
36	0	0	0	0	0	0	0	0	1	1	1	2	2	2	3	3	3	2	1	1	1	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	4
37																																								
38																																								
39	2	2	2	2	2	3	4	5	14	37	31	62	67	61	70	73	74	49	34	31	25	36	32	39	39	50	63	64	62	62	62	63	62	64	58	63	61	56	67
40	0	0	0	0	0	0	0	0	1	2	2	2	2	5	6	7	8	6	6	9	11	13	11	13	16	17	18	19	19	21	22	22	23	24	24	26	29	32	35
41	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
42	2	2	2	2	3	3	4	5	15	39	32	64	70	66	76	80	82	56	41	40	35	50	43	52	55	66	81	84	81	84	84	85	85	88	82	89	90	88	102
43																																								
44																																								
45	33	39	42	47	50	58	72	91	288	739	617	1,255	1,356	1,235	1,421	1,492	1,507	1,015	715	669	541	792	685	845	848	1,071	1,342	1,375	1,335	1,349	1,351	1,368	1,354	1,394	1,284	1,377	1,360	1,279	1,507
46																																								
47																																								
48	11,282	11,807	12,184	12,849	13,705	14,840	15,440	16,158	17,016	16,943	16,921	17,819	18,308	18,979	19,485	19,392	18,865	18,725	18,903	19,453	20,146	20,433	21,095	21,902	22,232	22,547	23,032	22,313	22,580	22,742	23,232	23,963	24,103	24,018	24,326	25,025	25,235	25,788	27,034
49	3,079	3,222	3,325	3,507	3,740	4,050	4,214	4,410	4,644	4,624	4,618	4,863	4,996	5,180	5,318	5,292	5,149	5,110	5,159	5,309	5,498	5,576	5,757	5,977	6,067	6,153	6,286	6,089	6,162	6,207	6,340	6,540	6,578	6,555	6,639	6,830	6,887	7,038	7,378
50																																								
51	0.27%	0.31%	0.33%	0.35%	0.34%	0.37%	0.44%	0.54%	1.60%	4.13%	3.46%	6.68%	7.03%	6.16%	6.90%	7.28%	7.55%	5.12%	3.57%	3.23%	2.51%	3.63%	3.05%	3.62%	3.57%	4.46%	5.48%	5.79%	5.55%	5.56%	5.45%	5.35%	5.26%	5.44%	4.94%	5.15%	5.03%	4.62%	5.20%
52																																								
53																																								
54	51.3	53.4	54.7	57.2	60.6	86.8	92.3	99.4	112.6	112.5	105.2	117.3	114.8	122.9	119.4	110.5	93.4	92.8	89.4	86.3	87.0	86.8	84.9	92.0	93.2	90.0	89.1	89.9	89.7	90.1	89.9	91.9	89.3	84.0	82.0	82.6	83.0	82.8	88.0
55																																								
56	0.12%	0.13%	0.14%	0.15%	0.15%	0.12%	0.14%	0.17%	0.47%	1.22%	1.10%	1.96%	2.17%	1.91%	2.27%	2.58%	3.13%	2.14%	1.62%	1.67%	1.44%	2.04%	1.79%	2.03%	2.09%	2.63%	3.23%	3.32%	3.25%	3.32%	3.35%	3.32%	3.41%	3.73%	3.59%	3.83%	3.86%	3.80%	4.14%
57																																								
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2000s						2010s											Cumulative	Entity emissions						to 2015	to 2016	to 2017	to 2018
2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	MtCO2e							Cumulative MtCO2e	Cumulative MtCO2e	Cumulative MtCO2e	Cumulative MtCO2e
																	(except where noted)	V (V = verified)						(except where noted)	(except where noted)	(except where noted)	(except where noted)
																							kg CO2/tCO2	to 2015	to 2016	to 2017	to 2018 (na)
1,314	1,378	1,355	1,303	1,363	1,225	1,238	1,401	1,471	1,341	1,360	1,487	1,620	1,548	1,578			V 51,938	Oil & NGLs	MtCO2	linked				47,192	48,812	50,361	51,938
104	153	160	146	155	167	183	163	176	180	186	189	198	170	174			V 4,140	Natural Gas	MtCO2	linked				3,598	3,796	3,966	4,140
																	-	Coal	MtCO2	linked				-	-	-	-
1,418	1,532	1,516	1,450	1,518	1,392	1,421	1,564	1,647	1,521	1,546	1,676	1,818	1,718	1,751			56,078	V Combustion total	MtCO2	sum				50,791	52,609	54,327	56,078
