Carbon in Our Daily Lives

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Climate Mitigation Services
Snowmass, Colorado
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Notes & to-do's:

Folio 1

Table 1	Elec CO2 factor (Aspen 2007)
1.731	lb CO2e, HCE (2007, est.)
1.265	lb CO2e, City Electric (2004)
0.605	lb CO2e, (2007 est., PhilO)
0.715	lb CO2e, CMS adjust PO 2006/07
1.223	lb CO2e, average of HCE & City
Natural gas CO2 factor	
116.9	lb CO2 per million Btu (Aspen)
132.1	lb CO2e per million Btu (Aspen)

Elec CO2 factor, US 2006	
2,344	US elec power sector, 2006, MtCO2
3	coal mining methane, MtCH4
65	coal mining methane, MtCO2e (23xCO2)
2	natural gas systems methane (pwr)
35	natural gas syst methane, MtCO2e
2,444	total power sector CO2 & CH4, MtCO2e
3,817	total retail sales, billion kWh, 2006
1.354	lb CO2 per delivered kWh, 2006
1.412	lb CO2e per delivered kWh, 2006
1.363	lb CO2 per kWh "output emission rate" EPA eGRID, 2004

Table 2		Conversions	
100	liters =	1.0	hectoliter
100	liters =	26.4	gallon
1	liter =	0.264	gallon
1	gallon =	128.0	fluid oz (US
1	gallon =	8.0	pints
1	lb	453.59	grams
1	gallon =	10.67	12-oz bott
1	HP	0.746	kW

Table 3 — Summary table of (partial) results: other calcuations below

		Energy (kWh per yr)	Emissions per yr, event, or item		CO2 per day (lb CO2/day)	CO2 per hour (lb CO2/hr)	CO2 per minute (lb CO2/min)	CO2 per second (lb CO2/sec)	
One gallon of gasoline:			19.6	lb CO2 per gallon					
One gallon of milk (emissions from fertilizer to table):			6.4	lb CO2e per gallon					
One lb of beef:			22.10	lb CO2e per pound					
One aircraft carrier:			8,086	lb CO2 per mile			*Lovins: Make Fuel Efficiency Our Gulf Strategy, 1990*		
One Airbus A380			188	lb CO2 per mile					
One Cessna 182:	see box below		1.6	lb CO2 per mile		213			
One Hawker 900EX bizjet			15.1	lb CO2 per mile		7,830			
One Gulfsteam IV bizjet			19.7	lb CO2 per mile		10,231			
Aspen ave personal vehicle (18.6 mpg)			1.0	lb CO2 per mile					*Aspen Inventory*
Snowmobile for an hour (excluding driving the infernal machine somewhere):			87	lb CO2/hr	520	87			
US household (single family)			26,028	lb/yr	71	3.0	0.05		*Cool Citizens*
Aspen-specific estimates									
Per Aspen household (average)			50,800	lb/yr	139	5.8	0.10		
Aspen, most consumptive HH (to our knowledge)			506,540	lb/yr	1,388	57.8	0.96		
Per household vehicle			11,380	lb/yr	31	1.3	0.02		
RFTA bus:			164	lb/hr	3,271	163.5	2.73		
Average Aspen vehicle (while driven)		tons CO2/yr	61	lb/hr	na	61.3	1.02		
All Aspen driving per day:		202,774	405,548,000	lb CO2/yr	1,111,090	46,295	772	12.9	
Commercial aviation (2004)		186,631	373,262,000	lb CO2/yr	1,022,636	42,610	710	11.8	
Private aviation (2004)		157,856	315,712,000	lb CO2/yr	864,964	36,040	601	10.0	
All Aspen residences		149,440	298,880,000		818,849	34,119	569	9.5	
All Aspen second homes		90,497	180,994,000		495,874	20,661	344	5.7	
Emissions per occupied day, residents			na		144	6.0	0	0.0	
Emissions per occupied day, second homes			na		606	25.3	0	0.0	
Aspen buildings & facilities (gas, electr	273,311	tons CO2/yr	546,622,000	lb CO2/yr	1,497,595	62,400	1,040	17.3	
Total Aspen GHG emissions (2004)	840,875	tons CO2/yr	1,681,750,000	lb CO2/yr	4,607,534	191,981	3,200	53.3	
One gallon Aspen water			0.00126	lb CO2 per gallon	na	0.00033	lb CO2 per liter		
One gallon Aspen wastewater treated			0.01162	lb CO2 per gallon	na	0.00307	lb CO2 per liter		
Combined water supply & water treatment			0.01288	lb CO2 per gallon	na	0.00340	lb CO2 per liter		
Aspen water, ave. 131,000 gallons per hh-yr			1,687	lb CO2/yr	4.6	0.19			
Pond circulating pump (large), Old Snov	1.731	49,012	84,863	lb CO2/yr	233	9.69			
Four exterior lights on 12 hrs/day		1,752	2,372	lb CO2/yr	6.5	0.27			
UPS package delivery			4.7	lb CO2 per package					

US average annual use	Electricity (lb CO2/kWh (ave))	Energy (kWh per yr)	Emissions per yr (lb CO2/yr)		CO2 per day (lb CO2/day)	CO2 per hour (lb CO2/hr)	CO2 per minute (lb CO2/min)	CO2 per second (lb CO2/sec)	Reference
Central AC	1.354	2,796	3,785		10.37	0.43			RECS 2001
Average US household using AC	1.354	2,262	3,062		8.39	0.35			RECS 2001
Ceiling fan (2.8 fans/hh)	1.354	138	187		0.51	0.02			RECS 2001
Clothes washer (excl. hot water)	1.354	120	162		0.45	0.02	1,544	lb CO2/yr	RECS 2001
Clothes washer	1.354	1,080	1,462		4.01	0.17			Heede HMM (1995)
Clothes dryer	1.354	1,079	1,461		4.00	0.17			RECS 2001
Dishwasher (unit only, excludes DHW)	1.354	512	693		1.90	0.08			RECS 2001
Aquarium	1.354	550	745		2.04	0.08			ECOS
Furnace fan	1.354	500	677		1.85	0.08			RECS 2001
Home lighting	1.354	940	1,273		3.49	0.15			RECS 2001
Home lighting, single-family household	1.354	1,500	2,031		5.56	0.23			CMS, RECS
Pool pump	1.354	1,500	2,031		5.56	0.23			ACE3, RECS 2001
Hot tub	1.354	2,300	3,114		8.53	0.36	CMS used REMP, 0.75 lb CO2e/hr		ACE3, RECS 2001
TV, color analog	1.354	307	416		1.14	0.05			RECS
TV, plasma 46 inch	1.354	224	303		0.83	0.03			ECOS
TV, LCD 40 inch	1.354	190	257		0.70	0.03			ECOS
TiVO	1.354	363	491		1.35	0.06			ECOS
DVD player	1.354	34	46		0.13	0.01			ACE3 9th
Cable TV box	1.354	239	324		0.89	0.04			ECOS
Satellite dish	1.354	130	176		0.48	0.02			RECS 2001
Water heater (electric)	1.354	2,835	3,838		10.51	0.44			RECS
Water heater (gas)	1.354		-		-	-			
Refrigerator (average in use)	1.354	1,239	1,677		4.60	0.19			RECS
Refrigerator (best side-by-side 25.6 cf	1.354	580	785		2.15	0.09			ACE3 9th
Toaster	1.354	45	61		0.17	0.01			ACE3 7th
Well pump	1.354	400	542		1.48	0.06			ACE3 9th
Bottled water dispenser, hot&cold	1.354	827	1,120		3.07	0.13			ACE3 9th
Desktop computer	1.354	262	355		0.97	0.04			RECS 2001
Laptop computer	1.354	77	104		0.29	0.01			RECS 2001
Monitor (LCD)	1.354	70	95		0.26	0.01			ECOS
Home security system	1.354	195	264		0.72	0.03			ECOS
Fax machine	1.354	216	292		0.80	0.03			RECS
Engine block heater	1.354	200	271		0.74	0.03			RECS 2001
Waterbed heater	1.354	900	1,218		3.34	0.14			RECS 2001

Flying & Driving & Military

Folio 2

Private Aviation

	gallons/hr	miles per hour	miles per gallon	lb CO2/hr	lb CO2 per mile
Hawker 900EX	375	520	1.39	7,830	15.06
Gulfstream IV	490	520	1.06	10,231	19.68
Cessna 182	11.6	132	11.41	213	1.61

Airbus A380

One Airbus A380 **188** lb CO2 per mile

Aircraft carrier fuel and emissions

One aircraft carrier: **8,086** lb CO2 per mile — Lovins "Make Fuel Efficiency Our Gulf Strategy" 1990

EF bunker fuel 26.033 lb CO2/gallon

	bbl per hr	gallons per hour	gallons per day	lb CO2 per day	tons CO2 per day	lb CO2 per hour	lb CO2 per minute	lb CO2 per second
Gar Smith, Earth Island Journal	134	5,628	135,072	3,516,329	1,758	146,514	2,442	40.7
USS Independence			150,000	3,904,950	1,952	162,706	2,712	45.2

USS Independence, at 25 knots = 690.6 statute miles/day **5,654 lb CO2 per mile**

"At it top speed of 25 knots, the USS Independence (a 1070-foot-long aircraft carrier with 4.1 acres of flight deck and a crew of 2300) consumes 150,000 gallons of fuel a day."

"battleships ... consume 68 barrels per hour"

Midway & Independence

USS Independence

USS Independence

USS Kitty Hawk

USS Kitty Hawk

USS Kitty Hawk

unknown carrier

Kitty Hawk: *Don't Tread on Me*

F-16 and F-18 fighter jets

Tom Shanker, Int Herald Tribune	When an F-16 lights up its afterburners, it consumes nearly 28 gallons of fuel per minute.
Gar Smith	With its afterburner kicked in, Cutler states, the "relatively fuel-efficient" F-15 fighter torches fuel at the astounding rate of four gallons per second - 14,400 gallons per hour.
Gar Smith	At peak thrust, F-15 fighters burn 25 gallons per minute.
Gar Smith	A B-52 bomber gulps down 86 barrels per hour.
Gar Smith	Under standard conditions the Army's M-1 Abrams tank gets eight gallons per mile. In the heat of battle, however, the M-1 Abrams tank can eat up seven barrels - 252 gallons (base
www.f-16.net/f-16_forum_viewtopic-t	F-16 on a "1.0 mission" uses abt 700-900 gallons of fuel
www.f-16.net/f-16_forum_viewtopic-t	F-16 1 hr mission: start with 12,000-12,300 lb and returns with ~3000-3500 lb, say uses ~

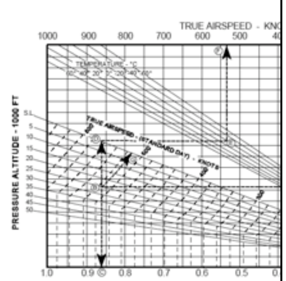
9,000	lb/hr
6.7	lb per gallon
1,343	gallons per hr
22.39	gallons/minute
28,337	**lb CO2/hour**

See Gar Smith's article for data n Abrams tanks (~0.125 gpm)

Mach conversion charts (TAS & IAS)

www.mirage-jet.com/COMPAR_1/comp

	Mach 0.5 sea level	Mach 0.8 15,000 ft	Mach1.4 36,000ft	Mach 0.5 sea level	Mach 0.8 15,000 ft	Mach1.4 36,000ft
	kg/min	kg/min	kg/min	gallons/minute	gallons/minute	gallons/minute
Mirage	360	275	230	118	90	76
F-16C	415	310	260	137	102	86
F-18C	495	380	300	163	125	99
	lb/min	lb/min	lb/min	lb CO2/minute	lb CO2/minute	lb CO2/minute
Mirage	794	606	507	2,499	1,909	1,596
F-16C	915	683	573	2,881	2,152	1,805
F-18C	1,091	838	661	3,436	2,638	2,082
	lb CO2/hour	lb CO2/hour	lb CO2/hour	tons CO2/hour	tons CO2/hour	tons CO2/hour
Mirage	149,930	114,530	95,789	74.96	57.26	47.89
F-16C	172,836	129,106	108,283	86.42	64.55	54.14
F-18C	206,154	158,259	124,942	103.08	79.13	62.47



F-15C sky flash

F-16

F-18 Hornet sky flash

F-18 afterburner on take=off

www.mirage-jet.com/COMPAR_1/compar_1

max power fuel rate

Combat Fuel Consumption @ Max. Power

	Mach 0.5 sea level	Mach 0.8 15,000 ft	Mach1.4 36,000ft
		4,572 m	10,973 m
	kg/min	kg/min	kg/min
Mirage 2000	360	275	230
F16 C	415	310	260
F18 C	495	380	300

Private & Commercial Aviation compared: travel to Aspen

Folio 3

example of one 1,000-mile trip, one way

	First leg to DEN	2nd leg, DEN-ASE	First leg to DEN	2nd leg, DEN-ASE	trip emissions/pax
	miles	miles	lb CO2	lb CO2	lb CO2
Commercial air travel	880	120	370	86	456
		same, using GEO ra	343	77	420
	same, using GEO & CMS data on ASE		343	112	455

	lb CO2/pax-mile	Flight distance
Short flight	0.720	0-120 miles
Medium flight	0.560	121-800 miles
Long flight	0.420	801-2500 miles
Extended flight	0.360	2501-25000 miles

	Fuel rate	Fuel rate	Fuel consumption	Emissions	trip emissions/pax
Private aviation	gallons/nm	gallons/stat mile	gallons 1000 miles	lb CO2 1000 miles	assumes 4 pax
Hawker 400XP	0.46	0.40	402	8,399	2,100

