

	A	B	C	D	E	F	G	H	I
1	From the carbon content of natural gas to estimated emissions per billion cubic feet (Bcf)								
2				Climate Mitigation Services Rick Heede Carbon Majors Project 4-Jun-13	Copyright Climate Mitigation Services				
3									
4									
5									
6									
7									
8									
9									
10	Table 1	Natural Gas							
11									
12									
13									
14									
15	Step 1:	Carbon in produced natural gas (net production)	14.46	1.028		14.86		54.44	
16	Step 2:	Energy inputs to gas extraction, transport, processing, & delivery	(applied in SummaryRanking.xls)			14.86		54.44	
17	Step 3:	Vented carbon dioxide, gas operations	(applied in SummaryRanking.xls)			14.86		54.44	
18	Step 4:	Direct venting of methane (intentional & fugitive), gas ops	(applied in SummaryRanking.xls)			14.86		54.44	
19	Step 5:	Flaring of natural gas, gas operations	(applied in SummaryRanking.xls)			14.86		54.44	
20	Step 6:	Adjust for carbon sequestered through non-energy uses of gas	estimated in "non-energy uses"		0.98144	14.58		53.43	
21	Step 7:	Adjust for oxidation rate	100 percent		1.00000	14.58		53.43	
22	Step 8:	Convert step 7 factor to emissions per billion cubic feet (Bcf)	Million tonnes Carbon and CO2 per billion cf (Bcf)			0.01458		0.05343	
23	Step 9:	Link to Gas Emissions worksheet	Million tonnes Carbon and CO2 per billion cf (Bcf)			0.01458		0.05343	
24									
25									
26									
27									
28									
29									
30									
31									
32									
33									
34									
35									
36	Table 2a	Values (based on EPA and EIA factors)	14.46	1.104		15.97		94.5%	93.0%
37	Table 2b	Values (based on IPCC and UN factors)	15.30	1.105		16.91		105.9%	87.9%
38	Table 2c	Standard heating value (per UN), "net calorific value."	39,021	kJ/m ³					
39			39.02	MJ/m ³					
40			35.31467	cf/m ³					
41			1.1050	MJ/cf (calculated)					
42			1.1050	GJ/kcf					
43			1,055	J/Btu					
44									
45									
46									
47	Table 2d	IPCC default values	48.00	net calorific value, TJ/Gg				35.3147	
48			15.30	default carbon content, kgC/GJ				1.8870	mtCO2/Bcm
49									
50			14.50	kg C/million Btu					
51									
52									

Gas Emissions Factor Calc

EIA / EPA background data on default values for natural gas

Table A-40: Composition of Natural Gas (Percent)

Compound	Average	Median
Methane	93.07	95.00
Ethane	3.21	2.79
Propane	0.59	0.48
Higher Hydrocarbons	0.32	0.30
Non-hydrocarbons	2.81	1.43
Higher Heating Value (Btu per cubic foot)	1,027	1,031

Source: Gas Technology Institute (1992).

Table A-43: Carbon Content of Flare Gas (Tg C/QBtu)

Relevant Sub-Sample	Average Carbon Content
>1,100 Btu/cf	15.31

Source: EPA (2010)

EPA (2012) Table A-43, Annex 2, page A-65.

EPA Energy Hub	
0.001028	mmBtu/scf
53.02	kgCO2/mmBtu
0.054505	kgCO2/scf
54.50	kgCO2/kcf
14.87	kgC/kcf
100.11% % of final (F15)	

Table A-42: Carbon Content Coefficients for Natural Gas (Tg Carbon/QBtu)

Fuel Type	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Natural Gas	14.45	14.46	14.46	14.46	14.44	14.46	14.47	14.46	14.46	14.44	14.46	14.46	14.46	14.46	14.46	14.46	14.46

Source: EPA (2010)

EPA (2012) Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990 – 2010, Annex 2: Methodology and Data for Estimating CO2 Emissions from Fossil Fuel Combustion,