5	5	5	5	5	5	5	5	6	5	5	6	6	6	6			199	Oil & NGLs: Venting	MtCO2	calculated	3.83	linked		181	187	193	199
21	22	22	21	22	20	20	22	23	21	22	24	26	25	25			828	Oil & NGLs: Flaring	MtCO2	calculated	15.94	linked		752	778	803	828
6	9	9	8	9	10	10	9	10	10	11	11	11	10	10			237	Own fuel use	MtCO2	calculated	57.26	linked		206	217	227	237
3	4	5	4	4	5	5	5	5	5	5	5	6	5	5			118	Natural Gas: Venting	MtCO2	calculated	28.53	linked		103	108	113	118
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			7	Natural Gas: Flaring	MtCO2	calculated	1.74	linked		6	7	7	7
35	41	41	39	41	39	41	42	45	42	43	46	49	45	46			1,390	V Venting & Flaring total	MtCO2	sum				1,248	1,298	1,343	1,390
																	-	Cement	MtCO2	linked							
1,453	1,572	1,556	1,488	1,559	1,431	1,461	1,606	1,692	1,563	1,589	1,722	1,868	1,763	1,798			V 57,468	V Total CO2 emissions	MtCO2	sum	row 18+24+26			52,039	53,907	55,670	57,468
																							kg CH4/tCO2				
3	3	3	3	3	2	2	3	3	3	3	3	3	3	3			100	Methane: Oil & NGLs	MtCH4	calculated	1.92	linked		91	94	97	100
1	2	2	1	2	2	2	2	2	2	2	2	2	2	2			41	Methane: Natural Gas	MtCH4	calculated	9.88	linked		36	38	39	41
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	Methane: Coal	MtCH4	calculated	4.03	linked		-	-	-	-
4	4	4	4	4	4	4	4	5	4	4	5	5	5	5			V 141	Total methane emissions	MtCH4	sum				126	131	136	141
																							GWP				
71	74	73	70	73	66	67	75	79	72	73	80	87	83	85			2,797	Methane: Oil & NGLs	MtCO2e	calculated	28			2,542	2,629	2,712	2,797
29	42	44	41	43	46	51	45	49	50	51	52	55	47	48			1,145	Methane: Natural Gas	MtCO2e	calculated	28			995	1,050	1,097	1,145
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	Methane: Coal	MtCO2e	calculated	28			-	-	-	-
100	117	117	111	116	112	117	121	128	122	125	132	142	130	133			3,942	V Total methane emissions	MtCO2e	sum	per IPCC SAR			3,537	3,679	3,809	3,942
1,552	1,689	1,674	1,599	1,675	1,543	1,578	1,726	1,820	1,686	1,713	1,855	2,010	1,894	1,931			V 61,410	V Total attributed emissions	MtCO2e	sum				55,576	57,586	che 59,479	61,410
28,308	29,264	30,231	31,135	31,854	31,414	33,018	34,136	34,660	34,825	35,089	35,106	35,251	35,681	36,443			V 1,612,851	CDIAC CO2 emissions	MtCO2					1,505,476	1,540,727	1,576,408	1,612,851
7,726	7,986	8,250	8,497	8,693	8,573	9,011	9,316	9,459	9,504	9,576	9,581	9,620	9,738	9,946			V 440,166	Oil, Natural Gas, Coal, Flaring, & Cement	Mt Carbon								
																	CDIAC sums December 2019										
5.13%	5.37%	5.15%	4.78%	4.89%	4.55%	4.43%	4.70%	4.88%	4.49%	4.53%	4.91%	5.30%	4.94%	4.93%			3.56%	Entity percent of total CO2 emissions	Percent					3.46%	3.50%	3.53%	3.56%
91.7	94.7	98.4	99.5	101.2	99.9	105.1	109.5	113.4	115.2	118.2	117.8	118.4	120.0	122.7			V 6,971	CDIAC/EDGAR methane	Tg CH4					6,610	6,728	6,848	6,971
3.88%	4.40%	4.26%	3.97%	4.11%	4.01%	3.99%	3.93%	4.03%	3.78%	3.77%	4.01%	4.28%	3.88%	3.87%			2.02%	Entity percent of total CH4 emissions	Percent					1.91%	1.95%	1.99%	2.02%

Cell: FY48
Comment: Rick Heede:
CAI compares entity emissions to the CDIAC / Global Carbon Project (www.globalcarbonproject.org) annual estimate of carbon dioxideee emissions from fossil fuels and cement production. The CAI Carbon Majors methodology is based on the CDIAC methdology; see: Heede, Richard (2019) Carbon Majors: Accounting for carbon and methane emissions 1854-2010 Methods & Results Report, ISBN 978-3-659-57841-0, OmniScriptum, Riga, 148 pp.
