

Summary of CO2 & methane emissions from identified oil & NGL production

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Richard Heede
Climate Accountability Institute
18-Oct-20

Crude Oil & Natural Gas Liquids

Rank	Entity	Production less sequestration		Ancillary emissions from flaring, venting, field use, refining and processing, etc.				Total oil & NGL emissions MtCO2e
		This study	Percent of CDIAC	Flaring CO2	Vented CO2	Fugitive methane	Fugitive methane	
		MtCO2	Percent	MtCO2	MtCO2	MtCH4	MtCO2e	
			IPCC values (28Dec12)	15.94	3.839	1.924 EPA	53.86	
			kg CO2/tCO2	kg CO2/tCO2	kg CH4/tCO2	kg CO2e/tCO2		

Rank	Entity	CMEs summed to 2018						28.0 xCO2
		y	y	y	y	y	y	
1	China, PR (coal & cement only)							
2	FSU (Former Soviet Union)	35,462	6.27%	565	136	68	1,910	38,073
3	Saudi Aramco, Saudi Arabia	51,958	9.18%	828	199	100	2,797	55,763
4	Chevron, USA	38,484	6.80%	614	147	74	2,073	41,317
5	ExxonMobil, USA	32,037	5.66%	511	123	62	1,725	34,396
6	Gazprom, Russia	2,937	0.52%	47	11	6	158	3,153
7	BP, UK	28,146	4.97%	449	108	54	1,516	30,219
8	Royal Dutch Shell, Netherlands (acq BG Feb16)	23,419	4.14%	373	90	45	1,261	25,144
9	National Iranian Oil Co., Iran	28,095	4.96%	448	108	54	1,513	30,164
10	Poland							
11	Coal India, India							
12	Pemex, Mexico	17,611	3.11%	281	67	34	948	18,908
13	British Coal Corporation, UK							
14	Russian Federation							
15	ConocoPhillips, USA	10,193	1.80%	163	39	20	549	10,944
16	Peabody Energy, USA							
17	PetroChina (CNPC), China	11,357	2.01%	181	44	22	612	12,193
18	Petroleos de Venezuela, Venezuela	12,911	2.28%	206	49	25	695	13,862
19	Total, France	10,161	1.80%	162	39	20	547	10,909
20	Abu Dhabi, United Arab Emirates	10,712	1.89%	171	41.1	21	577	11,501
21	Kuwait Petroleum Corp., Kuwait	12,283	2.17%	196	47	24	662	13,187
22	Iraq National Oil Company, Iraq	11,946	2.11%	190	46	23	643	12,825
23	Sonatrach, Algeria	5,707	1.01%	91	22	11	307	6,127
24	BHP Billiton, Australia	1,526	0.27%	24	6	3	82	1,639
25	CONSOL Energy, USA							
26	Czechoslovakia							
27	Petrobras, Brazil	7,050	1.25%	112	27	14	380	7,569
28	Nigerian National Petroleum, Nigeria	7,064	1.25%	113	27	14	380	7,584
29	Rosneft, Russian Federation	6,294	1.11%	100	24	12	339	6,758
30	ENI, Italy	4,173	0.74%	67	16	8	225	4,480
31	Anglo American, UK							
32	Petronas, Malaysia	3,412	0.60%	54	13	7	184	3,664
33	Pertamina, Indonesia	5,214	0.92%	83	20	10	281	5,598
34	Libya National Oil Corp., Libya	6,547	1.16%	104	25	13	353	7,029
35	Qatar Petroleum, Qatar	3,914	0.69%	62	15	8	211	4,202
36	Arch Coal Company, USA							
37	RWE, Germany							
38	Rio Tinto, UK							
39	Kazakhstan							
40	Equinor, Norway	3,945	0.70%	63	15	8	212	4,236
41	Lukoil, Russia	5,336	0.94%	85	20	10	287	5,729
42	Anadarko, USA	2,877	0.51%	46	11	6	155	3,089