Table A-42: Carbon Content Coefficients for Natural Gas (Tg Carbon/QBtu), page A-64

Table A4. Approximate Heat Content of Natural Gas, Selected Years, 1949-2011
(Btu per Cubic Foot)

Year	Production		Consumption ¹		
	Marketed	Dry	End-Use Sectors ²	Electric Power Sector ³	Total
1949	1,120	1,035	1,035	1,035	1,035
1950	1,119	1,035	1,035	1,035	1,035
1955	1,120	1,035	1,035	1,035	1,035
1960	1,107	1,035	1,035	1,035	1,035
1965	1,101	1,032	1,032	1,032	1,032
1970	1,102	1,031	1,031	1,031	1,031
1975	1,065	1,021	1,020	1,026	1,021
1976	1,063	1,020	1,019	1,023	1,020
1977	1,063	1,021	1,019	1,029	1,021
1978	1,088	1,019	1,016	1,034	1,019
1979	1,092	1,021	1,018	1,035	1,021
1980	1,068	1,026	1,024	1,035	1,026
1981	1,103	1,027	1,025	1,035	1,027
1982	1,107	1,028	1,026	1,036	1,028
1983	1,115	1,031	1,031	1,030	1,031
1984	1,109	1,031	1,030	1,035	1,031
1985	1,112	1,032	1,031	1,038	1,032
1986	1,110	1,030	1,029	1,034	1,030
1987	1,112	1,031	1,031	1,032	1,031
1988	1,109	1,029	1,029	1,028	1,029
1989	1,107	1,031	1,031	1,028	1,031
1990	1,105	1,029	1,030	1,027	1,029
1991	1,108	1,030	1,031	1,025	1,030
1992	1,110	1,030	1,031	1,025	1,030
1993	1,106	1,027	1,028	1,025	1,027
1994	1,105	1,028	1,029	1,025	1,028
1995	1,106	1,026	1,027	1,021	1,026
1996	1,109	1,026	1,027	1,020	1,026
1997	1,107	1,026	1,027	1,020	1,026
1998	1,109	1,026	1,027	1,020	1,026
1999	1,106	1,026	1,027	1,020	1,026
2000	1,107	1,026	1,027	1,020	1,026
2001	1,109	1,027	1,028	1,020	1,028
2002	1,109	1,027	1,028	1,020	1,028
2003	1,107	1,027	1,028	1,020	1,027
2004	1,107	1,027	1,028	1,020	1,027
2005	1,104	1,028	1,028	1,020	1,028
2006	1,103	1,028	1,028	1,020	1,028
2007	1,102	1,027	1,027	1,020	1,027
2008	1,100	1,027	1,027	1,020	1,027
2009	1,101	1,025	1,025	1,025	1,025
2010	1,067	1,023	1,023	1,022	1,023
2011	1,067	1,022	1,023	1,021	1,022

Data Sources: Coal and lignite production: EIA (2010); Unspecified Solid Fuels: EIA (2011); Coke, Natural Gas and Petroleum: US EPA (2011) Inventory of U.S. Emissions, Annex 4: IPCC Reference Approach for Estimating CO2 Emissions from Fossil Fuel Combustion

