

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
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2		<b>Summary of estimated process emissions from identified cement production</b>																		
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	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS
1	<b>Summary of estimated process emissions from identified cement production</b>																								
2	Richard Heede																								
3	Climate Mitigation Services																								
4	[20-Nov-12]																								
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15	1940s							1950s										1960s							
16	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
17																									
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21																									
22																									
23	1	1	0	0	0	0	0	0	1	1	2	2	2	3	3	5	6	7	4	4	5	5	5	5	4
24																									
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36	1	1	0	0	0	0	0	0	1	1	2	2	2	3	3	5	6	7	4	4	5	5	5	5	4
37																									
38	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	2	2	1	1	1	1	1	1	1
39																									
40	37	26	26	37	44	51	59	66	73	81	88	99	110	117	125	132	147	158	165	180	187	209	216	231	238
41																									
42	10	7	7	10	12	14	16	18	20	22	24	27	30	32	34	36	40	43	45	49	51	57	59	63	65
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	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC	BD	BE	BF	BG	BH	BI	BJ	BK	BL	BM	BN	BO	BP	BQ	BR	BS	
1	<b>Summary of estimated process emissions from identified cement production</b>																										
2	Richard Heede																										
3	Climate Mitigation Services																										
4	20-Nov-12																										
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14	dataset marker																										
15	1970s											1980s										1990s					
16	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	
17								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%	55.70%	55.70%	55.70%	55.70%	
18																								56.0%	56.4%	56.7%	
19																											
20																											
21																											
22																											
23	4	5	5	11	11	12	12	15	25	28	33	37	40	42	47	54	60	71	81	90	105	103	105	126	154	183	
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36	4	5	5	11	11	12	12	24	35	39	45	50	52	54	59	65	72	81	90	100	115	114	264	287	317	348	
37																											
38	1	1	1	3	3	3	3	7	9	11	12	14	14	15	16	18	20	22	25	27	31	31	72	78	86	95	
39																											
40	256	271	286	308	326	348	352	348	377	396	425	436	440	443	443	458	469	480	502	524	557	572	575	590	612	645	
41																											
42	70	74	78	84	89	95	96	95	103	108	116	119	120	121	121	125	128	131	137	143	152	156	157	161	167	176	
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	BT	BU	BV	BW	BX	BY	BZ	CA	CB	CC	CD	CE	CF	CG	CH	CI	CJ	CK	CL	CM	CN	CO		
1	<b>Summary of estimated process emissions from identified cement production **</b>																					0.5071	IPCC 1996	
2																						tCO2/t cementitious product	0.4987	CDIAC emission factor
3																						0.5400	WBCSD Sustainable Cement Initiative - general cement EF	
4																						0.5196	WBCSD GNR suggests 60 percent process emissions of global average of 866 kg CO2 per tonne of clinker	
5																						0.5203	IPCC tier 1 approach, IPCC 2006	
6																						0.5196	truing up to CDIAC process emission factor	
7																								
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12																								
13																								
14																								
15	<b>1990s</b>						<b>2000s</b>										<b>Sum to 2010</b>		<b>Cement process emissions</b>					
16	<b>1994</b>	<b>1995</b>	<b>1996</b>	<b>1997</b>	<b>1998</b>	<b>1999</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>Million tonnes CO2</b>		<b>Process emissions as percent of Gross CO2</b>				
17	57.1%	57.5%	57.8%	58.2%	58.6%	58.9%	59.3%	59.7%	60.1%	60.5%	60.9%	61.3%	63.7%	64.5%	65.8%	67.0%	66.4%							
18	24	24	24	24	24	24	24	24	24	27	30	31	34	35	32	27	27	551						
19	210	237	245	255	267	286	298	330	362	430	484	533	617	679	692	806	890	9,150						
20	28	28	27	27	26	25	25	24	22	24	26	26	29	34	35	30	31	587						
21	38	39	41	42	43	45	46	48	51	53	55	58	61	64	64	60	62	1,008						
22	20	20	20	20	20	20	20	20	20	20	21	25	28	29	28	24	24	463						
23	43	44	45	45	46	47	47	48	49	48	51	53	59	62	68	62	61	1,044						
24	13	13	14	13	12	11	11	11	11	10	10	10	11	10	10	9	10	402						
25																								
26	376	405	415	426	438	457	470	504	537	613	678	735	838	914	930	1,017	1,106	13,205			<b>Emissions from identified cement prod'n (MtCO2)</b>			
27	103	111	113	116	120	125	128	138	147	167	185	201	229	249	254	278	302	3,604			<b>Carbon in identified cement prod'n (MtC)</b>			
28	682	722	744	766	766	795	828	868	923	1,011	1,092	1,173	1,301	1,400	1,414	1,509	1,638	32,519			<b>CDIAC cement emissions (Million tonnes of CO2)</b>			
29	186	197	203	209	209	217	226	237	252	276	298	320	355	382	386	412	447	8,875			<b>CDIAC cement emissions (Million tonnes of carbon)</b>			
30	55.2%	56.1%	55.8%	55.6%	57.2%	57.5%	56.8%	58.0%	58.2%	60.6%	62.1%	62.7%	64.4%	65.3%	65.7%	67.4%	67.5%	40.6%			<b>Percent of cumulative CDIAC cement emissions</b>			
31	<b>Total emissions from identified cement production through 2010 (million tonnes CO2)</b>																	<b>13,205</b>						
32																		4,055	<b>Cement process emissions, excluding China</b>					
33	** CMS has 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). 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 gross CO2 emissions for 1990, 2000, 2005, and 2006. This percentage (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).																							

Process emissions

Cell: CN2

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: CN4

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:  $(12.01 \text{ g C/mole CaCO}_3 + 56.08 \text{ g CaO/mole CaCO}_3) * 0.635 \text{ g CaO/g cement} = 0.136 \text{ g C/g cement.}$ "  
"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](http://cdiac.ornl.gov/epubs/ndp/ndp030/ndp0301.htm#co2man)

Cell: CN6

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.wbcscement.org](http://www.wbcscement.org)

Cell: CN8

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., [wbcscement.org](http://wbcscement.org).  
Page 30:  
(1) about 60% of gross CO2 emissions originate from 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: CN11

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 (EFcl) 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/2006glvol3.html](http://www.ipcc-nggip.iges.or.jp/public/2006glvol3.html)

Cell: CN13

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 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](http://cdiac.ornl.gov/epubs/ndp/ndp030/ndp0301.htm#co2man)

Cell: CN18

Comment: Rick Heede:

\* CMS has 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.)  
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 gross CO2 emissions for 1990, 2000, and 2005-2009.  
This percentage (in row 12) is applied to each entity's gross 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: CN23

Comment: Rick Heede:

CMS uses CDIAC emissions from cement production in China 1929-2010.

Cell: CN40

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:  $C=12.0107 + O=15.9994 * 2 = 44.0095/12.0107 = 3.664191$ .

Cell: CN42

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.

Dec11: CMS added CDIAC extrapolations for gas emissions from their dataset "Preliminary 2009-2010 Global & National Estimates by Extrapolation" (undated) to the main file cited above.

Cell: CN52

Comment: Rick Heede:

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Comment: Rick Heede:

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