Private / commercial air travel multiplier	5.00

Adopted by GEO	lb CO2/pax-mile	Flight distance	CMS recommendation lb CO2/pax-mile	
Short flight	0.640	0-250 miles	0.720	CMS
Medium flight	0.450	251-800 miles	0.520	Dec-08
Long flight	0.390	801-2500 miles	0.360	
Extended flight	0.390	2501-25000 miles	0.290	

Driving

	gallons/hr	miles per hour	miles per gallon	lb CO2/hr	lb CO2 per mile
Hummer H2	5.61	60	10.7	110	1.83
Average Aspen personal vehicle	3.13	60	19.15	61	1.02
Average commuting vehicle, Hershey P	2.63	60	22.8	52	0.86
Toyota Prius	1.47	60	40.8	29	0.48
Drive Aspen to Glenwood rt (miles, not	4.18	80 miles, not mpg	19.2	82	1.02
RFTA bus	7.60	40	5.3	164	4.09
				21.5	lb CO2/gallon B5 fuel

RFTA, pax #	lb CO2 per mile
10	0.409
20	0.204
40	0.102

RFTA calculation of emissions per passenger-mile, 2007

Valley Routes	2,223,772	vehicle miles
Ridership	1,629,234	riders
16 miles per rider	26,067,744	passenger-miles
Fuel	303,280	gallons
Emissions	3,037	tons CO2
Emissions/pax-mile	0.233	lb CO2/pax-mile

Average passengers per private jet, ASE

Source	passengers per aircraft	
valet	5.0	4 to 6
pilot 1	3.5	3 to 4
pilot 2	3.5	2 to 5
pilot 3	4.0	2 to 6
caterer	3.5	3 to 4
average of above	3.9	

Driving and flying compared

Driving: Aspen to Glenwood and back	mpg	distance (miles)	Fuel	lb CO2
	18.63	80.00	4.29	84

	MPG		Miles ASE-DEN	ASE-DEN-ASE	Gallons/vehicle	CO2/vehicle	Lb CO2, driver	Lb CO2, driver + pax
Aspen to DIA and back	18.63	typical Aspen veh.	200	400	21.47	420	420	210

	Emissions/pax-mile	Aircraft type	Miles ASE-DEN	ASE-DEN-ASE	Gallons/pax (ow)	Gallons/pax (rt)	CO2/pax one way	CO2 per pax rt
Flying ASE-DEN-ASE (11 CMS flights)	0.93	CRJ-700 & Dash-8	132	264	6.04	12.08	123.61	247
(Pasted in case of lost link):	0.935		132.209		6.04			

CMS field rsrch on fuel per pax-mile ASE-DEN	
0.935	lb CO2/pax-mile

Aspen traffic congestion on a bad day

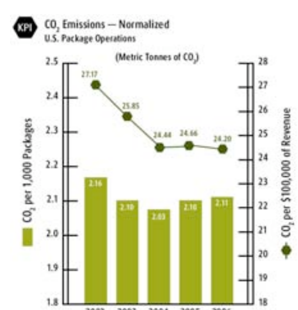
	# of vehicles		MPG	Gallons per hour	Dwell time minutes	Total Gal per hr	Total lb CO2/hr	Lb CO2/vehicle
One hour of sitting in traffic jam	700	lite vehicles 4-5 p	18.63	0.80	15	140	2,739	3.91
each vehicle stop & go for 15 minutes	240	medium trucks, var	14.00	1.00	15	60	1,258	5.24
	60	heavy trucks, buse:	6.00	1.20	15	18	403	6.72
	1,000					218	4,400	4.40
	may be conservative							

One UPS package delivery

2.11 tonnes CO2 per 1,000 packages
means 2.11 kg CO2 per package, or 4.65 lb CO2 per package

lb CO2 per package
4.65

water consumption (vehicle wash)	6.18	million cubic meter:	1,633	million gallons
	264.17	gallons/m^3		



UPS: 2007 revenue of $49.7 billion, 425,300 global employees, 4.0 billion packages & docs (15.8 million per day), fleet of 268 jet aircraft (9th largest airline) plus 311 chartered aircraft, founded in 1907.

Skiing & recreation

Folio 4

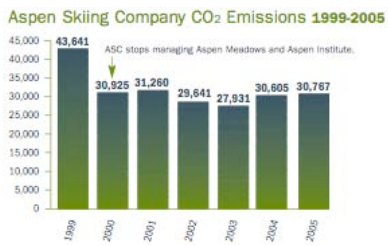
Skiing for a day at Aspen

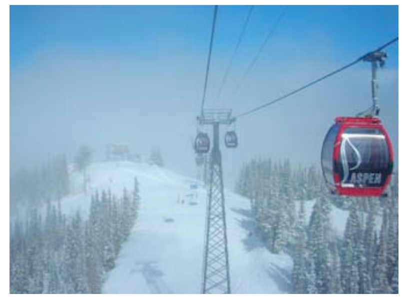
One ski day at Aspen Ski Co	Total emissions, tons CO2	Skier days	lb CO2per skier day
	30,767	1,367,207	45.0
After REC for all electricity	8,811	1,367,207	12.9

Compare Heli-skiing

Emissions/pax-day
lb CO2/pax (40)
419

One ride on the SilverQueen Gondola — 2.89 lb CO2 per gondola rider





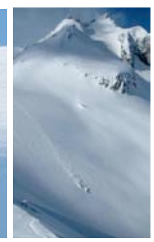
Heli-skiing, per day (Canadian Rockies)

gallons per liter:	0.264
lb CO2 per gallon JetA:	20.88

	Bell 212 chopper					
	Fuel burn	Fuel burn	Fuel burn	Emissions per hr	Emissions per day	Emissions/pax-day
Canadian Mountain Holidays	lb per hr	liters per hr	gallons per hr	lb CO2 per hr	lb CO2 per day	lb CO2/pax (40)
(Monashees, Revelstoke, Gothics, etc)	625	380	100.4	2,096	16,768	419.2
Bell 212 helicopter		gallons per day:	803			

seats up to 14 + pilot, CMH: 11 pax/group
one chopper (gothics) busy 9 to 5 ferrying four groups of 11 pax each all day
assumes a few go in after lunch and average load is 40 pax for the day



One visit to an athletic club

	Basic data			
One day at a local athletic club (prelim	600	visitors per day	219,000	visitors per yr
	1,637	tons CO2e/yr	14.95	lb CO2e per visit
	$ 200,000	~health Club util bills		
Large Red Mtn home	$ 30,943	large Red Mtn bills		
	253	tons CO2e		
	$ 122	per ton CO2e		

Average of Aspen Club & ARC — 20.96

"Hey, buddy! Unless you're passing, get out of the left lane!"

Aspen Recreation Center (ARC) energy & emissions

	Natural gas		Electricity		Gas + Elec			
natural gas (KM)		Tons CO2e		Tons CO2e	Tons CO2e	Visitors, 2007		lb CO2/million btu
electricity (HCE)		lb CO2-e/ccf		lb CO2/kWh (HCE)		estimated	lb CO2/visitor	132.1
	CCF	11.392	kwh	1.731		16,406		
Jan	21,841	124	159,600	138	263	16,406	32.0	
Feb	19,688	112	167,200	145	257	16,406	31.3	
Mar	17,966	102	154,400	134	236	16,406	28.8	
Apr	2,080	12	165,600	143	155	16,406	18.9	
May	14,560	83	151,200	131	214	16,406	26.1	
Jun	12,068	69	160,000	139	207	16,406	25.3	
Jul	9,250	53	192,800	167	220	16,406	26.8	
Aug	9,603	55	192,000	166	221	16,406	26.9	
Sep	11,129	63	162,400	141	204	16,406	24.9	
Oct	13,386	76	103,600	90	166	16,406	20.2	
Nov	18,905	108	174,400	151	259	16,406	31.5	
Dec	18,866	107	169,600	147	254	16,406	31.0	
Sum, ARC 2006	169,342	976	1,952,800	1,692	2,655	196,875	27.0	
	Gas/Elec %:	36.8%		63.7%	average per day	539.38	27.0	lb CO2 per visitor

Libations & Vittles

Folio 5

Aspen city water

	tons CO2/gallon	lb CO2/1000 glns	
Water supply	0.00000063	1.26	
Wastewater treatment		11.62	
Total emissions per 1,000 gallons		**12.88**	
Emissions per gallon		0.01288	lb CO2/gallon
Emissions per liter		0.00340	lb CO2/liter

assumes that water is from Aspen Water Plant (data from ASC Sust Rpt),
that water used is also flushed and treated by Aspen Sanitation,
excludes emissions from pumping water up, say, Red Mtn.

Seawater desalination, reverse osmosis

50 million gallon per day facility planned for Carlsbad CA
Heede, 2008c

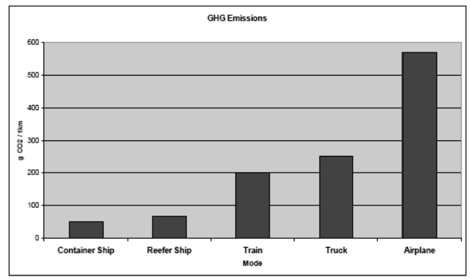
Electric demand	4,898	kWh/acre-foot of desalinated water, RO
Emissions (US rate)	1.354	lb CO2/delivered kWh
Emissions, 1 AF	6,631	lb CO2 to desalinate 1 acre-foot
Conversion	43,560	gallons per acre-foot
Emissions per gallo	**0.1522**	**lb CO2 per gallon of desalinated water, RO**
Emissions per liter	**0.0402**	**lb CO2 per liter of desalinated water, RO**

Bottled water: Fiji Water, 1 liter

One bottle (l liter) of Fiji Water

Fiji water bottle (one liter) Fiji to Aspen					
Manufac. PET bottle (l liter), 25 g	93.00	grams CO2			
Shipping blanks from China	4.30	grams CO2			
Shipping filled bottles to San Francisco	153.00	grams CO2	CMS: Pablo used 17 g GHGs per tonne-km for Fiji example, vs CE Delft's 52.1 g CO2/t-km for the French wine example.		
Bottled water: 1 liter Fiji, del. San Franc	250.30	grams CO2	0.5518	lb CO2	Pablo Paster
Trucking one liter Fiji from SF to Aspen	191.22	grams CO2	0.4216	lb CO2	
Total manuf., shipping l Fiji to Aspen	**441.52**	**g CO2/liter Fiji**	**0.9734**	**lb CO2**	

Figure 1. Comparative cargo emissions



Comparative cargo emissions

Container ship	52.1	g CO2e/tkm	CE Delft
Refrigerated ship	67.1	g CO2e/tkm	CE Delft
Train	200.0	g CO2e/tkm	WRI GHG Protocol
Trucking emissions rate (Pablo)	252.0	g CO2e/tkm	WRI GHG Protocol
Airplane	570.0	g CO2e/tkm	CE Delft

www.onlineconversion.com/drivingdistance.htm

Trucking distance SF to Denver	2,032	km
Trucking distance Denver to Aspen	320	km
Sum SF to Aspen	2,352	km

One metric tonne of water trucked SF	592,704	g CO2e
	593	kg CO2e
Thus, 1 liter trucked SF to Aspen	0.593	kg CO2e
Thus, 1 liter trucked SF to Aspen	1.307	lb CO2e

CMS will use this EF for trucking:
81.30 g CO2/tonne-km

1	gallon
5.7	mpg
30,000	lb freight
10.1	kg CO2 per gallon diesel
1.61	km per mile
2204.6	lb per tonne
22.384	lb CO2 per gallon
3.927	lb CO2 per vehicle mile
1.781	kg CO2 per vehicle mile
1.106	kg CO2 per km
0.074	kg CO2 per ton km
0.081	kg CO2 per tonne-km

CMS re-calculation of trucking emissions, 15Jan08

Trucking emissions rate (CMS)	81.3	g CO2 per tonne-km
One metric tonne of water trucked SF	191,218	g CO2e
Thus, l liter trucked SF to Aspen	0.191	kg CO2e
Thus, l liter trucked SF to Aspen	0.422	lb CO2e

	MJ/ton-km	mt CO_2e/ton-km x10^6	Source
Inland Water	0.3	21	[13]
Rail	0.3	18	[13]
Truck	2.7	183	[13]
Air	10.0	678	[15]
Oil Pipeline	0.2	16	[13, 14]
Gas Pipeline	1.7	176	[13, 14]
Int. Air	10.0	678	[15]
Int, Water Container	0.2	14	[16]
Int, Water Bulk	0.2	11	[16]
Int, Water Tanker	0.1	7	[16]

Weber et al (2008) "Food Choices," EST, supplement data.

Cup of Joe: Starbucks Coffee

(Forbes article)

One cup of coffee		
	40,000	cups at San Mateo Starbucks, one month
	4,900	lb carbon (store utils only)
	0.123	lb carbon per cup
	0.449	**lb CO2 per cup**

	gallons/yr				
John Ryan: 2 cups per day	34	100	beans/cup	6,000	beans/tree
700 cups per year	34	70,000	beans/yr	11.7	trees/yr

Starbucks CSR 2006	133	million kg coffee
	6.57	kWh per sf of retail space per month
	0.059	therms/sf-month
	12,440	worldwide stores
		average sf per store (NA)
	40,000	cups per month (San Mateo store only)

Starbucks CSR 2006 Global coffee production 2005/06: 7 billion kg, of which St bought 133 million kg (p7),
2003 inventory: electricity 81%, coffee roasting and natural gas 18%, company-owned vehicles and aircraft 1% (p. 16).