43	Occidental, USA	2,996	0.53%	48	11	6	161	3,216
44	Centura (AlphaNR, Massey), USA							
45	Oil and Gas Corp., India	3,323	0.59%	53	13	6	179	3,568
46	Repsol, Spain (acq Talisman May2015)	2,684	0.47%	43	10	5	145	2,882
47	Glencore, Switzerland							
48	Ukraine							
49	Sasol, South Africa							
50	North Korea							
51	Egyptian General Petroleum, Egypt	2,268	0.40%	36	9	4	122	2,435
52	Petroleum Development Oman, Oman	2,322	0.41%	37	9	4	125	2,493
53	Sinoco, China	2,672	0.47%	43	10	5	144	2,868
54	Marathon, USA	2,166	0.38%	35	8	4	117	2,326
55	Petoro, Norway	1,821	0.32%	29	7	4	98	1,955
56	CNOOC, PR China (acq Nexen Jan2013)	2,452	0.43%	39	9	5	132	2,632
57	TurkmenGaz, Turkmenistan	369	0.07%	6	1	1	20	397
58	LafargeHolcim, France							
59	Yukos, Russia	2,645	0.47%	42	10	5	142	2,840
60	Sonangol, Angola	2,630	0.46%	42	10	5	142	2,823
61	Hess, USA	1,753	0.31%	28	7	3	94	1,882
62	Singareni Collieries, India							
63	Ecopetrol, Colombia	2,094	0.37%	33	8	4	113	2,248
64	Czech Republic							
65	Devon Energy, USA	973	0.17%	16	4	2	52	1,044
66	Suncor, Canada	1,767	0.31%	28	7	3	95	1,897
67	EnCana, Canada	629	0.11%	10	2	1	34	675
68	Westmoreland Mining, USA							
69	Novatek, Russian Federation	237	0.04%	4	1	0	13	254
70	Canadian Natural Resources, Canada	1,063	0.19%	17	4	2	57	1,141
71	Cyprus Amax, USA							
72	Murray Coal Corporation, USA							
73	Exaro, South Africa							
74	Apache, USA	796	0.14%	13	3	2	43	855
75	PetroEcuador	1,506	0.27%	24	6	3	81	1,616
76	Kiewit Mining Group, USA							
77	Syrian Petroleum, Syria	1,208	0.21%	19	5	2	65	1,297
78	North American Coal, US							
79	HeidelbergCement, Germany (acq Italcementi)							
80	Alliance Resource Partners, USA							
81	Cloud Peak, USA							
82	Bahrain Petroleum Corporation	373	0.07%	6	1	1	20	401
83	Vistra Luminant, USA							
84	EOG Resources, USA	452	0.08%	7	2	1	24	485
85	Chesapeake, USA	206	0.04%	3	1	0	11	222
86	RAG, Germany							
87	Husky, Canada	649	0.11%	10	2	1	35	697
88	Tecok Resources, Canada							
89	Wintershall, Germany	418	0.07%	7	2	1	23	449
90	Impex, Japan	497	0.09%	8	2	1	27	534
91	YPF, Argentina	475	0.08%	8	2	1	26	510
92	UK Coal, UK							
93	Cemex, Mexico							
94	Noble Energy, USA	278	0.05%	4	1	0	15	298
95	Woodside, Australia	238	0.04%	4	1	0	13	256
96	OMV Group, Austria	360	0.06%	6	1	1	19	387
97	PTTEP, Thailand	193	0.03%	3	1	0	10	207
98	Murphy Oil, USA	385	0.07%	6	1	1	21	413
99	Polish Oil & Gas, Poland	344	0.06%	5	1	1	19	369
100	Southwestern, USA	29	0.01%	0	0	0	2	31
101	Santos, Australia	220	0.04%	4	1	0	12	236
102	Pioneer, USA	273	0.05%	4	1	1	15	293
103	Taiheyo, Japan							
104	EQT Corporation, USA	31	0.01%	0	0	0	2	33
105	Obsidian, Canada	164	0.03%	3	1	0	9	176
106	Antero, USA	53	0.01%	1	0	0	3	57
107	Whitehaven Coal, Australia							
108	Vale, Brazil							