Reference of the full global carbon budget 2019: Pierre Friedlingstein, Matthew W. Jones, Michael O'Sullivan, Robbie M. Andrew, Judith Hauck, Glen P. Peters, Wouter Peters, Julia Pongratz, Stephen Sitch, Corinne Le Quéré, Dorothee C. E. Bakker, Josep G. Canadell, Philippe Ciais, Rob Jackson, Peter Anthoni, Leticia Barbero, Ana Bastos, Vladislav Bastrikov, Meike Becker, Laurent Bopp, Erik Buitenhuis, Naveen Chandra, Frédéric Chevallier, Louise P. Chini, Kim I. Currie, Richard A. Feely, Marion Gehlen, Dennis Gilfillan, Thanos Gkritzalis, Daniel S. Goll, Nicolas Gruber, Sören Gutekunst, Ian Harris, Vanessa Haverd, Richard A. Houghton, George Hurtt, Tatiana Ilyina, Atul K. Jain, Emilie Joetzjer, Jed O. Kaplan, Etsushi Kato, Kees Klein Goldewijk, Jan Ivar Korsbakken, Peter Landschützer, Siv K. Lauvset, Nathalie Lefèvre, Andrew Lenton, Sebastian Lienert, Danica Lombardozzi, Gregg Marland, Patrick C. McGuire, Joe R. Melton, Nicolas Metzl, David R. Munro, Julia E. M. S. Nabel, Shin-Ichiro Nakaoka, Craig Neill, Abdirahman M. Omar, Tsuneo Ono, Anna Peregon, Denis Pierrot, Benjamin Poulter, Gregor Rehder, Laure Resplandy, Eddy Robertson, Christian Rödenbeck, Roland Séférian, Jörg Schwinger, Naomi Smith, Pieter P. Tans, Hanqin Tian, Bronte Tilbrook, Francesco N Tubiello, Guido R. van der Werf, Andrew J. Wiltshire, Sönke Zaehle. Global Carbon Budget 2019, Earth Syst. Sci. Data, 2019. https://doi.org/10.5194/essd-11-1783-2019
See also: Gilfillan, D., Marland, G., Boden, T. and Andres, R.: Global, Regional, and National Fossil-Fuel CO2 Emissions.

Cell: FY54
Comment: Rick Heede:
This study's total fugitive and vented methane from oil and natural gas systems and coal mining are summed here and compared to CDIAC's estimate for 1860 to 1969 (Stern & Kaufmann, 1998). CAI uses revised data rom EDGAR for 1970-2015, with extrapolation by CAI for 2016-2018 (based on growth of emissions from oil, gas, and coal production).There is a non-linearity at 1969/1970 btw dataasets.
Methane emissions may be revised if a more comprehensive and integrated dataset becomes available.
Furthermore, the Stern & Kaufman does not estimate methane emissions from oil (only gas-related CH4). The most recent EDGAR Nov19 datasets aggregate methane emissions from the Oil & Gas sector. CAI disaggregates methane from oil and methane from gas on the basis of an earlier EDGAR dataset 1970-2008 that reports CH4 from oil and gas separately. CAI uses this average allocation of ~695% from gas and ~30.5% from oil to estimate methane emissions from both sectors. This, given the fluctuations of methane emissions --the proportion from natural gas increases over time (from 50% in 1970 to 76% in 2008) -- this disaggregation is only approximate.

Stern, David I., & Robert K. Kaufmann (1998) "Annual Estimates of Global Anthropogenic Methane Emissions: 1860-1994," in Trends Online: A Compendium of Data on Global Change, Carbon Dioxide Information Analysis Center, Oak Ridge National Lab., U.S. DOE, Oak Ridge, Tenn., U.S.A. http://cdiac.esd.ornl.gov/trends/meth/ch4.htm#flaring

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