Year	Marketed prod'n, HHV	Dry natural gas, HHV	Average of Mark & Dry
1949	1,120	1,035	1,078
1950	1,119	1,035	1,077
1955	1,120	1,035	1,078
1960	1,107	1,035	1,071
1965	1,101	1,032	1,067
1970	1,102	1,031	1,067
1971	1,103	1,031	1,067
1972	1,100	1,027	1,064
1973	1,093	1,021	1,057
1974	1,097	1,024	1,061
1975	1,095	1,021	1,058
1976	1,093	1,020	1,057
1977	1,093	1,021	1,057
1978	1,088	1,019	1,054
1979	1,092	1,021	1,057
1980	1,098	1,026	1,062
1981	1,103	1,027	1,065
1982	1,107	1,028	1,068
1983	1,115	1,031	1,073
1984	1,109	1,031	1,070
1985	1,112	1,032	1,072
1986	1,110	1,030	1,070
1987	1,112	1,031	1,072
1988	1,109	1,029	1,069
1989	1,107	1,031	1,069
1990	1,105	1,029	1,067
1991	1,108	1,030	1,069
1992	1,110	1,030	1,070
1993	1,106	1,027	1,067
1994	1,105	1,028	1,067
1995	1,106	1,026	1,066
1996	1,109	1,026	1,068
1997	1,107	1,026	1,067
1998	1,109	1,031	1,070
1999	1,107	1,027	1,067
2000	1,107	1,025	1,066
2001	1,105	1,028	1,067
2002	1,103	1,024	1,064
2003	1,103	1,028	1,066
2004	1,104	1,026	1,065
2005	1,104	1,028	1,066
2006	1,103	1,028	1,066
2007	1,102	1,027	1,065
2008	1,100	1,027	1,064
2009	1,101	1,025	1,063
2010	1,097	1,023	1,060
2011	1,097	1,022	1,060
average	1,104.3	1,027.6	1,065.9
	1,042		linked table 1

EIA (2012) Annual Energy Review 2011, Table A4.

Note: "The values in this table are for gross heat contents."

AB AC AD AE AF AG AH AI AJ AK AL AM AN AO AP AQ AR

IPCC background data on default values for natural gas

TABLE 2.2 (CONTINUED)
DEFAULT EMISSION FACTORS FOR STATIONARY COMBUSTION IN THE ENERGY INDUSTRIES
 (kg of greenhouse gas per TJ on a net calorific basis)

Fuel	CO ₂			CH ₄			N ₂ O			
	Default emission factor	Lower	Upper	Default emission factor	Lower	Upper	Default emission factor	Lower	Upper	
Coal Tar	n 80 700	68 200	95 300	n 1	0.3	3	r 1.5	0.5	5	
Derived Gases	Gas Works Gas	n 44 400	37 300	54 100	n 1	0.3	3	0.1	0.03	0.3
	Coke Oven Gas	n 44 400	37 300	54 100	r 1	0.3	3	0.1	0.03	0.3
	Blast Furnace Gas	n 260 000	219000	308 000	r 1	0.3	3	0.1	0.03	0.3
	Oxygen Steel Furnace Gas	n 182 000	145 000	202 000	r 1	0.3	3	0.1	0.03	0.3
Natural Gas	56 100	54 300	58 300	r 1	0.3	3	0.1	0.03	0.3	
Municipal Wastes (non-biomass fraction)	n 91 700	73 300	121 000	30	10	100	4	1.5	15	
Industrial Wastes	n 143 000	110 000	183 000	30	10	100	4	1.5	15	
Waste Oils	n 73 300	72 200	74 400	30	10	100	4	1.5	15	
Peat	106 000	100 000	108 000	n 1	0.3	3	n 1.5	0.5	5	
Solid Biofuels	Wood / Wood Waste	n 112 000	95 000	132 000	30	10	100	4	1.5	15
	Sulphite lyes (Black Liquor) ^(a)	n 95 300	80 700	110 000	n 3	1	18	n 2	1	21
	Other Primary Solid Biomass	n 100 000	84 700	117 000	30	10	100	4	1.5	15
	Charcoal	n 112 000	95 000	132 000	30	10	100	4	1.5	15
Liquid Biofuels	Biogasoline	n 70 800	59 800	84 300	r 3	1	10	0.6	0.2	2
	Biodiesels	n 70 800	59 800	84 300	r 3	1	10	0.6	0.2	2
	Other Liquid Biofuels	n 79 600	67 100	93 300	r 3	1	10	0.6	0.2	2
Gas Biomass	Landfill Gas	n 54 600	46 200	66 000	r 1	0.3	3	0.1	0.03	0.3
	Sludge Gas	n 54 600	46 200	66 000	r 1	0.3	3	0.1	0.03	0.3
	Other Biogas	n 54 600	46 200	66 000	r 1	0.3	3	0.1	0.03	0.3
Other non-fossil fuels	Municipal Wastes (biomass fraction)	n 100 000	84 700	117 000	30	10	100	4	1.5	15