Total CO2 & methane emissions	446,764	78.94%	7,123	1,712	859	24,062	479,662
	446,764 vertical check		1.55%	0.38%		5.33%	479,662
	Oil & NGL CO2		Flaring CO2		Oil-related Methane		
This study, MtCO2	446,764	This study, MtCO2	7,408	This study, MtCO2	24,062	This study, MtCO2e	
CDIAC emissions, MtCO2	565,950	CDIAC oil CO2	16,105	CDIAC Flaring CO2	32,337	CDIAC CH4, MtCO2e	
Percent this study of total CDIAC 1751-2010	78.9%	Percent of CDIAC	46.0%	Percent of CDIAC	74.41%	Percent of CDIAC	

Summary of CO2 & methane emissions from identified coal and cement production

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Rank	Entity
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Coal				
Coal CO2 emissions		Fugitive methane emissions		Total coal emissions
This study	Percent of CDIAC	Fugitive methane	Fugitive methane	Total coal emissions
MtCO2	Percent	MtCH4	MtCO2e	MtCO2e

Cement production	
Calculating emissions	
Cement	Percent of CDIAC
MtCO2	Percent

IPCC values (22Dec12) 4,035 112.97

kg CH4/tCO2 kg CO2e/tCO2

CMEs summed to 2018 28.0 xCO2

Rank	Entity
1	China, PR (coal & cement only)
2	FSU (Former Soviet Union)
3	Saudi Aramco, Saudi Arabia
4	Chevron, USA
5	ExxonMobil, USA
6	Gazprom, Russia
7	BP, UK
8	Royal Dutch Shell, Netherlands (acq BG Feb16)
9	National Iranian Oil Co., Iran
10	Poland
11	Coal India, India
12	Pemex, Mexico
13	British Coal Corporation, UK
14	Russian Federation
15	ConocoPhillips, USA
16	Peabody Energy, USA
17	PetroChina (CNPC), China
18	Petroleos de Venezuela, Venezuela
19	Total, France
20	Abu Dhabi, United Arab Emirates
21	Kuwait Petroleum Corp., Kuwait
22	Iraq National Oil Company, Iraq
23	Sonatrach, Algeria
24	BHP Billiton, Australia
25	CONSOL Energy, USA
26	Czechoslovakia
27	Petrobras, Brazil
28	Nigerian National Petroleum, Nigeria
29	Rosneft, Russian Federation
30	ENI, Italy
31	Anglo American, UK
32	Petronas, Malaysia
33	Pertamina, Indonesia
34	Libya National Oil Corp., Libya
35	Qatar Petroleum, Qatar
36	Arch Coal Company, USA
37	RWE, Germany
38	Rio Tinto, UK
39	Kazakhstan
40	Equinor, Norway
41	Lukoil, Russia
42	Anadarko, USA
43	Occidental, USA
44	Contura (AlphaNR, Massey), USA
45	Oil and Gas Corp., India
46	Repsol, Spain (acq Talisman May2015)
47	Glencore, Switzerland
48	Ukraine
49	Sasol, South Africa
50	North Korea
51	Egyptian General Petroleum, Egypt
52	Petroleum Development Oman, Oman
53	Sinopec, China
54	Marathon, USA
55	Petoro, Norway
56	CNOOC, PR China (acq Nexen Jan2013)
57	TurkmenGaz, Turkmenistan
58	LafargeHolcim, France
59	Yukos, Russia
60	Sonangol, Angola
61	Hees, USA
62	Singarenl Collieries, India
63	Ecopetrol, Colombia
64	Czech Republic
65	Devon Energy, USA
66	Suncor, Canada
67	EnCana, Canada
68	Westmoreland Mining, USA
69	Novatek, Russian Federation
70	Canadian Natural Resources, Canada
71	Cyprus Amax, USA
72	Murray Coal Corporation, USA
73	Exaro, South Africa
74	Apache, USA
75	PetroEcuador
76	Kiewit Mining Group, USA
77	Syrian Petroleum, Syria
78	North American Coal, US
79	HeidelbergCement, Germany
80	Alliance Resource Partners, USA
81	Cloud Peak, USA
82	Bahrain Petroleum Corporation
83	Vistra Luminant, USA
84	EOG Resources, USA
85	Chesapeake, USA
86	RAG, Germany
87	Husky, Canada
88	Teck Resources, Canada
89	Wintershall, Germany
90	Inpex, Japan
91	YPF, Argentina
92	UK Coal, UK
93	Cemex, Mexico
94	Noble Energy, USA
95	Woodside, Australia
96	OMV Group, Austria
97	PTTEP, Thailand
98	Murphy Oil, USA
99	Polish Oil & Gas, Poland
100	Southwestern, USA
101	Santos, Australia
102	Pioneer, USA
103	Taiheyo, Japan
104	EQT Corporation, USA
105	Obsidian, Canada
106	Antero, USA
107	Whitehaven Coal, Australia
108	Vale, Brazil

