Summary of estimated process emissions from identified cement production

Richard Heede
Climate Accountability Institute
16-Oct-20

dataset marker

Cement	Notes	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948
			1920s						1930s											1940s			
Cemex																							
China, PRC			0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	1	1	1	0	0	0	0
HeidelbergCement																							
Holcim																							
Italcementi																							
Lafarge																							
Taiheiyo																							
Emissions from identified cement prod'n (MtCO2/yr)			0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	1	1	1	0	0	0	0
Carbon in identified cement prod'n (MtC/yr)			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CDIAC cement emissions (Million tonnes of CO2/yr)			37	37	37	29	26	26	29	33	40	40	44	48	40	44	40	37	26	26	37	44	51
			1928: first year CDIAC cement data																				
CDIAC cement emissions (Million tonnes of carbon/yr)			10	10	10	8	7	7	8	9	11	11	12	13	11	12	11	10	7	7	10	12	14
Percent of total CDIAC cement emissions identified																							

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	1950s										1960s										1970s				
1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
0	0	1	1	2	2	2	3	3	5	6	7	4	4	5	5	5	5	4	4	5	5	11	11	12	12
0	0	1	1	2	2	2	3	3	5	6	7	4	4	5	5	5	5	4	4	5	5	11	11	12	12
0	0	0	0	1	1	1	1	1	1	2	2	1	1	1	1	1	1	1	1	1	1	3	3	3	3
59	66	73	81	88	99	110	117	125	132	146	157	165	178	187	206	215	230	238	255	268	282	300	317	336	337
16	18	20	22	24	27	30	32	34	36	40	43	45	48	51	56	59	63	65	70	73	77	82	87	92	92

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	BA	BB	BC	BD	BE	BF	BG	BH	BI	BJ	BK	BL	BM	BN	BO	BP	BQ	BR	BS	BT	BU	BV	BW	BX	BY	BZ
15						1980s										1990s						1990s				
16	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
18	55.70%	55.70%	55.70%	55.70%	55.70%	55.70%	55.70%	55.70%	55.70%	55.70%	55.70%	55.70%	55.70%	55.70%	55.70%	55.7%	56.0%	56.4%	56.7%	57.1%	57.5%	57.8%	58.2%	58.6%	58.9%	59.3%
21																24	24	24	24	24	24	24	24	24	24	24
23	15	25	28	33	37	40	42	47	54	60	71	81	90	105	103	105	126	154	183	210	237	245	255	267	286	298
25																31	30	29	29	28	28	27	27	26	25	25
27																33	34	35	36	38	39	41	42	43	45	46
29																21	21	20	20	20	20	20	20	20	20	20
31																41	41	42	43	43	44	45	45	46	47	47
33	9	10	12	13	13	13	12	12	11	11	10	9	10	10	11	12	11	12	12	13	13	14	13	12	11	11
36	24	35	39	45	50	52	54	59	65	72	81	90	100	115	114	264	287	317	348	376	405	415	426	438	457	470
38	7	9	11	12	14	14	15	16	18	20	22	25	27	31	31	72	78	86	95	103	111	113	116	120	125	128
40	334	357	373	396	402	405	405	403	413	420	424	442	459	488	500	501	514	536	556	592	626	640	659	656	685	716
42	91	97	102	108	110	111	110	110	113	115	116	120	125	133	136	137	140	146	152	162	171	175	180	179	187	195
44	7.3%	9.7%	10.6%	11.5%	12.5%	12.9%	13.4%	14.5%	15.9%	17.0%	19.1%	20.4%	21.7%	23.5%	22.8%	52.8%	55.8%	59.1%	62.6%	63.6%	64.7%	64.9%	64.6%	66.8%	66.7%	65.7%

** CMS has
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tCO2/t cementitious product	
0.5071	IPCC 1996
0.4987	CDIAC emission factor
0.5400	WBCSD Sustainable Cement Initiative - general cement EF
0.5196	WBCSD GNR suggests 60 percent process emissions of global average of 866 kg CO2 per tonne of clinker
0.5203	IPCC tier 1 approach, IPCC 2006
0.5196	truing up to CDIAC process emission factor