One 12 oz bottle of New Belgium beer

Folio 6

Beer (SAG Miller lpc)	12.7400	kg CO2/hl	hectoliter
	0.1274	kg CO2/l	
	0.2809	lb CO2/l	
Brewery only, excluding glass, refrigeration & transportati	1.0632	lb CO2/gallon	
	0.0997	**lb CO2/bottle (12 oz)**	

New Belgium Brewing Company	24	lb CO2 per bbl (31 gallons)
Dec07 prelim calc	0.774	lb CO2 per gallon
brewing & fermentation only;	**0.073**	**lb CO2 per 12 oz bottle**
excludes electricity (RECs)		

1	lb
453.59	gram

Life Cycle Assessment: The Carbon Footprint of a Six-pack of Fat Tire Amber Ale

Six-pack LCA analysis New Belgium Brewery	Upstream segment	Upstream grams CO2e	Brewery segment	Brewery grams CO2e	Downstream segment	Downstream grams CO2e	Total
	Packaging, glass c	853	Brewing ops (gas)	123	Distribution	278	
Jenn Orgolini, NBB Corp Sust	Raw materials	678	corp	46	retail	2,690	
presentation to Craft Brewers Assn			waste disposal	4	Use	262	
detail to follow with LCA rpt, 2008					Waste	50	
Per six-pack (grams CO2e)		1,531		173		3,278	4,982
Percent of total		30.7%		3.5%		65.8%	100.0%
Per bottle (grams CO2e)		255		29		546	830
Per six-pack (lb CO2e)		3.38		0.38		7.23	10.98
Per bottle (lb CO2e)		**0.56**		**0.06**		**1.20**	**1.83**

Note: New Belgium excludes electricity emissions due to 100% RECs

Brewing emissions only	123	grams per six
Brewing emissions only	21	grams per bottle
Brewing emissions only	0.2712	lb per six
Brewing emissions only	0.0452	lb per bottle
Compare to SAG per bottle	0.0997	lb per bottle

Bottle of wine: from vineyard to Aspen

Per 750 ml
www.wine-economics.org/workingpapers/AAWE_WP09.pdf

	Total emissions, Chicago delivery		Total emissions, Aspen delivery		Four glasses per bottle
	kg CO2 / 750 mL	lb CO2/bottle	kg CO2 / 750 mL	lb CO2/bottle	lb CO2/glass
Wine: French	2.12	4.67	2.804	**6.18**	1.55
Wine: Australian	3.60	7.94	3.086	**6.80**	1.70
Wine: California	2.24	4.94	2.492	**5.49**	1.37

Source: Colman & Paster (2007)

Table 1
Comparison of carbon intensity: a sample of select routes (in grams of CO2)

	SF	Chicago	NY
Napa	1201	2243	2651
Australia	2567	3601	4017
France	3227	2117	1811
Argentina Bulk	1701	2730	3178

Food-related emissions, selected items

Weber & Matthews interpolated by Heede	Factor	Supply chain emission factor	Units
	Fraction of red meat	lb CO2e/lb	lb CO2e/lb
Beverages	0.025	0.56	lb CO2e/lb beverages
Cereals/Carbs	0.137	3.02	lb CO2e/lb cereals/carbs
Chicken/Fish/Eggs	0.270	5.96	lb CO2e/lb chicken/fish/eggs
Dairy Products	0.187	4.13	lb CO2e/lb dairy products
Fruits/Vegetables	0.072	1.59	lb CO2e/lb fruits/vegetables
Oils/Sweets/Condiments	0.072	1.59	lb CO2e/lb oils/sweets/condiments
Red meat	1.000	22.10	lb CO2e/lb red meat

Dairy Products (lb CO2 per gallon)	35.65	lb CO2e/gallon milk

Note: Weber & Matthews value for dairy products is 5.55 times the Heede result for milk

Table 3	Nature Conservancy "Food Calculator"		
www.nature.org/initiatives/climatechange/calcul	Emissions per year	Emissions per day	Emissions per meal
	tons CO2e/yr	lb CO2e/d	lb CO2/meal
Meat most days	4.10	22.47	7.49
Meat most meals	5.80	31.78	10.59
Meat rarely	1.50	8.22	2.74
Meat, never	0.90	4.93	1.64

all data for single-occupant household, or "self" — assumes 3 meals/day

Table 10	Summary of GHG emissions from milk supply chain, Heede 2007			
	Source	g CO2e/gallon	lb CO2e per gallon	Percent
	Land	not estimated		
	Farm building construction	not estimated		
	Farmer's household	not estimated		
	Feed	715	1.577	**24.57%**
	Methane (eructation)	1,040	2.293	**35.74%**
	Methane (manure)	66	0.145	**2.27%**
	Nitrous (manure)	113	0.249	**3.88%**
	On the farm	6	0.013	**0.20%**
	Transportation to processing	1	0.003	**0.04%**
	Processing	1	0.002	**0.03%**
	Trucking	14	0.030	**0.47%**
	At the Grocery Story	not estimated		
	Driving 2 miles RT to pick up milk	955	2.105	**32.80%**
	Total milk supply chain	**2,911**	**6.417**	**100.0%**

One gallon of milk weighs (lb):	8.621	3.910 kg
CO2e per gallon of milk: percent of its weight:	74.4%	
Carbon-e per gallon of milk: percent of its weight:	20.3%	

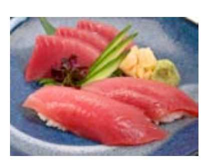
All except driving	1,956	4.312	67.2%

Heede, Richard (2007) From the Dairy Farm to the Consumer: Organic vs Conventional Milk: Comparing Supply Chain Emissions, commissioned by Sustainable Settings, Carbondale, CO

Sushi (yellow tail)

Sushi (TreeHugger.com)	15 gr	**224.1**	gr CO2/piece
		0.494	lb CO2/piece

Trucking and air-freight only; fishing vessel fuel and refrigeration excluded



(get photo of hamachi)

Folio 7

Cheeseburger cheeseburger

Estimate by Jamais Cascio

final estimate (with methane)		
low	high	unit
2.85	3.10	kg CO2e/burger
6.28	6.83	lb CO2/burger
6.56	lb CO2 per burger (average)	

initial estimate (without methane)		
0.13	0.43	kg carbon/burger
0.47	1.56	kg CO2/burger
1.03	3.44	lb CO2/burger

www.openthefuture.com/2006/12/the_footprint_of_a_cheeseburge.html

Residential calculations

Heated driveway

Heated driveway, per hour

basic parameters	
150	Btu per sf boiler capacity
10	drive width
100	drive length
1,000	drive sf
150,000	Btu/hr boiler
1,027	btu per cf gas at sea level
862	btu per cf gas (adjusted for local billing pressure at Aspen, Heede 2006)
86%	boiler efficiency

Note: The calculations based on natural gas consumption (e.g., driveways and showers) have been adjusted for local billing pressure, i.e., from 1,027 to 862 Btu per cubic foot of gas. While gas is sold in Aspen in ccf, costs are adjusted to ~Rifle LBP adjustment, yet energy content is also adjusted so as to accurately reflect carbon emissions per ccf. Verify.

performance per hour (1,000 sf)	
174	cf gas per hour
120.59	lb CO2 per mcf (EIA, 1605b factor)
20.98	lb CO2 per hour of operation
	average lb CO2 per hour over season

Note

performance per sf of heated area per hour	
0.174	cf gas per sf per hour of operation
0.0210	lb CO2 per sf per hour of operation
	average lb CO2 per hour over season

CMS prelim: fair estimate per hour of operation (i.e., when snowing, and boiler is in full operation)

Heated driveway, per season

For a 1,000 sf driveway on 24/7/22 weeks	
3,696	hrs per 22-week season (assumed on 24hrs/day)
642,932	cf gas per 22-week season
77,533	lb CO2 per 22-week season
38.8	tons CO2 per 22-week season

Per sf of heated driveway per year	
554,400	Btu/sf-yr
642.93	cf gas per sf per season
77.53	lb CO2 per sf per season
0.04	tons CO2 per sf per season

assume boiler on 4 hrs/d per 22-week winter, 1,000 SF	
616	hrs per 22-week season (4 hrs/day)
12,922	lb CO2 per 22-week season
6.46	**tons CO2 per 22-week season**

Dickinson data	
34,425	Btu/sf-yr
229.50	hrs per season
39.92	cf gas per sf per season
4.81	lb CO2 per sf per season
4,814	lb CO2 per sample driveway (1000 sf)

Dickinson data	
34,425	Low: Btu/sf-yr
230	implies hrs/yr (at 150 Btu/sf)
100,000	High: Btu/sf-yr
667	implies hrs/yr (at 150 Btu/sf)
4,814	Low: lb CO2 per 1,000 sf per season
13,985	High: lb CO2 per 1,000 sf per season
20.98	Low: lb CO2 per 1,000 sf per hour of operation
60.94	High: lb CO2 per 1,000 sf per hour of operation
39,922	Low: cf gas per 1,000 sf per season
115,969	High: cf gas per 1,000 sf per season

Spa (100 SF, year round use)		Gas-fired
100	SF	
430,000	Btu/SF-yr	
49,425,287	Btu/yr	
14,486	kWh/yr	
$ 20,280	REMP fee	
Emissions rate	132	lb CO2e/million Btu
tons CO2e/yr	3.27	
lb CO2e/day	17.89	
lb CO2e/hr	**0.75**	

Aspen Pitkin County Energy Standards, Codes, Guidelines, REMP fees, examples, etc.

CMS note: corroborate with actuals? (seems very low)

Heated Driveway (500 SF)		Gas-fired
500	SF	
19,784,482	Btu/yr	
39,569	Btu/SF-yr	
34,425	boiler Btu/SF-yr, 0.87 AFUE	
$ 8,118	REMP fee	
Emissions rate	132	lb CO2e/million Btu
tons CO2e/yr	1.31	
lb CO2e/day	7.16	
lb CO2e/hr	**0.30**	

Heated Pool (600 SF, year round)		Gas-fired
600	SF	
332,000	Btu/SF-yr	
228,965,520	Btu/yr	
67,106	kWh/yr	
$ 93,948	REMP fee	
Emissions rate	132	lb CO2e/million Bt
tons CO2e/yr	15.13	
lb CO2e/day	82.89	
lb CO2e/hr	**3.45**	

Heated Pool (600 SF, summer only)		Gas-fired
600	SF	
29,000	Btu/SF-yr	
20,000,000	Btu/yr	
5,862	kWh/yr	
$ 8,206	REMP fee	
Emissions rate	132	lb CO2e/million Btu
tons CO2e/yr	1.32	
lb CO2e/day	7.24	
lb CO2e/hr	**0.30**	

Plowing the driveway, part 1

Low estimate		
assume 20 plows/yr, 0.5 gallon/plow	0.50	gallon per plow
	10.00	gallons per year (plowing only)
	3.33	plow travel (12 mpg, 20 X/yr, 30 mile rt, 15 jobs)
	13.33	gallons per year (plowing plus driving)
	22.38	diesel fuel EF (22.384 lb CO2/gallon)
	298	lb CO2 per year
High estimate: 2x low estimate	597	lb CO2 per year
Highest estimate, 40 plows per year	1,194	lb CO2 per year

Plowing the driveway, part 2 (small driveways, in town)

	gallons	driveways	gallons/driveway	CO2/driveway
Light storms 3-6 in	18.0	35	0.51	11.5
Storms >6 inches	45.0	35	1.29	28.8
Average	31.5	35	0.90	20.1
Weighted average (3 light storms for 1 heavy storm)			0.71	15.8

Storm frequency, in-town plows per year

	storms per winter	CO2/driveway	CO2 per winter	Longer driveway CO2/winter	
Light winter	10	15.8	158	317	2x left
Medium winter	30	15.8	475	950	
Heavy winter	50	15.8	791	1,583	
Average winter	30	15.8	475	950	

One nice hot 10 minute shower

Folio 8

One gallon of hot water:	1	gallon weighs	8.35	lbs
	1	cubic foot is	7.48	gallons
	1	cubic foot weighs	62.43	lbs
	55	Fahrenheit inlet T		
	145	F tank T		

Pipeline natural gas (ASL)

117.1	lb CO2/million btu
0.0001	lb CO2 per Btu

21Feb07 CMS: Correct EF to 132 lb CO2 per million Btu (cell C18)

Calculation for one gallon heated by natural gas and electricity

3,412 Btu per kWh (end use)

	Gas Calc		Electricity Calc	
One gallon of hot water:	90	o F tank delta T	90	F tank delta T
	751	Btu content/gallon heated to 145 F	0.220	kWh content per gallon heated to 145 F
	873	heating losses (at 86% AFUE)	0.222	heating losses (1 %; powerplant losses excluded)
	1,025	standby losses (14.8 %)	0.261	standby losses (14.8 %)
	1,281	pipe losses (20 %)	0.326	pipe losses (20 %)
	70.6%	% Btu added to deliver hot water	48.2%	% kWh added to deliver hot water

High flow shower	109	F shower T	means 3 gals hot + 2 gallons cold: High estimate at 5 gpm	3.00	gpm hot
Low flow shower	109	F shower T	means 1.5 gals hot + 1 gallon cold: Low estimate at 2.5 gpm	1.50	gpm hot

					Btu content of delivered water		energy to deliver hot water	
High flow shower	30	gallons hot 10 min	250.36	lbs hot water	22,532	Btu 10 min shwr	38,439	Btu 10 min shwr
Low flow shower	15	gallons hot 10 min	125.18	lbs hot water	11,266	Btu 10 min shwr	19,220	Btu 10 min shwr

this is for gas (accounts for 86% AFUE)

Gas-fired shower

High flow shower	30	glns hot water del.	44.58	cf gas	5.38	lb CO2 10-m shwr
Low flow shower	15	glns hot water del.	22.29	cf gas	2.69	lb CO2 10-m shwr
					0.18	lb CO2e/gallon

Gas emissions if no LBP adjustment

Note		
	4.50	lb CO2
	2.25	lb CO2

Electric hot water shower: Holy Cross Energy

High flow shower	30	glns hot water del.	9.79	kWh	16.95	lb CO2 10-m shwr
Low flow shower	15	glns hot water del.	4.89	kWh	8.47	lb CO2 10-m shwr
					0.56	lb CO2e/gallon

GHG intensity: Holy Cross Energy

1.795	lb CO2e/kWh, HCE (2004)
1.731	lb CO2e, HCE (2007, est.)