y	y	y	y	y	y
209,346	27.52%	845	23,650	232,995	
64,852	8.52%	262	7,326	72,179	
1,086	0.14%	4	123	1,208	
1,317	0.17%	5	149	1,466	
918	0.12%	4	104	1,022	
978	0.13%	4	111	1,089	
24,576	3.23%	99	2,776	27,353	
21,870	2.87%	88	2,471	24,341	
17,742	2.33%	72	2,004	19,746	
17,659	2.32%	71	1,995	19,654	
14,867	1.95%	60	1,680	16,547	
6,807	0.89%	27	769	7,576	
8,725	1.15%	35	986	9,710	
8,634	1.13%	35	975	9,610	
6,975	0.92%	28	788	7,763	
6,608	0.87%	27	746	7,354	
6,531	0.86%	26	738	7,268	
6,089	0.80%	25	688	6,777	
6,061	0.80%	24	685	6,745	
636	0.08%	3	72	708	
1,725	0.23%	7	195	1,920	
5,348	0.70%	22	604	5,953	
4,521	0.59%	18	511	5,032	
4,292	0.56%	17	485	4,777	
4,013	0.53%	16	453	4,466	
3,527	0.46%	14	398	3,926	
2,907					7.28%
2,513	0.33%	10	284	2,797	
2,370	0.31%	10	268	2,638	
2,028	0.27%	8	229	2,257	
1,611	0.21%	7	182	1,793	
1,568	0.21%	6	177	1,746	
1,552	0.20%	6	175	1,727	
1,425	0.19%	6	161	1,586	
1,366	0.18%	6	154	1,520	
1,300	0.17%	5	147	1,447	
1,290	0.17%	5	146	1,436	
1,201	0.16%	5	136	1,337	
1,049	0.14%	4	119	1,168	
910	0.12%	4	103	1,013	
792	0.10%	3	90	882	
232	0.03%	1	26	258	
226	0.03%	1	25	251	

y	y
18,650	46.72%
2,907	7.28%
1,502	3.76%
770	1.93%
518	1.30%

Total CO2 & methane emissions	477,139	62.71%	1,925	53,902.02	531,041	24,348	60.99%
	477,139 vertical check				531,041 vertical	24,348 vertical check	
CMEs summed to 2018							
Coal CO2		Coal-related Methane		Cement			
This study, MtCO2	477,139	This study, MtCO2e	53,902	This study, MtCO2e	24,348	This study, MtCO2e	
CDIAC emissions, MtCO2	760,840	CDIAC coal CO2	69,037	CDIAC CH4, MtCO2e	39,922	CDIAC cement CO2	
Percent this study of total CDIAC 1751-2010	62.7%	Percent of CDIAC	60.5%	Percent of CDIAC	61.0%	Percent of CDIAC	

Cell: M9
Comment: Rick Heede:
This section sums emissions from combustion of produced crude oil and NGLs reported by identified oil and gas companies (including national oil and gas companies). Non-fuel uses of gas are accounted for, and IPCC coefficients are applied to net production and combustion. Emissions of CO2 from company energy use, vented CO2, flaring, and methane sources are also detailed below and in related worksheets.
See production worksheets ("OilGasAdnoc-Encana.xls", "OilGasENI-NorskHydro.xls", "OilGasOxy-Shell.xls", and "OilGasSaudi-Yukos.xls") and production and emissions sums in "SumOil.xls" and "SumGas.xls" and "AncillaryCH4&CO2.xls" for production data, emissions estimates, results, and methodological discussion.