^(a)Includes the biomass-derived CO₂ emitted from the black liquor combustion unit and the biomass-derived CO₂ emitted from the kraft mill lime kiln.
 n indicates a new emission factor which was not present in the IPCC 1996 Guidelines.
 r indicates an emission factor that has been revised since the IPCC 1996 Guidelines.

TABLE 1.4 (CONTINUED)
DEFAULT CO₂ EMISSION FACTORS FOR COMBUSTION¹

Fuel type English description	Default carbon content (kg/GJ)	Default carbon oxidation Factor	Effective CO ₂ emission factor (kg/TJ) ²	
			Default value	95% confidence interval
	A	B	C=A*B*44/12*1000	Lower Upper
Natural Gas	15.3	1	56 100	54 300 58 300

IPCC 2006 Table 1.4

Natural Gas 48.00 TJ/Gg
 (46.5 to 50.4 TJ/Gg)

2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 1: Introduction, table 1.2 Default Calorific Values

	AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC	BD	BE	BF	BG	BH	BI
1	United Nations background data on heat value of natural gas																
2																	
3																	
4	Table V								Table V (continued - suite)								
5	HEAT VALUES OF GASES								HEAT VALUES OF GASES								
6	POUVOIRS CALORIFIQUES DES GAZ								POUVOIRS CALORIFIQUES DES GAZ								
7	NATURAL GAS - GAZ NATUREL								NATURAL GAS - GAZ NATUREL								
8	(Kilojoules/Cubic Metres) - (Kilojoules/Mètres Cubes)								(Kilojoules/Cubic Metres) - (Kilojoules/Mètres Cubes)								
9	Standard Heat Value								Pouvoir calorifique standard								
10	39021								39021								
11	Albania			35000 (N)				Albanie									
12	Algeria			39565 (N)				Algérie									
13	Argentina			40337* (G)				Argentine									
14	Australia			35658 (G)				Australie									
15	Austria			39600 (G)				Autriche									
16	Bangladesh			35064				Bangladesh									
17	Belarus			34760 (N)				Bélarus									
18	Belgium			39687* (G)				Belgique									
19	Bolivia			37263				Bolivie									
20	Brazil			43740				Bésil									
21	Brunei			43000				Brunéi									
22	Bulgaria			35152* (G)				Bulgarie									
23	Canada			38550* (G)				Canada									
24	China			38979 (N)				Chine									
25	Chile			37263				Chili									
26	Colombia			34598				Colombie									
27	Croatia			38000 (G)				Croatie									
28	Denmark			40901 (N)				Danemark									
29	Ecuador			48441* (G)				Équateur									
30	Estonia			33537				Éstonie									
31	Finland			39170 (G)				Finlande									
32	France			39205* (G)				France									
33	Germany			33339 (G)				Allemagne									
34	Greece			57211 (G)				Grèce									
35	Hungary			32456 (N)				Hongrie									
36	India			38586 (N)				Inde									
37	Iran (Islamic Rep. of)			39356*				Iran (Rép. islamique)									
38	Ireland			37604* (G)				Irlande									
39	Israel			38728*				Israël									
40	Italy			37306 (G)				Italie									
41	Japan			41023 (G)				Japon									
42	Kazakhstan			33949 (N)				Kazakhstan									
43	Latvia			33597				Lettonie									
44	Lithuania			33949				Lituanie									
45	Luxembourg			40773 (G)				Luxembourg									
46	Mexico			44257* (G)				Mexique									
47	Netherlands			33320 (G)				Pays-Bas									
48	2009 Energy Statistics Yearbook United Nations / 2009 Annuaire des statistiques de l'énergie des Nations Unies xlv																
49	Table V, United Nations (2012) Energy Statistics Yearbook 2009, UN Statistics Division, Jun12; unstats.un.org/unsd/energy/yearbook/default.htm																
50	Note: the "Standard Heat Value" of 39,021 kJ/m ³ is based on Table 12, page 28, United Nations (1987) <i>Energy Statistics: Definitions, Units of Measure and Conversion Factors</i> , UN Statistical Office, New York, Series F-44, 65 pp., unstats.un.org/unsd/publication/SeriesF/SeriesF_44E.pdf																
51																	
52																	