Electric hot water shower: Aspen Electric Dept

High flow shower	30	glns hot water del.	9.79	kWh	7.00	lb CO2 10-m shwr
Low flow shower	15	glns hot water del.	4.89	kWh	3.50	lb CO2 10-m shwr
					0.23	lb CO2e/gallon

GHG intensity; City Electric Dept

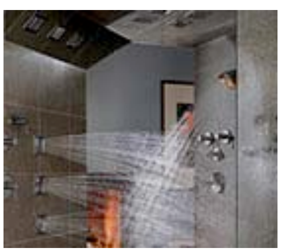
1.265	lb CO2e, City Electric (2004)
0.605	lb CO2e, (2007 est., PhilO)
0.715	lb CO2e, average used here

Electric hot water shower: Average US electric carbon factor

High flow shower	30	glns hot water del.	9.79	kWh	13.25	lb CO2 10-m shwr
Low flow shower	15	glns hot water del.	4.89	kWh	6.62	lb CO2 10-m shwr
					0.44	lb CO2e/gallon

GHG intensity; Average US EF

1.354	lb CO2 per delivered kWh 2006 (used here)
1.412	lb CO2e per delivered kWh, 2006



Average of all three emission factors (Aspen)

High flow shower	9.77	lb CO2 for a 10-minute shower
Low flow shower	4.89	lb CO2 for a 10-minute shower
Average of Low & High	7.33	lb CO2 for a 10-minute shower

Average of all three emission factors (US)

High flow shower	9.31	lb CO2 for a 10-minute shower
Low flow shower	4.66	lb CO2 for a 10-minute shower
Average of Low & High	6.98	lb CO2 for a 10-minute shower
Average of Low & High (US)	3.49	lb CO2 for a 5-minute shower

Aspen lighting: four exterior lights

	watts	lb CO2e/kWh	lb CO2e/hr	
Four exterior 100-w night lights	400	1.223	0.49	
CMS assumes four 100-w A-lamps, average of City and Holy Cross carbon intensity				
Alternative: lb CO2 per day (assume 12-hr/night duty)			5.87	lb CO2e/day

US lighting: four exterior lights

	watts	lb CO2e/kWh	lb CO2e/hr	
Four exterior 100-w night lights	400	1.354	0.54	
CMS assumes four 100-w A-lamps, average US carbon intensity				
Alternative: lb CO2 per day (assume 12-hr/night duty)			6.50	lb CO2e/day
Replace with four 26-w CFLs	104	1.354	0.14	
CMS assumes four 26-w CFLs, average US carbon intensity				
Alternative: lb CO2 per day (assume 12-hr/night duty)			1.69	lb CO2e/day

Aspen energy & emissions data, Heede ASHES

Heede, 2007, Anybody Home? Asepn Second Homes Energy Study, Sopris Fdn.

Total residential emissions, Aspen UGB 2004

149,442	Tons CO2-e
1,956,154	Million Btu

Average residential emissions, per unit

51,021	lb CO2-e
334	million Btu

Average residential emissions, per sq ft

23.17	lb CO2-e/sqft
0.152	million Btu/sqft

Ave electric, /sq ft-yr, housing type & HCE vs City

108,441,661	total kWh
18,512	average kWh/unit-yr
8.41	average kWh/sqft-yr
8,728	ave Kwh/condo
32,831	ave kWh/SingleFam

Author’s rammed-earth passive solar energy-saving low-carbon home in Old Snowmass, Colorado

	Total HH: lbs	Total HH: tonnes	Per SqFt-yr	kWh	kWh/sf-yr
2003	14,306	6.49	3.58	3,941	0.99
2004	16,678	7.57	4.17	3,989	1.00
2005	14,194	6.44	3.55	4,998	1.25
2006	17,899	8.12	4.47	5,186	1.30
2007	13,553	6.15	3.39	4,380	1.10
2008	14,496	7.25	3.62	5,573	1.39
6-yr average	15,187	7.00	3.80	4,678	1.17
monthly average	1,266	0.58	0.32	390	0.10

2008	Lb CO2	
Electricity	8,973	
Less Wind credit	1,932	
Net Electricity	7,041	
Propane	7,455	per month
Total HH	14,496	1,208
Per SqFt-yr	3.62	

Pond circulating pump

Folio 9

1	HP	0.746	kW
	1.731	lb CO2e, HCE (2007, est.)	

Typical large pond system	head (ft)	Gallons per minute	Pump motor (HP)	Pump motor (kW)	hrs per year	kWh per yr	Cost/yr (9c/kWh)	lb CO2/yr (HCE)	tons CO2/yr
specs	25	550	7.50	5.60	8,760	49,012	$ 4,411	**84,863**	42.43
					If system runs half the year				
	Gallons per hour	Gallons per second	CFS	lb H2O per sec	hrs per year	kWh per yr	Cost/yr (9c/kWh)	lb CO2/yr (HCE)	tons CO2/yr
	33,000	9.17	1.2254	76.50	4,380	24,506	$ 2,206	**42,431**	21.22

Water conversions				
	1	gallon =	0.1337	cubic feet
	1	gallon =	8.3453	lb H2O
	1	CF =	7.4805	gallons
	1	CF =	62.43	lb H2O

Gallons per year	cubic feet/yr	lb H2O per yr	tons per yr	per half yr
144,540,000	19,322,188	1,206,229,662	603,115	

Aspen: Primary & Second Homes: emissions per occupied day

Heede, 2007, Anybody Home? Aspen Second Homes Energy Study, Sopris Fdn.

Table 9	Primary Emissions per occ. day	Second Emissions per occ. day	Factor of Second/Primary Emissions per occ. day
	lb CO2-e/unit/day	lb CO2-e/unit/day	lb CO2-e/unit/day
	calculated	calculated	calculated
Condos	**86**	**352**	**4.07**
Duplex/Triplex	**186**	**672**	**3.62**
Multi-units	**792**	**2,252**	**2.84**
Single-Family Homes	**197**	**993**	**5.05**
Average	**144.22**	**606.03**	**4.20**

Data on US average household energy and emissions, RECS 2005

energy data from RECS tables, emission calculations by CMS as below

		lb CO2/yr	household SF	lb CO2/sf-yr	lb CO2/day
RECS 2005	Average US household emissions	22,622	2,171	10.4	62
RECS 2005	Average single-family emissions	26,129	2,720	9.6	72
RECS 2005	Homes 4,000 sf or more	32,839	5,147	6.4	90
RECS 2005	Homes 1,000 to 1,499 sf	19,452	1,157	16.8	53
Heede 2002 using 1997 EIA RECS data	Average single-family emissions	26,028	2,850	9.1	71

Heede 2002: Cool Citizens Brief: Household Solutions

Total and average residential fuel consumption & CO2 emissions, US 2005

Energy Information Administration, Residential Energy Consumption Survey 2005 (RECS), and per household CO2 calculations by CMS, 4Dec08

	US households	Electricity	Natural gas	Heating oil	Electricity	Total	Total	Total	Total	Total
	millions	billion kWh	Bcf	million gallons	kWh/hh-yr	tons CO2-yr	tons CO2/hh-yr	lb CO2/hh-yr	lb CO2/day	lb CO2/hr
	RECS data	RECS data	RECS data	RECS data	RECS data	CMS calc	CMS calc	CMS calc	CMS calc	CMS calc
Total..	111.1	1,285	4,632	6,237	11,571	1,256,639,093	11.3	**22,622**	62.0	2.6
Census Region and Division										
Northeast...	20.6	171	1,073	5,192	8,290	243,642,699	11.8	**23,655**	64.8	2.7
New England.....................................	5.5	41	232	2,157	7,478	67,396,280	12.3	**24,508**	67.1	2.8
Middle Atlantic..................................	15.1	130	841	3,035	8,583	175,966,439	11.7	**23,307**	63.9	2.7
Midwest..	25.6	276	1,676	426	10,778	304,953,709	11.9	**23,825**	65.3	2.7
East North Central............................	17.7	185	1,253	389	10,396	212,654,843	12.0	**24,029**	65.8	2.7
West North Central...........................	7.9	91	423	Q	11,643	91,884,762	11.6	**23,262**	63.7	2.7
South...	40.7	614	926	408	15,094	489,190,860	12.0	**24,039**	65.9	2.7
South Atlantic...................................	21.7	328	432	373	15,099	257,713,656	11.9	**23,752**	65.1	2.7
East South Central............................	6.9	108	165	Q	15,731	86,625,470	12.6	**25,109**	68.8	2.9
West South Central..........................	12.1	178	330	N	14,722	144,418,961	11.9	**23,871**	65.4	2.7
West..	24.2	224	956	210	9,274	218,381,901	9.0	**18,048**	49.4	2.1
Mountain...	7.6	83	327	Q	10,992	79,940,059	10.5	**21,037**	57.6	2.4
Pacific..	16.6	141	628	168	8,494	137,905,147	8.3	**16,615**	45.5	1.9
Four Most Populated States										
New York..	7.1	50	355	1,848	7,027	78,263,563	11.0	**22,046**	60.4	2.5
Florida..	7.0	116	32	N	16,449	80,448,480	11.5	**22,985**	63.0	2.6
Texas..	8.0	121	212	N	15,206	96,225,573	12.0	**24,056**	65.9	2.7
California..	12.1	85	482	Q	7,039	88,701,435	7.3	**14,661**	40.2	1.7
All Other States....................................	76.9	913	3,550	4,372	11,880	912,139,471	11.9	**23,723**	65.0	2.7
Urban/Rural Location (as Self-Reported)										
City...	47.1	480	2,073	1,822	10,182	473,232,482	10.0	**20,095**	55.1	2.3
Town..	19.0	208	943	1,384	10,947	215,656,798	11.4	**22,701**	62.2	2.6
Suburbs...	22.7	282	1,256	1,096	12,465	281,991,453	12.4	**24,845**	68.1	2.8
Rural..	22.3	316	360	1,935	14,122	286,299,692	12.8	**25,677**	70.3	2.9