	2000s									2010s												
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019		Cumulative Million tonnes CO2	Cement process emissions
	59.7%	60.1%	60.5%	60.9%	61.3%	63.7%	64.5%	65.8%	67.0%	66.4%	67.1%	68.0%	68.7%	68.9%	69.1%	69.3%	69.6%	69.8%			CMEs summed to 2018	Process emissions as percent of Net CO2
	24	24	27	30	31	34	35	32	27	27	27	27	26	28	28	29	28	28		V	770	Cemex
	330	362	430	484	533	617	679	700	822	941	1,050	1,105	1,206	1,246	1,175	1,205	1,200	1,239		V	18,650	China, PRC
	24	22	24	26	26	29	34	35	30	31	30	30	34	35	35	39	49	51		V	890	HeidelbergCement
	48	51	53	55	58	61	64	64	60	62	61	63	64	66						V	1,263	Holcim
	20	20	20	21	25	28	29	28	24	24	29	27	25	25	25	19				V	612	Italcementi
	48	49	48	51	53	59	62	68	62	61	63	64	61	62	90	87	89	84		V	1,645	Lafarge
	11	11	10	10	10	11	10	10	9	9	8	9	10	22	22	15	16	16		V	518	Taiheiyo
	504	537	613	678	735	838	914	937	1,034	1,156	1,267	1,325	1,425	1,484	1,375	1,394	1,381	1,418		y	24,348	Emissions from identified cement prod'n (MtCO2)
																					CMEs summed to 2018	
	138	147	167	185	201	229	249	256	282	315	346	362	389	405	375	381	377	387		y	6,645	Carbon in identified cement prod'n (MtC)
	748	791	851	907	959	1,046	1,122	1,138	1,173	1,249	1,341	1,374	1,424	1,476	1,435	1,465	1,476	1,507		V	39,922	CDIAC cement emissions (Million tonnes of CO2)
																					1929-2018	
	204	216	232	248	262	285	306	310	320	341	366	375	389	403	392	400	403	411		V	10,895	CDIAC cement emissions (Million tonnes of carbon)
	67.3%	68.0%	72.0%	74.7%	76.7%	80.1%	81.5%	82.4%	88.1%	92.5%	94.5%	96.5%	100.1%	100.5%	95.8%	95.2%	93.6%	94.1%		y	61.0%	Percent of cumulative CDIAC cement emissions

Total emissions from identified cement production (million tonnes CO2) 24,348

5,698 Cement process emissions, excluding China

collected data from company CSR reports on gross CO2 emissions on each entity's emissions from both process emissions (calcining limestone) and thermal + electric input emissions. ("Gross cement emissions" worksheet.)
estimate process emissions only (to exclude each entity's fossil fuel emissions), CMS uses WBCSD's CSI data on average industry process emissions as a percent of gross CO2 emissions for 1990, 2000, 2005, and 2006.
tage (in row 12: interpolated between CSI data years, extrapolating to 2008, and assuming pre-1990 equal to 1990) is applied to each entity's gross CO2 emissions from cement manufacturing (previous worksheet).

Cell: CW2
Comment: Rick Heede:
CMS lists the IPCC 1996 Guideline factor of EF clinker = 0.646 * 0.785 = 0.5071 tCO2 per tonne of clinker produced.
(Average clinker lime percentage of 64.6 percent; molecular weight ratio of CO2/CaO = 78.5 percent.)

Cell: CW4
Comment: Rick Heede:
To quote from Boden et al (1995): "This conversion factor was obtained by dividing the molar mass of carbon by the molar mass of calcium oxide and multiplying this quotient by the average fraction of calcium oxide contained in cement: (12.01 g C/mole CaCO3 ÷ 56.08 g CaO /mole CaCO3) * 0.635 g CaO /g cement = 0.136 g C /g cement."
"The consensus that 63.5% of the typical cement in the world is composed of calcium oxide is based on the opinions of experts consulted in the field, as well as inspection of composition data by type and country (Griffin 1987)."
CMS: The formula: (12.01/56.08)*0.635*3.667 = 0.4987, rounded up to 0.500.
CDIAC (1995) Estimates of Global, Regional, and National Annual CO2 Emissions from Fossil-Fuel Burning, Hydraulic Cement Production, and Gas Flaring: 1950-1992, by T. A.. Boden, G. Marland, & R. J. Andres. cdiac.ornl.gov/epubs/ndp/ndp030/ndp0301.htm#co2man

Cell: CW6
Comment: Rick Heede (Mar10):
WBCSD's Cement Sustainability Initiative reports average global gross emissions per tonne of clinker produced at 866 kg CO2 per tonne (declining from 914 kg CO2/tonne in 1990. See rpt for geographic, process (wet vs dry), or temporal variables, and entity reporting by region.
Process emissions from calcining limestone into clinker is typically 540 kg CO2 per tonne of clinker.
WBCSD, Cement Sustainability Initiative (2009) Cement Industry Energy and CO2 Performance "Getting the Numbers Right", World Business Council for Sustainable Development, 44 pp., www.wbcsdcement.org

Cell: CW8
Comment: Rick Heede:
WBCSD Cement Sustainability Initiative (2009) Cement Industry Energy and CO2 Performance "Getting the Numbers Right", World Business Council for Sustainable Development, 44 pp., wbcsdcement.org.
Page 30:
(1) about 60% of gross CO2 emissions originate fom limestone decomposition
(2) 40% are fuel emissions where, apart from energy efficiency, the fuel composition plays a role.
In Figure 6.4: Gross CO2 emissions per tonne of clinker, 2006: GNR global average 866 kg CO2 per tonne of clinker.
CMS: Thus 60 percent of 866 kgCO2/t = 519.6 kg CO2/tonne.