3. Gaseous fuels

Table 12. Gaseous fuel equivalents a/

FROM Thousand cubic metres b/	INTO						
	Giga- joules	Million Btus	Megawatt hours	Giga- calories	Barrels oil	Tons coal equivalent	Tons oil equivalent
	M U L T I P L Y B Y						
Natural gas	39.02	36.98	10.84	9.32	6.50	1.331	0.932
Coke oven gas	17.59	16.67	4.88	4.20	2.94	0.600	0.420
Blast furnace gas	4.00	3.79	1.11	0.96	0.66	0.137	0.096
Refinery gas a/	46.1	43.7	12.8	11.0	7.69	1.571	1.100
Gasworks gas	17.59	16.67	4.88	4.20	2.94	0.600	0.420
Biogas	20.0	19.0	5.6	4.8	3.36	0.686	0.480
Methane	33.5	31.7	9.30	8.0	5.59	1.143	0.800
Ethane	59.5	56.3	16.5	14.2	9.92	2.029	1.420
Propane	85.8	81.3	23.8	20.5	14.33	2.929	2.050
Isobutane	108.0	102.0	30.0	25.8	18.0	3.686	2.580
Butane	111.8	106.0	31.0	26.7	18.6	3.814	2.670
Pentane	134.0	127.0	37.2	32.0	22.36	4.571	3.200

United Nations (1987) *Energy Statistics: Definitions, Units of Measure and Conversion Factors*,

UN Statistical Office, New York, Series F-44, 65 pp.,

Footnotes to Table 12:

a/ All heat values correspond to net calorific value.

b/ Under standard reference conditions. To convert from SRC to STP, multiply by 1.0757.

Gas Emissions Factor Calc

Cell: G13

Comment: Rick Heede:

We use the isotopic value of CO2 in converting from carbon to CO2. CO2 conversion is, precisely: $CO2/C: (C: 12.0107) + (O = 15.9994 \times 2) = 44.0095/12.0107 = 3.664191$. Kevin Baumert, WRI, May 2005, personal communication.

Cell: C15

Comment: Rick Heede:

CMS first considered applying an emission factor based on the IPCC default value and the UN "Standard Heating Value" for natural gas (see Table 2c below), but rejected this EF as being unreasonably high. CMS and our technical reviewers agreed that applying a factor based on US EPA and EIA factors provides a conservative emission factor based on published, substantiated, and peer-reviewed data. The EF combines the EPA's value of 14.46 Tg/QBtu with the average HHV heating values of Marketed and Dry Natural Gas Production for 1949-2011. These factors are documented and described at right.

Cell: D15

Comment: Rick Heede:

EIA and EPA data on carbon content of natural gas (14.46 kgC per million Btu -- usually expressed as 14.46 TgC/QBtu: 14.46 million tonnes of carbon per quadrillion (10^{15} Btu)). EPA (2012) Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990 – 2010, Annex 2: Methodology and Data for Estimating CO2 Emissions from Fossil Fuel Combustion, Table A-42: Carbon Content Coefficients for Natural Gas (Tg Carbon/QBtu), page A-64.