B	C	D	E	F	G	H	I	J	K	L
Climate Zone[1]									Folio 10	
Less than 2,000 CDD and--										
Greater than 7,000 HDD....................	10.9	106	602	1,317	9,721	131,770,791	**12.1**	**24,178**	66.2	2.8
5,500 to 7,000 HDD...........................	26.1	246	1,618	2,464	9,452	299,734,061	**11.5**	**22,968**	62.9	2.6
4,000 to 5,499 HDD...........................	27.3	314	1,239	2,309	11,504	320,273,897	**11.7**	**23,463**	64.3	2.7
Fewer than 4,000 HDD......................	24.0	262	789	Q	10,932	233,666,503	**9.7**	**19,472**	53.3	2.2
2000 CDD or More and--										
Less than 4,000 HDD........................	22.8	357	383	Q	15,632	268,562,230	**11.8**	**23,558**	64.5	2.7
Type of Housing Unit										
Single-Family Detached........................	72.1	951	3,376	4,622	13,204	929,603,856	**12.9**	**25,787**	70.6	2.9
Single-Family Attached..........................	7.6	70	403	Q	9,263	71,681,640	**9.4**	**18,864**	51.7	2.2
Apartments in 2-4 Unit Buildings...........	7.8	59	365	545	7,579	68,044,246	**8.7**	**17,447**	47.8	2.0
Apartments in 5 or More Unit Buildings.	16.7	120	369	702	7,170	112,282,911	**6.7**	**13,447**	36.8	1.5
Mobile Homes......................................	6.9	85	118	114	12,214	71,394,275	**10.3**	**20,694**	56.7	2.4
Ownership of Housing Unit										
Owned...	78.1	996	3,541	4,753	12,749	974,424,421	**12.5**	**24,953**	68.4	2.8
Single-Family Detached....................	64.1	855	3,038	4,222	13,355	837,419,940	**13.1**	**26,129**	71.6	3.0
Single-Family Attached......................	4.2	38	238	Q	9,209	40,072,306	**9.5**	**19,082**	52.3	2.2
Apartments in 2-4 Unit Buildings.......	1.8	14	122	187	7,658	18,925,507	**10.5**	**21,028**	57.6	2.4
Apartments in 5 or More Unit Building	2.3	17	50	Q	7,381	14,521,919	**6.3**	**12,628**	34.6	1.4
Mobile Homes..................................	5.7	71	94	73	12,340	59,237,149	**10.4**	**20,785**	56.9	2.4
Rented...	33.0	290	1,091	1,483	8,781	282,675,767	**8.6**	**17,132**	46.9	2.0
Single-Family Detached....................	8.0	96	338	401	11,997	92,098,191	**11.5**	**23,025**	63.1	2.6
Single-Family Attached......................	3.4	32	166	Q	9,328	31,669,631	**9.3**	**18,629**	51.0	2.1
Apartments in 2-4 Unit Buildings.......	5.9	45	244	358	7,555	49,179,036	**8.3**	**16,671**	45.7	1.9
Apartments in 5 or More Unit Building	14.4	103	319	655	7,137	97,114,613	**6.7**	**13,488**	37.0	1.5
Mobile Homes..................................	1.2	14	24	Q	11,608	11,601,338	**9.7**	**19,336**	53.0	2.2
Year of Construction										
Before 1940..	14.7	135	876	2,146	9,176	173,543,673	**11.8**	**23,611**	64.7	2.7
1940 to 1949...	7.4	63	389	709	8,546	76,884,927	**10.4**	**20,780**	56.9	2.4
1950 to 1959...	12.5	121	614	1,046	9,663	132,855,724	**10.6**	**21,257**	58.2	2.4
1960 to 1969...	12.5	133	580	760	10,671	135,784,396	**10.9**	**21,726**	59.5	2.5
1970 to 1979...	18.9	216	624	778	11,445	198,085,382	**10.5**	**20,961**	57.4	2.4
1980 to 1989...	18.6	234	576	364	12,602	203,197,101	**10.9**	**21,849**	59.9	2.5
1990 to 1999...	17.3	253	638	304	14,565	220,877,592	**12.8**	**25,535**	70.0	2.9
2000 to 2005...	9.2	131	334	128	14,179	115,659,914	**12.6**	**25,143**	68.9	2.9
Total Floorspace (Square Feet)										
Fewer than 500.....................................	3.1	18	85	Q	5,915	17,803,275	**5.7**	**11,486**	31.5	1.3
500 to 999...	22.2	174	542	968	7,850	165,290,114	**7.4**	**14,891**	40.8	1.7
1,000 to 1,499......................................	19.1	196	687	520	10,290	185,763,460	**9.7**	**19,452**	53.3	2.2
1,500 to 1,999......................................	14.4	171	613	426	11,897	162,900,967	**11.3**	**22,625**	62.0	2.6
2,000 to 2,499......................................	12.8	161	551	646	12,623	153,423,084	**12.0**	**23,972**	65.7	2.7
2,500 to 2,999......................................	10.1	124	502	714	12,302	125,735,011	**12.4**	**24,898**	68.2	2.8
3,000 to 3,499......................................	8.2	105	388	683	12,869	105,571,041	**12.9**	**25,749**	70.5	2.9
3,500 to 3,999......................................	5.7	77	311	698	13,467	80,705,298	**14.2**	**28,318**	77.6	3.2
4,000 or More..	15.7	259	953	1,477	16,489	257,782,666	**16.4**	**32,839**	90.0	3.7
Household Size										
1 Person..	30.0	229	1,022	1,480	7,625	240,439,263	**8.0**	**16,029**	43.9	1.8
2 Persons..	34.8	411	1,393	2,153	11,810	401,154,212	**11.5**	**23,055**	63.2	2.6
3 Persons..	18.4	243	793	1,222	13,229	231,758,898	**12.6**	**25,191**	69.0	2.9
4 Persons..	15.9	221	754	823	13,920	209,993,183	**13.2**	**26,414**	72.4	3.0
5 Persons..	7.9	119	416	417	15,031	112,643,829	**14.3**	**28,517**	78.1	3.3
6 or More Persons.................................	4.1	62	252	143	15,289	59,997,449	**14.6**	**29,267**	80.2	3.3
2005 Household Income Category										
Less than $10,000................................	9.9	79	337	503	8,015	81,824,413	**8.3**	**16,530**	45.3	1.9
$10,000 to $14,999..............................	8.5	73	274	580	8,659	74,831,886	**8.8**	**17,608**	48.2	2.0
$15,000 to $19,999..............................	8.4	81	275	532	9,632	79,612,346	**9.5**	**18,955**	51.9	2.2
$20,000 to $29,999..............................	15.1	151	615	598	10,006	149,614,899	**9.9**	**19,817**	54.3	2.3
$30,000 to $39,999..............................	13.6	156	484	679	11,425	146,583,489	**10.8**	**21,556**	59.1	2.5
$40,000 to $49,999..............................	11.0	130	457	603	11,810	126,106,733	**11.5**	**22,928**	62.8	2.6
$50,000 to $74,999..............................	19.8	247	831	987	12,451	235,673,214	**11.9**	**23,805**	65.2	2.7
$75,000 to $99,999..............................	10.6	146	508	923	13,759	143,580,831	**13.5**	**27,091**	74.2	3.1
$100,000 or More.................................	14.2	222	851	832	15,700	217,829,448	**15.3**	**30,680**	84.1	3.5
Income Relative to Poverty Line										
Below 100 Percent................................	16.6	152	593	906	9,127	153,773,679	**9.3**	**18,527**	50.8	2.1
100 to 150 Percent...............................	12.9	135	450	586	10,451	128,487,354	**10.0**	**19,921**	54.6	2.3
Above 150 Percent...............................	81.5	999	3,588	4,745	12,247	974,977,549	**12.0**	**23,926**	65.6	2.7
Eligible for Federal Assistance[2]										
Yes...	38.6	375	1,430	2,262	9,722	375,808,689	**9.7**	**19,472**	53.3	2.2
No...	72.5	910	3,201	3,975	12,554	880,759,340	**12.1**	**24,297**	66.6	2.8
Payment Method for Utilities										
All Paid by Household...........................	97.5	1,183	4,134	5,088	12,124	1,142,165,965	**11.7**	**23,429**	64.2	2.7
Some Paid, Some in Rent.....................	4.7	34	166	345	7,373	36,884,646	**7.8**	**15,696**	43.0	1.8
All Included in Rent..............................	7.6	51	283	737	6,760	61,233,619	**8.1**	**16,114**	44.1	1.8
Other Method..	1.3	17	49	Q	13,185	14,461,622	**11.1**	**22,249**	61.0	2.5
Ethnic Origin of Householder										
Hispanic Descent..................................	14.8	144	533	765	9,735	141,434,034	**9.6**	**19,113**	52.4	2.2
Non-Hispanic Descent...........................	96.3	1,141	4,099	5,472	11,854	1,115,194,291	**11.6**	**23,161**	63.5	2.6
Race of Householder[3]										
White..	79.1	953	3,307	4,842	12,041	930,351,478	**11.8**	**23,523**	64.4	2.7
Hispanic..	5.0	50	152	175	9,869	46,665,707	**9.3**	**18,666**	51.1	2.1
Non-Hispanic....................................	74.1	903	3,155	4,667	12,189	883,692,105	**11.9**	**23,851**	65.3	2.7
Black..	13.4	148	604	512	11,049	145,122,937	**10.8**	**21,660**	59.3	2.5
Hispanic..	0.3	3	12	Q	8,979	2,754,222	**9.2**	**18,361**	50.3	2.1
Non-Hispanic....................................	13.1	145	591	469	11,103	141,649,797	**10.8**	**21,626**	59.2	2.5
Asian..	3.3	28	139	Q	8,328	27,334,074	**8.3**	**16,566**	45.4	1.9
Multi-Racial..	1.3	15	56	Q	11,755	13,529,922	**10.4**	**20,815**	57.0	2.4
Other..	7.1	73	272	360	10,331	72,046,988	**10.1**	**20,295**	55.6	2.3
Undetermined (Race Reported as Hispa	6.9	69	254	450	10,030	67,734,765	**9.8**	**19,633**	53.8	2.2

Global, national, and Aspen emission scenarios to 2100 AD

Folio 11

	Global Industrial million tonnes C/yr	MtCO2/yr	MtCO2/day	million tons per day	tons CO2 per day	tons CO2/hour	tons CO2/minute	tons CO2/sec
Global emissions fossil fuel, 2005 (CDI/	7,910	28,984	79.4	87.53	87,530,927	3,647,122	60,785	1,013

Marland & Boden, May 2007

lb CO2/hr	lb CO2/minute	lb CO2/sec
7,294,243,954	121,570,733	2,026,179

2004 per capita fossil-fuel CO2 emission rates

http://cdiac.ornl.gov/trends/emis/top2004.cap

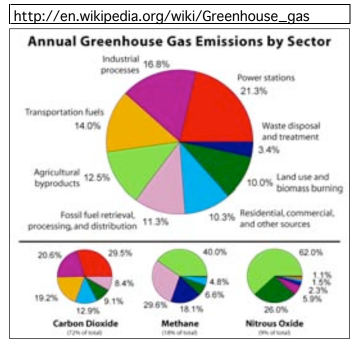
United Nations Statistics Division
Greenhouse Gas Emissions (industrial CO2, methane, and N2O)
http://unstats.un.org/unsd/environment/air_greenhouse_emissions.htm

	Rank & Nation	CO2 per capita tonnes C/yr	CO2 per capita lb CO2/yr	CO2 per capita lb CO2/day			CO2e per capita tonnes CO2e/yr	CO2e per capita lb CO2e/yr	CO2 per capita lb CO2e/day
1	Qatar	21.63	174,729	479		Qatar	na		
2	Kuwait	10.13	81,831	224		Kuwait	na		
3	UAE	9.32	75,288	206		UAE	na		
4	Aruba	8.25	66,644	183		Aruba	na		
5	Luxembourg	6.81	55,012	151		Luxembourg	27.71	61,089	167
6	Trinidad & Tobago	6.80	54,931	150		Trinidad & Tobago	13.49	29,740	81
7	Brunei	6.56	52,992	145		Brunei	na		
8	Bahrain	6.53	52,750	145		Bahrain	34.34	75,706	207
9	USA	5.61	45,318	124	2004	USA	23.92	52,734	144
10	Canada	5.46	44,106	121	2004	Canada	23.72	52,293	143
11	Norway	5.22	42,168	116	2004	Norway	11.95	26,345	72
13	Australia	4.41	35,624	98	2004	Australia	26.54	58,510	160
18	Saudi Arabia	3.71	29,970	82		Saudi Arabia	na		
28	Russian Federation	2.89	23,346	64		Russian Federation	na		
33	Japan	2.69	21,730	60		Japan	10.59	23,347	64
36	Germany	2.67	21,568	59		Germany	12.28	27,072	74
52	Spain	2.08	16,802	46		Spain	10.03	22,112	61
85	Romania	1.14	9,209	25		Romania	7.10	15,653	43
92	China, PRC	1.05	8,482	23		China, PRC	3.36	7,407	20
##	India	0.34	2,747	8		India	1.33	2,932	8
##	Albania	0.32	2,585	7		Albania	1.72	3,792	10
##	Bhutan	0.05	404	1		Bhutan	0.72	1,587	4
##	Afghanistan	0.01	81	0		Afghanistan	na		

http://cdiac.ornl.gov/ftp/trends/co2_emis/weu.dat

Europe, 2004	2.13	17,206	47
Africa	0.34	2,747	8

http://en.wikipedia.org/wiki/Greenhouse_gas



Emissions of Greenhouse Gases in the United States, 2007

EIA (2008) Emissions of Greenhouse Gases in the United States, 2007.

	MtCO2e	tCO2e/capita	lb CO2e/capita	lb CO2e/day/cap
Carbon dioxide	6,021.8	19.96	44,014	**120.6**
Methane	699.9	2.32	5,116	14.0
Nitrous oxide	383.9	1.27	2,806	7.7
High-GWP gases	176.9	0.59	1,293	3.5
Total USA, 2007 (p)	7,282.4	24.14	53,228	**145.8**

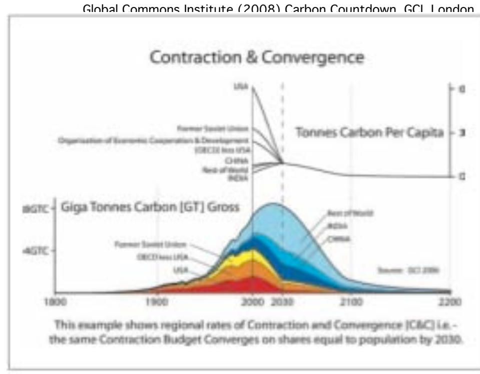
United States population, 2007	301,621,157

Emissions of CO2 in selected countries, 2005

EIA website 2005 world per capita emissions of CO2

	tCO2/capita	lb CO2/capita	lb CO2/day/cap
Afghanistan	0.03	66	0.2
Nigeria	0.82	1,808	5.0
India	1.57	3,461	9.5
China	4.07	8,973	24.6
Germany	10.24	22,575	61.8
USA	20.14	44,401	**121.6**
World	4.37	9,634	26.4

Global Commons Institute (2008) Carbon Countdown. GCI, London. www.gci.org.uk/



2050 CO2 emissions per capita per day

If applied to each region or country: Monbiot & GCI

Monbiot: reduce CO2 by 90 percent	World by 2050	**2.64**	lb CO2/capita-day
George Monbiot (2007) Heat.	USA by 2050	**12.16**	lb CO2/capita-day

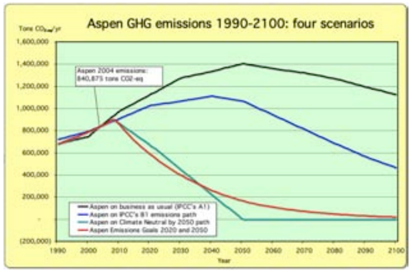
GCI: Contraction and Convergence	World by 2050	397	kg C/capita-yr
Global Commons Institute, London		1,456	kg CO2/cap-yr
		3,211	lb CO2/cap-yr
		8.80	lb CO2/cap-day

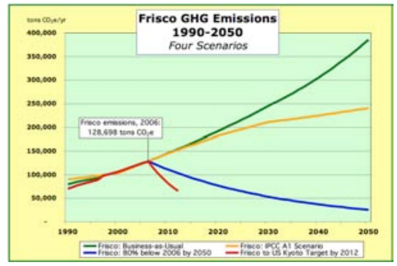
	kg carbon/yr	lb CO2/day	
Germany by 2050	382	8.45	
USA by 2050	374	8.29	Unadjusted to actual 2007 data (see cell ~K1124)
China by 2050	394	8.72	