Cell: CW11
Comment: Rick Heede:
IPCC (2006) Guidelines, Vol. 3, Chapter 2, Section 2.2.1.2 Choice of Emission Factors, Tier 1 Method, page 2.11.
"For the default CaO composition, 1 tonne of clinker contains 0.65 tonnes CaO from CaCO3. This carbonate is 56.03 percent CaO and 43.97 percent CO2 by weight (Table 2.1). The amount (X) of CaCO3 needed to yield 0.65 tonnes CaO is: X = 0.65/0.5603 = 1.1601 tonnes CaCO3 (unrounded). The amount of CO2 released by calcining this CaCO3 = 1.1601 • 0.4397 = 0.5101 tonnes CO2 (unrounded). Assuming a correction addition of 2 percent to account for CKD, the rounded default emission factor (EFclc) for clinker is 0.52 tCO2/tonne of clinker."
Intergovernmental Panel on Climate Change (2006) 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Volume 3: Industrial Processes and Product Use, Chapter 2: Mineral Industry Emissions, www.ipcc-nggip.iges.or.jp/public/2006gl/vol3.html

Cell: CW13
Comment: Rick Heede:
Note: CMS compared carbon emissions from world cement production using USGS production data 1926-2010 results in estimates ~3.8 percent higher than cement emission estimates by CDIAC (based on both totals 1950-2010).
Correcting the Carbon Majors calculations to that of CDIAC suggests a process emission factor of 519.6 - (519.6*0.00377) = 499.86 kg CO2/tonne.
CDIAC (1995) Estimates of Global, Regional, and Naitonal Annual CO2 Emissions from Fossil-Fuel Burning, Hydraulic Cement Production, and Gas Flaring: 1950-1992, by T. A.. Boden, G. Marland, & R. J. Andres. cdiac.ornl.gov/epubs/ndp/ndp030/ndp0301.htm#co2man

Cell: CN18
Comment: Rick Heede:
World Business Council for Sustainable Development (2016) Cement Industry Energy and CO2 Performance: Getting the Numbers Right (GNR), WBCSD Cement Sustainability Initiative, 20 pp.
No data on "Net emission rate," but chart on page 15 shows very slight improvement in "gross emission rate."
Until indicators are available from WBCSD to 2017, CAI assumes slight improvement from 2013: minus 2 per year from 612 kg CO2/tonne in 2013.
See Cement.xls, worksheet on "Cement Industry Data." column "X".

Cell: CW18
Comment: Rick Heede:
* CMS has collected data from company CSR reports on net CO2 emissions on each entity's emissions from both process emissions (calcining limestone) and thermal + electric input emissions. ("Net cement emissions" worksheet.)
In order to estimate process emissions only (to exclude each entity's fossil fuel emissions), CMS uses WBCSD's CSI data on average industry process emissions as a percent of net CO2 emissions for 1990, 2000, and 2005-2013.
This percentage (in row 12) is applied to each entity's net CO2 emissions from cement manufacturing (previous worksheet).
This percentage data series is derived in the Cement.xls workbook / "Cement industry data", Table 3, row "AB".

Cell: CW23
Comment: Rick Heede:
CMS uses CDIAC emissions from cement production in China 1929-2010.

Cell: CW31
Comment: Rick Heede:
LafargeHolcim CSR 2018; tables p. 65. Note: important new reporting on "net Scope 1 emissions total (121 MtCO2MtCO2) -- disaggregated into "emissions from raw materials" (82 MtCO2, 67.8%) and "emissions from fossil fuels" (39 MtCO2, 32.2%). Compare CAI MRR methodology, the Lafarge 2018 result: 84 MtCO2, ie very good agreement.

Cell: CW40
Comment: Rick Heede:
CDIAC data in million tonnes of carbon converted to CO2, which is 3.664191 times Carbon if carbon and oxygen isotopes are accounted for, per Kevin Baumert May05, then at World Resources Institute: CO2 conversion is, precisely: C=12.0107 + O=15.9994 x 2 = 44.0095/12.0107 = 3.664191.

Cell: CR42
Comment: Rick Heede:
January 2020: Linked to data in GCP / CDIAC Global CO2 1751-2018.xls. Note revisions of previous years for China from 1990-, flaring revisions, and cement corrections to 1930 (previously entered). Sums 1751-2018 verified. Linked to CDIAC global 1751-2018.xls (last updated Jan20).

Cell: CW42
Comment: Rick Heede:
From the associated "Methods" paper: CDIAC's emissions methodology is not described.
Boden, T.A., G. Marland, and R.J. Andres. 2009. Global, Regional, and National Fossil-Fuel CO2 Emissions. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A. doi 10.3334/CDIAC/00001.
Jan10: CMS added CDIAC extrapolations for gas emissions from their dataset "Preliminary 2007-08 Global & National Estimates by Extrapolation" (undated) to the main file cited above.
March 2019: Linked to data in CDIAC Global CO2 1751-2018.xls after GCP data through 2017 and forecast of +2.7% for 2018.
Sources: Cite as: Boden, T. A., Marland, G., and Andres, R. J.: Global, Regional, and National Fossil-Fuel CO2 Emissions, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A., doi 10.3334/CDIAC/00001_V2017, 2017; available at: http://cdiac.ess-dive.lbl.gov/trends/emis/overview_2014.html
Also see globalcarbonproject.org, 2017 Carbon Budget.

Cell: CW52
Comment: Rick Heede:

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Cell: CW53
Comment: Rick Heede:

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