Cell: AA9
Comment: Rick Heede:
This section sums emissions from combustion of produced natural gas reported by identified oil and gas companies (including national oil and gas companies). Non-fuel uses of gas are accounted for, and IPCC coefficients are applied to net production and combustion. Emissions of CO2 from company energy use, vented CO2, flaring, and methane sources are also detailed below and in related worksheets.
See production worksheets ("OilGasAdnoc-Encana.xls", "OilGasENI-NorskHydro.xls", "OilGasOxy-Shell.xls", and "OilGasSaudi-Yukos.xls") and production and emissions sums in "SumOil.xls" and "SumGas.xls" and "AncillaryCH4&CO2.xls" for production data, emissions estimates, results, and methodological discussion.

Cell: AL9
Comment: Rick Heede:
See production worksheets ("CoalAngloNorthAmerican.xls" and "CoalPeabodyXstrata.xls") and production and emissions sums in "SumCoal.xls" and "AncillaryCH4&CO2.xls" for production data, emissions estimates, results, and methodological discussion.

Cell: AP9
Comment: Rick Heede:
CMS methodology and results are shown in the worksheets "Cement.xls" and "SumCement.xls". CMS has included the largest six cement manufacturers plus PR China in an industry with relatively few large multinational companies meeting the threshold of > 10 MTC per year, hence our total is a fraction of CDIAC's estimated emissions of CO2 (the CDIAC estimates start in 1928). Most of this project's emissions estimates start in ~1990.

Cell: BI9
Comment: Rick Heede:
This section sums all emissions from identified producers of crude oil (including NGLs), natural gas, coal, and cement manufacturing. Emissions are estimated from primary production data, and account for net non-fuel uses and other factors discussed throughout this assemblage of ~one hundred worksheets.
This summary table also sums CO2 emissions from flaring, CO2 emissions from direct venting. CMS also sums emissions of methane associated with primary production and flaring in oil, gas, and coal operations, converts methane gas to CO2-equivalent (at IPCC AR4 value of 28 x CO2). The table sums all emissions sources for each entity, and ranks total emissions in tonnes CO2e and as a percent of total identified emissions. Finally, all estimates are compared to global industrial emissions of CO2 and methane from the CDIAC database of CO2 emissions by fuel, cement, flaring, and methane from ocoal, oil, and natural gas operations.

Cell: H11
Comment: Rick Heede:
Flaring rates are calculated in the worksheet "AncillaryCH4&CO2.xls".
In brief, flaring rate is computed for kg CO2 of flared associated gas per kg CO2 from oil combustion and is based on World Bank Global Gas Flaring Reduction data estimated from satellite reconnaissance. See the "Flaring and Venting" worksheet in the AncillaryCO2CH4.xls workbook.

Cell: I11
Comment: Rick Heede:
Recent data from the US EPA on venting from petroleum systems is used to compute vented CO2 as a function of CO2 from the combustion of oil and NGLs. See "Flaring and Venting" worksheet in AncillaryCH4&CO2.xls for details. CO2 vented from petroleum operations is small compared to CO2 venting from natural gas operations.

Cell: J11
Comment: Rick Heede:
The US EPA (2012) Draft Inventory of U.S Emissions and Sinks 2010 data on methane emissions from petroleum systems were used to develop a fugitive methane rate as a function of oil & NGL production and combustion (in kg CH4 per tonne CO2 from combusted liquids).
See "Oil and Gas ancillary CH4" worksheet in AncillaryCH4&CO2.xls for details.

Cell: L11
Comment: Rick Heede:
The IPCC Fifth Assessment Report (AR5) GWP value for methane -- 28xCO2 -- is used throughout.

Cell: V11
Comment: Rick Heede:
CMS reviews numerous estimates of flaring emissions in the oil and gas industries in the worksheets in "AncillaryCH4&CO2.xls". CMS allocates flaring to both oil and gas production, with the preponderance (90 percent) to oil operations and 10 percent to gas operations to account for flaring at natural gas production, field processing, and processing plants.
See "Flaring and Venting" worksheet in the "AncillaryCH4&CO2.xls" workbook for details.