	A	B	C	D	E	F	G	H	I	J	K	L
1061											Folio 12	
1062												
1063		World & selected country per capita emissions of industrial, from Global Commons Institute Contraction & Convergence model										
1064			Global Commons Institute, London, A campaign for Contraction & Convergence, www.gci.org.uk/								CMS revision to 2007 actual	
1065			World CO2	World per capita	China per capita	Germany per cap	US per capita	US per capita	US per capita	US per capita		
1066		World	tonnes carbon	kg carbon	kg carbon	kg carbon	kg carbon/yr	kg CO2/yr	lb CO2/yr	lb CO2/day		
1067												
1068		1990		1,379	592	3,440	5,177	18,969	41,819	115		
1069		1991		1,372	612	3,110	5,111	18,726	41,284	113		
1070		1992		1,328	633	3,002	5,057	18,530	40,852	112		
1071		1993		1,307	657	2,924	5,289	19,379	42,724	117		
1072		1994		1,315	688	2,893	5,322	19,501	42,991	118		
1073		1995	0.02913	1,320	733	2,830	5,263	19,286	42,517	116		
1074		1996		1,326	756	2,919	5,289	19,381	42,727	117		
1075		1997	0.20466	1,324	735	2,816	5,421	19,862	43,788	120		
1076		1998		1,302	687	2,773	5,384	19,728	43,492	119		
1077		1999		1,257	615	2,650	5,337	19,555	43,110	118		
1078		2000	6,594,400,000	1,257	613	2,637	5,389	19,746	43,532	119		
1079		2001	6,686,594,753	1,258	624	2,636	5,317	19,482	42,951	118		
1080		2002	6,765,685,136	1,253	636	2,617	5,214	19,106	42,120	115		
1081		2003	6,832,172,600	1,246	644	2,594	5,102	18,693	41,211	113		
1082		2004	6,886,550,950	1,237	652	2,564	4,980	18,249	40,232	110		
1083		2005	6,929,306,344	1,226	658	2,530	4,852	17,778	39,194	107		
1084		2006	6,960,917,293	1,215	664	2,492	4,718	17,288	38,113	104	US CO2 2007	
1085		2007	6,981,854,663	1,202	668	2,449	4,579	16,778	36,988	101	120.6	1.1900
1086		2008	6,992,581,671	1,187	672	2,403	4,435	16,251	35,828	98	116.8	1.1900
1087		2009	6,993,553,889	1,172	674	2,353	4,288	15,712	34,639	95	112.9	1.1900
1088		2010	6,985,219,242	1,155	676	2,300	4,138	15,163	33,428	92	109.0	1.1900
1089		2011	6,968,018,009	1,138	676	2,246	3,987	14,610	32,209	88	105.0	1.1900
1090		2012	6,942,382,821	1,120	677	2,188	3,835	14,052	30,980	85	101.0	1.1900
1091		2013	6,908,738,663	1,102	675	2,129	3,682	13,492	29,743	81	97.0	1.1900
1092		2014	6,867,502,874	1,082	674	2,068	3,529	12,930	28,505	78	92.9	1.1900
1093		2015	6,819,085,146	1,059	672	1,998	3,365	12,329	27,181	74	88.6	1.1900
1094		2016	6,763,887,524	1,042	670	1,941	3,222	11,808	26,031	71	84.9	1.1900
1095		2017	6,702,304,407	1,022	667	1,876	3,070	11,251	24,803	68	80.9	1.1900
1096		2018	6,634,722,546	1,001	664	1,810	2,920	10,700	23,590	65	76.9	1.1900
1097		2019	6,561,521,048	980	660	1,744	2,772	10,158	22,394	61	73.0	1.1900
1098		2020	6,483,071,371	959	656	1,677	2,627	9,625	21,218	58	69.2	1.1900
1099		2021	6,399,737,328	938	651	1,612	2,486	9,109	20,082	55	65.5	1.1900
1100		2022	6,311,875,083	917	647	1,546	2,348	8,603	18,967	52	61.8	1.1900
1101		2023	6,219,833,156	896	641	1,481	2,213	8,109	17,877	49	58.3	1.1900
1102		2024	6,123,952,420	874	635	1,416	2,081	7,626	16,812	46	54.8	1.1900
1103		2025	6,024,566,100	851	629	1,349	1,949	7,143	15,748	43	51.3	1.1900
1104		2026	5,921,999,775	832	623	1,286	1,829	6,701	14,772	40	48.2	1.1900
1105		2027	5,816,571,377	811	616	1,221	1,708	6,259	13,798	38	45.0	1.1900
1106		2028	5,708,591,194	790	610	1,158	1,591	5,831	12,854	35	41.9	1.1900
1107		2029	5,598,361,863	769	603	1,095	1,478	5,416	11,941	33	38.9	1.1900
1108		2030	5,486,178,379	749	596	1,034	1,369	5,016	11,059	30	36.1	1.1900
1109		2031	5,372,328,086	729	588	975	1,265	4,634	10,217	28	33.3	1.1900
1110		2032	5,257,090,684	709	581	917	1,164	4,266	9,405	26	30.7	1.1900
1111		2033	5,140,738,226	689	573	861	1,068	3,912	8,625	24	28.1	1.1900
1112		2034	5,023,535,119	669	565	806	975	3,573	7,877	22	25.7	1.1900
1113		2035	4,905,738,121	649	556	753	886	3,248	7,159	20	23.3	1.1900
1114		2036	4,787,596,347	630	548	702	802	2,939	6,479	18	21.1	1.1900
1115		2037	4,669,351,262	612	539	652	721	2,644	5,828	16	19.0	1.1900
1116		2038	4,551,236,685	593	530	604	645	2,362	5,208	14	17.0	1.1900
1117		2039	4,433,478,792	575	521	557	572	2,094	4,617	13	15.1	1.1900
1118		2040	4,316,296,106	557	512	512	502	1,839	4,055	11	13.2	1.1900
1119		2041	4,199,899,510	539	498	498	488	1,790	3,946	11	12.9	1.1900
1120		2042	4,084,492,236	522	485	485	475	1,741	3,837	11	12.5	1.1900
1121		2043	3,970,269,870	505	471	471	462	1,692	3,730	10	12.2	1.1900
1122		2044	3,857,420,353	489	458	458	449	1,644	3,624	10	11.8	1.1900
1123		2045	3,746,123,979	473	445	444	436	1,596	3,520	10	11.5	1.1900
1124		2046	3,636,553,393	457	431	431	423	1,550	3,417	9	11.1	1.1900
1125		2047	3,528,873,597	442	419	419	410	1,504	3,315	9	10.8	1.1900
1126		2048	3,423,241,944	427	406	406	398	1,459	3,216	9	10.5	1.1900
1127		2049	3,319,808,141	413	394	394	386	1,415	3,119	9	10.2	1.1900
1128		2050	3,218,714,248	397	382	382	374	1,372	3,024	8.29	9.9	1.1900
1129		2051	3,120,094,679	385	370	370	363	1,330	2,931	8	9.6	1.1900
1130		2052	3,024,076,202	373	359	359	352	1,289	2,841	8	9.3	1.1900
1131		2053	2,930,777,936	361	348	348	341	1,249	2,754	8	9.0	1.1900
1132		2054	2,840,311,356	349	337	337	330	1,210	2,669	7	8.7	1.1900
1133		2055	2,752,780,290	338	327	327	320	1,173	2,586	7	8.4	1.1900
1134		2056	2,668,280,917	327	317	317	310	1,137	2,507	7	8.2	1.1900
1135		2057	2,586,901,772	316	307	307	301	1,102	2,430	7	7.9	1.1900
1136		2058	2,508,723,742	306	298	298	292	1,069	2,357	6	7.7	1.1900
1137		2059	2,433,820,069	296	289	289	283	1,037	2,287	6	7.5	1.1900
1138		2060	2,362,256,346	287	280	280	275	1,007	2,219	6	7.2	1.1900
1139		2061	2,294,090,521	278	272	272	267	978	2,155	6	7.0	1.1900
1140		2062	2,229,372,895	269	265	265	259	950	2,095	6	6.8	1.1900
1141		2063	2,168,146,123	261	257	257	252	924	2,037	6	6.6	1.1900
1142		2064	2,110,445,212	253	250	250	245	899	1,983	5	6.5	1.1900
1143		2065	2,056,297,524	245	244	244	239	876	1,932	5	6.3	1.1900
1144		2066	2,005,722,772	238	238	238	233	855	1,884	5	6.1	1.1900
1145		2067	1,958,733,026	231	232	232	228	835	1,840	5	6.0	1.1900
1146		2068	1,915,332,705	225	227	227	223	816	1,799	5	5.9	1.1900
1147		2069	1,875,518,586	219	223	223	218	799	1,762	5	5.7	1.1900
1148		2070	1,839,279,796	213	218	218	214	784	1,728	5	5.6	1.1900
1149		2071	1,806,597,816	208	214	214	210	770	1,697	5	5.5	1.1900
1150		2072	1,777,446,481	203	211	211	207	757	1,670	5	5.4	1.1900
1151		2073	1,751,791,981	199	208	208	204	747	1,646	5	5.4	1.1900
1152		2074	1,729,592,855	195	205	205	201	737	1,625	4	5.3	1.1900
1153		2075	1,710,800,000	191	203	203	199	729	1,607	4	5.2	1.1900
1154		2076	1,692,584,000	189	201	201	197	721	1,590	4	5.2	1.1900
1155		2077	1,674,732,320	187	199	199	195	714	1,573	4	5.1	1.1900
1156		2078	1,657,237,674	185	197	197	193	706	1,557	4	5.1	1.1900
1157		2079	1,640,092,920	183	195	195	191	699	1,541	4	5.0	1.1900
1158		2080	1,623,291,062	182	193	193	189	692	1,525	4	5.0	1.1900
1159		2081	1,606,825,240	180	191	191	187	685	1,510	4	4.9	1.1900
1160		2082	1,590,688,736	178	189	189	185	678	1,494	4	4.9	1.1900
1161		2083	1,574,874,961	176	187	187	183	671	1,480	4	4.8	1.1900
1162		2084	1,559,377,462	174	185	185	181	665	1,465	4	4.8	1.1900
1163		2085	1,544,189,913	173	183	183	180	658	1,451	4	4.7	1.1900