Cell: E15

Comment: Rick Heede:

Natural gas producers typically report "natural gas available for sale", we use the EIA HHV heating values data for 1949-2011 for "Dry Natural Gas Production" from EIA (2012) Annual Energy Review 2011, Table A-4: Approximate Heat Content of Natural Gas 1949-2011 (reproduced on page 2 and linked to cell Y50). The Marketed Production averages 1,104.3 Btu/scf over 1949-2011, whereas Dry Natural Gas Production averages 1,027.6 Btu/scf. It might be more accurate to average of the "Dry" and "marketed" data sets 1949-2011 to 1,065.9 Btu/scf, but we apply the "dry" heating value as a conservatism. Note: these are "gross heating value", or HHV. Dry natural gas, on the other hand, has a default gross heating value of 1,028 Btu per cf (or 34.37 MJ/m³). Natural Gas Marketed Production is defined as "Natural gas gross withdrawals from production reservoirs, less gas used for reservoir repressuring; nonhydrocarbon gases removed in treating or processing operations; and quantities of vented natural gas and flared natural gas. Includes all quantities of natural gas used in field and processing operations." EIA AER glossary. Since both the carbon content and heating value factors are HHV we do not need to adjust for the HHV = 1.1 of LHV in this calculation. EPA and EIA both use HHV (unless otherwise noted).

Cell: C17

Comment: Rick Heede:

CMS accounts for company use of produced natural gas in the summary entity worksheet -- along with attributing fugitive methane emissions, vented CO2, flared gas, etc. See the SumRanking.xls worksheet for details. The objective is to attribute CO2 and CH4 emissions to the producing entities that are in addition to marketed natural gas, or in company terminology, "gas available for sale." These reported quantities do not account for field-use of gas in engines, compressors, processing plants, fugitive emissions, or vented CO2 (separating sour gas CO2 to the atmosphere).

Cell: C19

Comment: Rick Heede:

CMS attributes entrained CO2 removed from raw gas in the summary entity worksheet. See the SumRanking.xls worksheet for details. The "non-hydrocarbon gas removed from natural gas" rate equalled 3.12 percent (836.7 Bcf of 26,836 Bcf total production) in the U.S. in 2010 (EIA (2011) Natural Gas Annual 2010, Table 1). In addition, 3,431 Bcf was used for repressuring (12.79 percent), 166 Bcf was vented and flared (0.62 percent), 22,402 Bcf was marketed (83.48 percent), and 1,070 Bcf in processing loss (3.99 percent).

Cell: C21

Comment: Rick Heede:

CMS estimates and attributes methane releases from natural gas production, processing, and transportation, as well as flaring, in the Carbon Majors entity summary worksheet. See the SumRanking.xls worksheet for details.

Cell: C23

Comment: Rick Heede:

CMS attributes CO2 emissions from flaring operations at production and processing facilities in the Carbon Majors entity summary worksheet. See the SumRanking.xls worksheet for details and calculations.

Cell: C25

Comment: Rick Heede:

See the separate worksheet in this workbook ("Non-energy uses"), in which CMS calculates the percentage of the natural gas supplied (on average, over the past 31 years, based on US data by EIA and CMS adjustments for re-emission to the atmosphere) that is sequestered into fertilizers and methanol.

Cell: C27

Comment: Rick Heede:

IPCC 2006 Guidance uses a 100 percent oxidation factor (revised from 99.5 percent in the 1996 Guidance).

Gas Emissions Factor Calc

Cell: D36

Comment: Rick Heede:

EIA and EPA data on carbon content of natural gas (14.46 kgC per million Btu -- usually expressed as 14.46 TgC/QBtu: 14.46 million tonnes of carbon per quadrillion (10¹⁵ Btu)). EPA (2012) Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990 – 2010, Annex 2: Methodology and Data for Estimating CO₂ Emissions from Fossil Fuel Combustion, Table A-42: Carbon Content Coefficients for Natural Gas (Tg Carbon/QBtu), page A-64.