Cell: W11
Comment: Rick Heede:
Recent US EPA (2012) estimates of CO2 vented from natural gas systems -- chiefly Acid Gas Removal vents at processing plants to meet market specifications -- as a function of CO2 from combusted natural gas in the U.S. 1990-2010. This factor is applied to global natural gas operations, though the CO2 content of raw produced gas varies widely from region to region.

See the "Flaring & Venting" worksheet in "AncillaryCH4&CO2.xls" for details.

Cell: X11
Comment: Rick Heede:
The US EPA (2006) Global Mitigation of Non-CO2 Gases data on methane emissions from natural gas systems were used to develop a fugitive methane rate as a function of natural gas production and combustion (in kg CH4 per tonne CO2 from combusted natural gas).
See "Oil and Gas ancillary CH4" worksheet in AncillaryCH4&CO2.xls for details.

Cell: Y11
Comment: Rick Heede:
The IPCC Fifth Assessment Report (AR5) GWP value for methane -- 28xCO2 -- is used throughout.

Cell: AJ11
Comment: Rick Heede:
Stern and Kaufmann (1998) data on methane rates from coal mining were averaged with US EPA (2011) Global Anthropogenic Non-CO2 Greenhouse Gas Emissions and converted to a fugitive methane rate per tonne of CO2 from coal combustion: kg CH2/TCO2.
See the "Coal ancillary CH4" worksheet in AncillaryCO2CH4.xls for details on the methodology.

Cell: AK11
Comment: Rick Heede:
The IPCC Fifth Assessment Report (AR5) GWP value for methane -- 28xCO2 -- is used throughout.

Cell: BE11
Comment: Rick Heede:
The IPCC Fifth Assessment Report (AR5) GWP value for methane -- 28xCO2 -- is used throughout.

Cell: B12
Comment: Rick Heede:
Alphabetical rank.

Cell: Z13
Comment: Rick Heede:
25Nov14: This value modified from previous 59.24 kgCO2/TCO2 to 57.26 kgCO2/TCO2 upon modifying the methane data in AncillaryCH4&CO2 worksheet. This reduced total Own Fuel Use from 7,850 MtCO2 to 7,588 MtCO2 (net minus 262 MtCO2).
21Jan2020: This calculation (at [AncillaryCH4&CO2.xls]Entry CDP Scopes 1-3\10832) has been corrupted. We restore the value of 57.26438622 kg CO2/TCO2 in this cell. A revised calculation may update this value.

Cell: AL133
Comment: Rick Heede:
Data of emissions from coal mining is based on Stern & Kaufman 1998 for 1860 to 1969 (S&K data goes to 1994). However, we inserted EDGAR (European Joint Commission for coal mining and for combined oil and gas CH4 emissions. As of 21 January 2020, we link to "Coal methane column, sum at cell Z681, summing column Z from 1860 to 2018, in TgCH4 and converted to CO2e (GWP of 28xCO2, per IPCC AR4, 2007).
In the event a full historical database on coal (and/or oil and gas) methane emissions becomes available, then the data will be revised.

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>
Crippa, M., G. Oreggioni, D. Guizzardi, M. Muntean, E. Schaaf, E. Lo Vullo, E. Solazzo, F. Monforti-Ferrario, J.G.J. Olivier, & E. Vignati (2019) Fossil CO2 and GHG emissions of all world countries - 2019 Report, Publications Office of the European Union, Luxembourg. ISBN 978-92-76-11100-9. https://edgar.jrc.ec.europa.eu/overview.php?vP_GHG

Cell: BB133
Comment: Rick Heede (29 March 2012):
The CDIAC Industrial carbon emissions worksheet rounds each fuel column independently, and the sum shown here is 1 MtC (and 3.7 MtCO2) higher than CDIAC's own sum. We do not correct this so as to not throw off the percentages calculated here.
Update Jun20: CDIAC / GCP data 1751-2018 sums to 440,166 MtC, which, times 3.664191 CO2/C = 1,612,851 MtCO2.

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