	A	B	C	D	E	F	G	H	I	J	K	L
1164		2086	1,529,306,114	171	181	181	178	652	1,437	4	4.7	1.1900
1165		2087	1,514,719,992	169	180	180	176	646	1,423	4	4.6	1.1900
1166		2088	1,500,425,592	168	178	178	175	639	1,410	4	4.6	1.1900
1167		2089	1,486,417,080	166	176	176	173	633	1,397	4	4.6	1.1900
1168		2090	1,472,688,739	165	175	175	171	628	1,384	4	4.5	1.1900
1169		2091	1,459,234,964	163	173	173	170	622	1,371	4	4.5	1.1900
1170		2092	1,446,050,265	162	172	172	168	616	1,359	4	4.4	1.1900
1171		2093	1,433,129,259	160	170	170	167	611	1,346	4	4.4	1.1900
1172		2094	1,420,466,674	159	169	169	165	605	1,335	4	4.4	1.1900
1173		2095	1,408,057,341	158	167	167	164	600	1,323	4	4.3	1.1900
1174		2096	1,395,896,194	156	166	166	162	595	1,311	4	4.3	1.1900
1175		2097	1,383,978,270	155	164	164	161	590	1,300	4	4.2	1.1900
1176		2098	1,372,298,705	154	163	163	160	585	1,289	4	4.2	1.1900
1177		2099	1,360,852,730	152	161	161	158	580	1,279	4	4.2	1.1900
1178		2100	1,349,635,676	151	160	160	157	575	1,268	3	4.1	1.1900
1179												
1180												
1181											Folio 13	
1182												
1183												
1184												
1185				Aspen per capita emissions								
1186												
1187		“Aspen Emissions Goals 2020 and 2050”										
1188			Indexed to 2004	Projected emissions	Aspen population	Emissions per cap	Emissions per cap	Emissions per cap	Convergence	Emissions per cap	Emissions/cap	
1189			Peak in 2008	tons CO2e/yr	Res, 2nd, wkrs, vis	tons CO2e/cap	lb CO2e/cap	lb CO2e/cap-hr	% above target	lb CO2e/cap-day	lb CO2/cap-day	
1190		to 20% of 2004 by 2050			1.0%/yr increase				2 tonnes CO2e/cap			
1191		Aspen									convert to CO2	
1192		2000	94.13%	791,546	16,295	48.58	97,154	11.09	2203%	266	258	
1193		2001	95.57%	803,600	16,459	48.82	97,648	11.15	2215%	268	259	
1194		2002	97.02%	815,838	16,625	49.07	98,143	11.20	2226%	269	261	
1195		2003	98.50%	828,262	16,793	49.32	98,642	11.26	2237%	270	262	
1196		2004	100.00%	840,875	16,963	49.57	99,142	11.32	2249%	272	263	
1197		2005	101.76%	855,674	17,133	49.94	99,888	11.40	2265%	274	265	
1198		2006	103.55%	870,734	17,304	50.32	100,640	11.49	2282%	276	267	
1199		2007	105.37%	886,059	17,477	50.70	101,397	11.58	2300%	278	269	
1200		2008	107.23%	901,654	17,652	51.08	102,160	11.66	2317%	280	271	
1201		2009	105.34%	885,785	17,828	49.68	99,368	11.34	2254%	272	264	
1202		2010	101.50%	853,477	18,007	47.40	94,796	10.82	2150%	260	252	
1203		2011	97.80%	822,348	18,187	45.22	90,434	10.32	2051%	248	240	
1204		2012	94.23%	792,354	18,368	43.14	86,273	9.85	1957%	236	229	
1205		2013	90.79%	763,455	18,552	41.15	82,303	9.40	1867%	225	219	
1206		2014	87.48%	735,609	18,738	39.26	78,516	8.96	1781%	215	209	
1207		2015	84.29%	708,779	18,925	37.45	74,904	8.55	1699%	205	199	
1208		2016	81.22%	682,927	19,114	35.73	71,457	8.16	1621%	196	190	
1209		2017	78.25%	658,019	19,305	34.08	68,169	7.78	1546%	187	181	
1210		2018	75.40%	634,019	19,499	32.52	65,032	7.42	1475%	178	173	
1211		2019	72.65%	610,894	19,694	31.02	62,040	7.08	1407%	170	165	
1212		2020	70.00%	588,612	19,890	29.59	59,185	6.76	1342%	162	157	
1213		2021	67.34%	566,245	20,089	28.19	56,373	6.44	1279%	154	150	
1214		2022	64.78%	544,728	20,290	26.85	53,694	6.13	1218%	147	143	
1215		2023	62.32%	524,028	20,493	25.57	51,142	5.84	1160%	140	136	
1216		2024	59.95%	504,115	20,698	24.36	48,711	5.56	1105%	133	129	
1217		2025	57.67%	484,959	20,905	23.20	46,396	5.30	1052%	127	123	
1218		2026	55.48%	466,530	21,114	22.10	44,191	5.04	1002%	121	117	
1219		2027	53.37%	448,802	21,325	21.05	42,091	4.80	955%	115	112	
1220		2028	51.35%	431,748	21,539	20.05	40,091	4.58	909%	110	106	
1221		2029	49.39%	415,341	21,754	19.09	38,185	4.36	866%	105	101	
1222		2030	47.52%	399,558	21,971	18.19	36,371	4.15	825%	100	97	
1223		2031	45.71%	384,375	22,191	17.32	34,642	3.95	786%	95	92	
1224		2032	43.97%	369,769	22,413	16.50	32,996	3.77	748%	90	88	
1225		2033	42.30%	355,718	22,637	15.71	31,428	3.59	713%	86	83	
1226		2034	40.70%	342,200	22,864	14.97	29,934	3.42	679%	82	80	
1227		2035	38.93%	327,339	23,092	14.18	28,351	3.24	643%	78	75	
1228		2036	37.24%	313,123	23,323	13.43	26,851	3.07	609%	74	71	
1229		2037	35.62%	299,525	23,556	12.72	25,431	2.90	577%	70	68	
1230		2038	34.07%	286,517	23,792	12.04	24,085	2.75	546%	66	64	
1231		2039	32.59%	274,074	24,030	11.41	22,811	2.60	517%	62	61	
1232		2040	31.18%	262,172	24,270	10.80	21,604	2.47	490%	59	57	
1233		2041	29.82%	250,786	24,513	10.23	20,462	2.34	464%	56	54	
1234		2042	28.53%	239,895	24,758	9.69	19,379	2.21	440%	53	51	
1235		2043	27.29%	229,477	25,006	9.18	18,354	2.10	416%	50	49	
1236		2044	26.11%	219,511	25,256	8.69	17,383	1.98	394%	48	46	
1237		2045	24.97%	209,978	25,508	8.23	16,464	1.88	373%	45	44	
1238		2046	23.89%	200,859	25,763	7.80	15,593	1.78	354%	43	41	
1239		2047	22.85%	192,136	26,021	7.38	14,768	1.69	335%	40	39	
1240		2048	21.86%	183,792	26,281	6.99	13,987	1.60	317%	38	37	
1241		2049	20.91%	175,810	26,544	6.62	13,247	1.51	300%	36	35	
1242		2050	20.00%	168,175	26,809	6.27	12,546	1.43	285%	34	33	
1243		2051	19.14%	160,943	27,077	5.94	11,888	1.36	270%			
1244		2052	18.33%	154,119	27,348	5.64	11,271	1.29	256%			
1245		2053	17.56%	147,677	27,622	5.35	10,693	1.22	243%			
1246		2054	16.84%	141,593	27,898	5.08	10,151	1.16	230%			
1247		2055	16.16%	135,844	28,177	4.82	9,642	1.10	219%			
1248		2056	15.51%	130,411	28,459	4.58	9,165	1.05	208%			
1249		2057	14.89%	125,194	28,743	4.36	8,711	0.99	198%			
1250		2058	14.29%	120,186	29,031	4.14	8,280	0.95	188%			
1251		2059	13.72%	115,379	29,321	3.94	7,870	0.90	178%			
1252		2060	13.17%	110,764	29,614	3.74	7,480	0.85	170%			
1253		2061	12.65%	106,333	29,910	3.56	7,110	0.81	161%			
1254		2062	12.14%	102,080	30,209	3.38	6,758	0.77	153%			
1255		2063	11.65%	97,997	30,512	3.21	6,424	0.73	146%			
1256		2064	11.19%	94,077	30,817	3.05	6,106	0.70	138%			
1257		2065	10.74%	90,314	31,125	2.90	5,803	0.66	132%			
1258		2066	10.31%	86,701	31,436	2.76	5,516	0.63	125%			
1259		2067	9.90%	83,233	31,750	2.62	5,243	0.60	119%			
1260		2068	9.50%	79,904	32,068	2.49	4,983	0.57	113%			
1261		2069	9.12%	76,708	32,389	2.37	4,737	0.54	107%			
1262		2070	8.76%	73,639	32,712	2.25	4,502	0.51	102%			
1263		2071	8.41%	70,694	33,040	2.14	4,279	0.49	97%			
1264		2072	8.07%	67,866	33,370	2.03	4,067	0.46	92%			
1265		2073	7.75%	65,151	33,704	1.93	3,866	0.44	88%			
1266		2074	7.44%	62,545	34,041	1.84	3,675	0.42	83%			

	B	C	D	E	F	G	H	I
	2075	7.14%	60,044	34,381	1.75	3,493	0.40	79%
	2076	6.85%	57,642	34,725	1.66	3,320	0.38	75%
	2077	6.58%	55,336	35,072	1.58	3,156	0.36	72%
	2078	6.32%	53,123	35,423	1.50	2,999	0.34	68%
	2079	6.06%	50,998	35,777	1.43	2,851	0.33	65%
	2080	5.82%	48,958	36,135	1.35	2,710	0.31	61%





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CO2 savings from recycling (Aspen 2004)

Table 2: Saved emissions	Quantities Recycled and Sold	Carbon dioxide savings per tonne recycled	Total Pitkin County carbon dioxide savings	Attributed to Aspen	Carbon dioxide (Aspen's share)	Carbon (Aspen's share)
Pitkin County Landfill: Savings from Recycl	tonnes	tonnes CO2-eq/tonne	tons CO2-eq	Percent	sh tons CO2-eq/yr	tonnes carbon (C-eq)
Office paper	113	5.4	673	60%	**404**	100
Newsprint	1,184	2.5	3,264	60%	**1,958**	485
Cardboard	524	3.0	1,732	60%	**1,039**	257
Commingled materials	1,174	na	na	60%	**na**	na
Plastics (10.5 percent of commingled)	123	2.0	272	60%	**163**	40
Aluminum (6.5 percent of commingled	76	15.7	1,321	60%	**793**	196
Glass (65 percent of commingled)	763	0.4	337	60%	**202**	50
Steel (18 percent of commingled)	211	2.3	536	60%	**322**	80
Total Landfill recycling savings	2,996	na	8,134	60%	**4,881**	1,208

Recycling one aluminum beverage can

assumes Ackermann recycling savings are correct
compare (energy) savings; see Can Manuf Institute, www.cancentral.com
e.g., 1 lb alum saves 7.5 kWh
1 ton saves 2,350 gallons gasoline

	tonnes CO2e/tonne
Ackermann: CO2 saved per tonne alum	**15.7**

	cans/lb aluminum	cans per kg alum	empty can (grams)	cans per tonne	kg CO2e/kg alum	kg CO2e per can	lb CO2 per can
					CO2e savings (Ackermann & CMI data, CMS calcs)		
Can Manufacturers Institute	34.2	75.4	**13.3**	75,419	15.7	**0.208**	**0.459**

Local carbon offset programs

	Cost	per unit kWh	CO2e per kWh	kWh per ton offset	Cost per ton offset
Holy Cross WindPioneers carbon offset	$ 2.50	100	1.731	1,155	**$ 28.88**
$2.50 per 100 kWh					

	Cost per ton offset
Canary Tags	**$ 20.00**

TerraPass	**www.terrapass.com**
Bonneville EF	**www.greentagsusa.org** **www.greentagsusa.org/greentags/aspen/index.shtm**
Renewable Choice Energy	**www.renewablechoice.com**
Green Mountain Energy Company	**www.greenmountain.com**
Carbon Fund	**carbonfund.org**
TripleE Travel	**www.TripleE.com**
CO2Balance.com	
Native Energy	**www.nativeenergy.com**
Sterling Planet	**www.sterlingplanet.com**

Also see UCS Carbon Offset reviews

Fuel cycle emissions: diesel and gasoline

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	lb CO2 per gallon
Gasoline	19.564
Gasoline fuel cycle adder	5.282
Total gasoline fuel cycle emissions	**24.846**
Diesel	22.384
Diesel fuel cycle adder	4.253
Total diesel fuel cycle emissions	**26.637**

From Heede (2008) Paredon Oil & Gas Project

Estimated refinery or fuel cycle energy inputs and emission factors			
UCS/Wang	22.8	5.4	23.7%
Heede (2003)			15.5%
ANL GREET model	5,156	1,245	24.1%
FEIR cites GM	averages FEIR citation: 13 to 17%		15.0%
Delucchi (2003)			25.0%
Simple average of above upstream estimates			20.7%

ie, specific to California gasoline/diesel mix (esp Delucchi)

Volumetric CO2 calculations

International Carbon Bank & Exchange

Volume calculation of one ton CO_2

one cubic meter = 1,000 liters
one liter = .03531 cubic feet
one mole CO_2 = 44.0 g (C = 12, O = 16; CO_2 has one C and 2 O's; 12.0 + 32.0 = 44.0)
one tonne contains 22,730 moles of CO2 (1,000,000g / 44.0g per mole)
one mole is 24.47 liter (Boyle's law at 25°C and 1 atmosphere pressure) volume of one tonne CO_2 = 22,730 moles x 24.47 Łmole = 556,200 L = 556.2 m^3
One tonne of CO_2 occupies 556.2 m^3 of volume.
1 m^3 CO_2 = 0.0017979 tonne = 1.7979 kg.
1 ft^3 CO_2 = 1.7979 kg m^{-3}/ 35.31 m^3 ft^{-3} = 0.050918 kg = 0.112253 lbs CO_2.

www.eia.doe.gov/oiaf/1605/ archive/

1 thousand cubic feet carbon dioxide = 115.97 pounds
1 thousand cubic feet of methane = 42.28 pounds

CMS calculations

1000	cf CO2 weighs	115.970	lb, thus:
1	cf CO2 weighs	0.116	lb, thus:
1	lb CO2 equals:	8.623	cubic foot
1	ounce CO2 equals	0.539	cubic foot
1	cubic foot weighs	1.856	ounces

http://hypertextbook.com/facts/2002

party balloons of radius 0.1143 m	1	cubic meter equal	35.3147	cf
The volume of the balloon is 0.00625m	0.00625	m^3	0.2207	cf

CMS calculations

therefore it would take	39.07	balloons to equal	1.00	lb CO2
and	1.00	balloon contains	0.03	lb CO2
	1.00	balloon contains	0.41	ounces CO2
	1.00	ounce CO2 takes	2.44	balloons

CO2-filled ballons per year, day, hour, minute, second

	tons CO2e/yr	lb CO2e/yr	lb CO2e/day	lb CO2e/hour	lb CO2e/minute	lb CO2e/second
Aspen total emissions, 2004	840,875	1,681,750,000	4,607,534	191,981	3,200	53.3
Average Aspen residence		50,800	139.18	5.80	0.10	0.00

		balloons per year	balloons per day	balloons per hour	balloons/minute	balloons/second
Aspen total emissions, 2004		65,702,324,146	180,006,368	7,500,265	125,004	2,083
Average Aspen residence		1,984,646	5,437	226.6	3.78	0.06

/www.physlink.com/education/askexpe 1 cubic foot of air at standard temperature and pressure assuming average composition weighs approximately 0.0807 lbs.

http://cdiac.ornl.gov/pns/faq.html Using 5.137 x 10^18 kg as the mass of the atmosphere (Trenberth, 1981 JGR 86:5238-46), 1 ppmv of CO2= 2.13 Gt of carbon.

Global CO2 emissions converted into lb CO2, cubic feet CO2, and CO2-filled ballons per year, day, hour, minute, second

conversions by CMS from Worldwatch datum on industrial CO2 emissions in 2005

Global CO2 emissions, 2005

			lb CO2 per unit		cf CO2 per unit		ballons per unit
7.56	GtC						
27.70	billion tonnes CO2						
30.54	billion tons CO2						
83,657,878	tons CO2/day	167,315,755,118	lb CO2/day	1.44275E+12	cf CO2/day	6.54E+12	balloons/day
3,485,745	tons CO2/hr	6,971,489,797	lb CO2/hr	6.01E+10	cf CO2/hr	2.72E+11	balloons/hr
58,096	tons CO2/minute	116,191,497	lb CO2/min	1,001,909,947	cf CO2/min	4.54E+09	balloons/min
968	tons CO2/sec	1,936,525	lb CO2/sec	16,698,499	cf CO2/sec	75,655,828	balloons/sec

1.44275E+12 cf CO2/day equals 9.80 cubic miles CO2/day

1 cubic mile equals 1.47198E+11 cf

Cell: F9
Comment: Rick Heede:
CMS calculations of emissions factors for US average electricity, in units of lb CO2 and CO2e per delivered kWh. Based on Energy Information Administration (2008) Annual Energy Review 2007, DOE. CO2 and CO2 + methane emissions per delivered kWh of electricity (retail sales).

Cell: F10
Comment: Rick Heede:
US total emissions of CO2 from the eletric utility sector (thus excluding CHP & coml & indl generators): 2,343.9 million tonnes CO2 (MtCO2). AER (2008) table 12.3, "Carbon Dioxide Emissions From Energy Consumption by Sector by Energy Source, 2006", footnote 4: "Electricity-only and combined-heat-and-power (CHP) plants within the NAICS 22 category whose primary business is to sell electricity, or electricity and heat, to the public."

AER Table 12.7b: Emissions From Energy Consumption for Electricity Generation and Useful Thermal Output: Electric Power Sector, 1989-2006 estimates 2,322.9 MtCO2 (coal, gas, oil, MSW, and geothermal). Table 12.a (power sector plus CHP etc) estimates 2,459.8 MtCO2, all in 2006.