Cell: E36

Comment: Rick Heede:

We use the heat content of marketed natural gas (US average 1949-2010) at 1,105.9 Btu per cf, equiv to 36.98 MJ/m³, as representative of produced natural gas (this has varied from 1,088 to 1,120 since 1949). EIA (2011) Annual Energy Review 2010, Table A4 (reproduced on page 2 and averaged in and linked to cell W50).

Note: this is "gross heating value", or HHV. Dry natural gas, on the other hand, has a default gross heating value of 1,028 Btu per cf (or 34.37 MJ/m³).

Natural Gas Marketed Production is defined as "Natural gas gross withdrawals from production reservoirs, less gas used for reservoir repressuring; nonhydrocarbon gases removed in treating or processing operations; and quantities of vented natural gas and flared natural gas. Includes all quantities of natural gas used in field and processing operations." EIA AER glossary.

Since both the carbon content and heating value factors are HHV we do not need to adjust for the HHV = 1.1 of LHV in this calculation. EPA and EIA both use HHV (unless otherwise noted).

Cell: H36

Comment: Rick Heede:

The new IPCC / UN EF value is 16.3 percent higher than the EPA / EIA value; inverse is 86 percent.

Cell: C38

Comment: Rick Heede:

We derive an emission factor for natural gas production (prior to accounting for non-energy uses, vented CO₂, etc) from IPCC default factor (kgC/GJ) and GJ/thousand cubic feet (based on UN Statistics Dept "standard heating value" of natural gas (net calorific value)).

Numerically, this is: 15.30 kgC/GJ * 1.1050 GJ/kcf = 16.91 kgC/kcf, or 61.95 kgCO₂/kcf.

Cell: D38

Comment: Rick Heede:

The IPCC default value for natural gas is 15.3 kgC/GJ (range from 14.8 to 15.9 kgC/GJ) and is "on a net calorific basis." IPCC Guidelines 2006 Volume 2: Energy, chapter 1: Introduction, Table 1.3. Also listed as 56,100 kgCO₂/TJ in Table 2.2 on page 3. IPCC 2006 Guidelines vol 2, ch. 2: Stationary Combustion, Table 2.2.

Cell: E38

Comment: Rick Heede:

Calculated in Table 2c below and is based on UN Statistics' heating value for natural gas.

Cell: D40

Comment: Rick Heede:

Standard heating value of natural gas, "net calorific value." See Table V, United Nations (2012) Energy Statistics Yearbook 2009, UN Statistics Division, Jun12; unstats.un.org/unsd/energy/yearbook/default.htm. chapter on natural gas heating values puts "Standard Heat Value" at 39,021 kJ/m³. Reference to Table 12, page 28, United Nations (1987) Energy Statistics: Definitions, Units of Measure and Conversion Factors, UN Statistical Office, New York, Series F-44, 65 pp., unstats.un.org/unsd/publication/SeriesF/SeriesF_44E.pdf

Cell: D47

Comment: Rick Heede:

Net calorific value of natural gas shown as 48.0 TJ/Gg (range from 46.5 to 50.4 TJ/Gg), IPCC 2006 Guidelines vol 2, ch. 1: Introduction, Table 1.2.

Also lists crude oil at 42.3 TJ/Gg, and coal from 11.9 to 28.2 TJ/Gg.

Nowhere does the IPCC show conversions or default values for TJ or Gg per cubic meter of natural gas, or, for that matter, for crude oil or coal.

Thus we resort to UN heating value above.

Cell: D48

Comment: Rick Heede:

The IPCC default value for natural gas is 15.3 kgC/GJ (range from 14.8 to 15.9 kgC/GJ). IPCC Guidelines 2006 Volume 2: Energy, chapter 1: Introduction, Table 1.3. Also listed as 56,100 kgCO₂/TJ in Table 2.2 at right. IPCC 2006 Guidelines vol 2, ch. 2: Stationary Combustion, Table 2.2.

Cell: R51

Comment: Rick Heede:

"The U.S. Energy Information Administration typically uses gross heat content values." EIA AER Glossary.