Cell: B11
Comment: Rick Heede:
Holy Cross carbon coefficient ~1.61 lb CO2 per kWh; acct for T&D losses (6%) and methane from coal mining increases total EF to 1.731 lb CO2 per kWh consumed. Personal communication, HCE, Heede (2006) Aspen Emissions Inventory.

Cell: F11
Comment: Rick Heede:
AER (2008) Table 12.5 Methane emission, 2006, from energy sources: Coal mining 2.82 million tonnes methane (MtCH4), Natural gas systems 6.56 MtCH4, Petroleum systems 0.92 MtCH4, Mobile Combustion 0.21 MtCH4, Stationary combustion 0.39 MtCH4, Total energy 10.89 MtCH4. Total all methane (energy, waste mngt, agriculture, etc) 26.31 MtCH4.

Cell: F13
Comment: Rick Heede:
Methane emissions from natural gas systems totaled 6.56 MtCH4 in 2006. Since 5,091 Bcf of 21,653 Bcf of US gas consumption is in the electric power sector (excluding CHP) in 2006, CMS allocates 23.51 percent of methane emissions to power sector.

Cell: B14
Comment: Rick Heede:
Overeynder calculation adjusted as follows (prelim):
T&D grid losses (same as 2004: 4.58%);
methane emissions from MEAN coal-fired generation (based on same Xcel ancillary rate) of 7.51%;
divide emissions by sales, not gross production plus procurement: 4.80%;
Sum of adjustment: 16.89 above Overeynder estimate of 0.6115 lb COe = 0.7148 lb CO2e per kWh sold.

Cell: F16
Comment: Rick Heede:
AER (2008) Table 8.2b Electricity Net Generation: Electric Power Sector, 2006: 3,908.1 billion kWh.

However, CMS is interested in emission factors per unit if delivered electricity, hence use Table 8.9 Electricity End Use, 2006: "Total Retail Sales" of 3,670 billion kWh in 2006.

(Note: Total end use of 3,817 billion kWh includes 147 billion kWh of "direct use" (chiefly self-generated power).)

Cell: D17
Comment: Rick Heede:
Aspen Inventory 2007, natural gas worksheet, Table 3. The second datum -- lb CO2e per million Btu -- includes fugitive emissions of methane from the natural gas system (based on EIA AER 2007 data).

Cell: F19
Comment: Rick Heede:
US Environmental Protection Agency (2007) eGRID2006 version 2.1 (April 2007) Year 2004 Summary Tables, state emissions (US average given as 1,363 lb CO2 per MWh).

Cell: B27
Comment: Rick Heede:
DOE and EPA emissions coefficient. Combustion emissions only, does not include reduction for incomplete combustion (IPCC: 99 percent combustion factor for liquid fuels), nor the upstream "wells to wheels" emissions, roughly 30 percent above combustion alone.

Cell: B28
Comment: Rick Heede:
Heede, Richard (2007) From the Dairy Farm to the Consumer: Organic vs Conventional Milk: Comparing Supply Chain Emissions, commissioned by Sustainable Settings, Carbondale.

Per gallon	grams CO2	lb CO2	Percent of total
Feed	715	1.577	24.57%
Methane (eructation)	1,040	2.293	35.74%
Methane (manure)	66	0.145	2.27%
Nitrous (manure)	113	0.249	3.88%
On the farm	6	0.013	0.20%
Transportation to processing	1	0.003	0.04%
Processing	1	0.002	0.03%
Trucking	14	0.030	0.47%
At the Grocery Story not estimated			
Driving 2 miles RT to pick up milk	955	2.105	32.80%
Total milk supply chain	2,911	6.417	100.0%

Cell: B29
Comment: Rick Heede:
Weber, Christopher L., & H. Scott Matthews (2008) "Food-Miles and the Relative Climate Impacts of Food Choices in the United States," Env Science & Technology, forthcoming, 6 pp. red meat: 22.1 kg CO2e/kg, which converts to (surprise!) 22.1 lb CO2/lb.

Anderson, Kathryn (2007) Food, a paper for "Toward an Ethical CO2 Emissions Trajectory for Princeton", p. 14: conventional beef averages 13.04 lb CO2e per lb ground beef. This calculation should be checked for accuracy and boundary.

Cell: B30
Comment: Rick Heede:
Overeynderand Richardson estimated City Electric Dept's carbon intensity in early 2007 as 0.6053 lb CO2 per kWh. This does not follow the protocol used by CMS for 2004, does not included grid losses or methane, and may not fully account for WAPA purchases. As a preliminary precaution against underestimating City emissions, CMS will average 2004 and 2007 for use in this project.

Cell: B31
Comment: Rick Heede:
Bancroft et al (1991) "Water Heating" p. 14 estimates tank standby losses averaging 14.8 percent, which CMS applies to Btu input per gallon after heating losses (in the case of natural gas and propane).

Cell: B36
Comment: Rick Heede:
National Vehicle and Fuel Emissions Laboratory US Environmental Protection Agency. CMS data from Craig Harvey, harvey.craig@epa.gov: 1.571 million snowmobiles used 395.7 million gallons in 89.5 million hrs (2000). CMS calc: 395.7/89.5 = 4.42 gallons per hour; assuming gasoline EF of 19.594 lb CO2 = 86.63 lb CO2 per hour.

Cell: G36
Comment: Rick Heede:
Piper Foster contact in snowmobiling estimated the average snowmachine useage at "at least 6 hours" per typical outing. CMS thinks this may be high, but has no better data.

Cell: B37
Comment: Rick Heede:
18Jan08: Piper asked at the front desk and got word that the avg visitors/ day is 500-600. It was a little sketchy - the kids didn't seem totally sure. But when I started ball parking parameters, this is what two of them concluded, after rubbing their foreheads for a long while.

Cell: G46
Comment: Rick Heede:
CMS, Aspen inventory 2004: Commuting (125,714 tons CO2), tourist travel (40,340 tons CO2), driving around town (36,720 tons CO2), total 202,774 tons CO2.

Cell: G47
Comment: Rick Heede:
CMS inventory, 2004: 186,631 tons CO2 for commercial aviation. This accounts foremissions from 70 percent of 178,800 deplanements of commercial flights into the Aspen Pitkin County Airport as well as 70 percent of 94,200 deplanements estimated to be Aspen-bound but using other area airports (EGE, GJT, DEN) and driving to Aspen. Four-fifths of Aspen deplaning passengers are assumed (based on ASC and ACRA data) to be domestic, flying an average of 1,100 miles, and one-fifth are international flying 5,000 miles on average. See the inventory worksheet for details.

Cell: G48
Comment: Rick Heede:
Forbes mag (3Aug07), Sonia Narang, Carbon with that Latte?: "In its shop in downtown San Mateo, Calif., for instance, baristas serve up about 40,000 cups of coffee drinks every month. Just based on utility bills alone, that means Starbucks is serving up about 4,900 pounds of carbon with its drinks--or about two ounces per cup." No mention of natural gas in stores, or shipping and roasting coffee, or growing and processing. Last Starbucks GHG inventory in 2003 (by CH2MHill): North American stores have doubled since to 6,281 stores, plus 1,500 international.

Cell: E55
Comment: Rick Heede:
Aspen Skiing Company (2006) Sustainability Report, p. 6.

Cell: E56
Comment: Rick Heede:
CMS Aspen inventory 2004:
2,975 tons CO2 (elec) + 273 tons CO2 (gas) = 3,248 tons CO2e total = 6,496,000 lb CO2e total
559 million gallons treated, thus 0.0116 lb CO2 per gallon treated in 2004.

Cell: E58
Comment: Rick Heede:
Lee Cassin, Sep98 analysis of 184 Aspen household water consumption, in which 130,700 gallons per year average. (See Sopris Fdn / ASHES folder / Profiles.)

Cell: B61
Comment: Rick Heede:
See notes in DailyCarbonNotes.doc: UPS emissions inventory and CMS calculations. Also see row (~) 392 below.

Cell: K64
Comment: Rick Heede:
CMS estimates 2007 HCE carbon (and methane) intensity by taking HCE's 2006 carbon intensity (1.61 lb CO2 per kWh) times the ancillary methane emissions ratio developed for Xcel used for Frisco inventory, 2007.
Formula: =1.61*(1.953/1.816)
See CMS interview with Steve Casey, HCE, Dec07.

Cell: B66
Comment: Rick Heede:
Central AC in 57.5 million US households average 2,796 kWh per year. Room AC in 23.3 million households average 950 kWh per year.

RECS data on EIA website: Table 2. Residential Consumption of Electricity by End Use, 2001, www.eia.doe.gov/emeu/recs/recs2001/enduse2001/enduse2001.html

Cell: B67
Comment: Rick Heede:
In all, 80.8 million households use AC, total national 182.8 billion kWh, or 2,262 kWh per AC-average household. RECS 2001 data, see above ref.

Cell: B68
Comment: Rick Heede:
RECS 2001 data, 193 million ceiling fans in 70 million homes typicaly use 50 kWh each per year, 138 kWh per household per year.

Cell: B69
Comment: Rick Heede:
With hot water (US average washing cycles, fuel, and emissions): 1,544 lb CO2 per year.

Cell: B72
Comment: Rick Heede:
RECS 2001 data, 512 kWh per year, not including heating water coming into the unit.

Cell: B75
Comment: Rick Heede:
EIA RECS 2001 data, as above, cies 940 kWh/yr for indoor and exterior lighting. Single-family homes average is higher, 1,500 to 2,900 kWh/yr (CMS, Heede 2002B), footnote 36, Aspen average is unknown.

Cell: B78
Comment: Rick Heede:
RECS data 2001, 3.3 milllion “hot tub / pool / spa heaters” average 2,300 kWh per unit per year.

Cell: B81
Comment: Rick Heede, 4Dec08:
Three HDTV technologies: plasma, LCD, and rear-projection microdisplay (aka DLP, or digital light processing). A study by CNET found that, on average, plasma TVs are the least efficient, consuming 0.33 watt of electricity per square inch of screen, while LCD TVs are slightly better at 0.28 watt per inch. Your best choice to save energy is DLP, which consumes only 0.13 watt per inch.” No mention of CRTs. EPA: 275 million TVs consume >50 billion kWh (50+ TWh) (UCS: “10 coal-fired powerplants”). My Samsung 40” LCD is 19.5x34.75 = 678 sq inches = 190 W. S similar sized plasma TV would use 224 kWh or 303 lb CO2/yr. The rpt sum did not mention wattage or average on-cycle per day.

Cell: B83
Comment: Rick Heede:
Figure comes from ACE3 “Energy Consumption of Household Products” Assumes 1 hr/day play’ 1 hour/day on; 22 hours/day standby.

Cell: B88
Comment: Rick Heede:
EIA RECS 2001 data: Refrigerators average 1,239 kWh/yr per unit and 1,462 kWh per household (ie, 1.18 fridges per household; Aspen is clearly higher). US consumption for all fridges totals 156.1 billion kWh, or 105 million tons CO2 (calc by CMS based on US electric EF of 1.354 lb CO2/kWh).

www.eia.doe.gov/emeu/recs/recs2001/enduse2001/enduse2001.html

Cell: B93
Comment: Rick Heede:
EIA RECS data 2001: 54.2 million destop units average 262 kWh/yr, 14.2 million laptop units average 77 kWh/yr. Clearly, very out of date on both saturation and electric usage.

Cell: B98
Comment: Rick Heede:
EIA RECS data 2001, cited above, block heater 200 kWh and 2.3 million units.

Cell: B121
Comment: Rick Heede:
CMS (very preliminary) multiplies the cost and emissions of a large Red Mtn home ($30,943 and 253.3 tons) by the Aspen Club’s annual combined utility cost totaling $200,000.

Cell: B132
Comment: Rick Heede:
CMS assumes aveage speed of 40 mph. City routes will be lower, and hybrid buses on Hwy 82 Valley routes somewhat higher.

Cell: E218
Comment: Rick Heede:
Wikipedia: Forbes notes “H2 gets a paltry 13 mpg on the highway and 10 mpg in the city” Motortrend observed 12 mpg. Car and Driver observed 10 mpg. A reviewer at about.com got 8.6 mpg. Edmunds observed 9.2 mpg. Four Wheeler magazine observed 10.8 mpg in their final long term report of a H2 SUT. Their worst tank was 7.2 mpg and best tank was 15.3 mpg. Consumer Guide observed 10.7 mpg, even with mostly highway driving. Automobile Magazine averaged less than 10 mpg. US News observed 9.5 mpg according to its trip computer. Cars.com observed 11.4 mpg according to its trip computer in mostly highway driving. Car and Driver notes that the 2008 H2 is more efficient than previous models and will get 11.5 mpg.

Cell: E220
Comment: Rick Heede:
This is a composite average of fuel consumed and miles driven by passenger cars plus small SUVs/pick-up trucks plus large SUVs/pick-up trucks. This number is also used to estimate saved fuel from RFTA bus services (a calculation that uses 1.63 persons per vehicle).

Note: this number is driven by data and does not have to be revised. Its revision depends on fuel economy by individual mpg data in the body of the worksheet. The result for 2007 (19.15 mpg) is a substantial improvement over the 2004 result (18.6 mpg), due to the shifting vehicle type survey conducted in each year.

Cell: B222
Comment: Rick Heede:
Based on CMS commuting survey in Hershey Pennsylvania, 186 survey returns, fuel economy of each vehicle from EPA website, average daily commute of 13.2 miles per day, 6,400 miles per year, 283 gallons of fuel, 5,553 lb CO2 per year, average 22.77 mpg, and 0.86 lb CO2 per mile.

Cell: E224
Comment: Rick Heede:
Motor Trend 2004 Prius: Average test mpg of 40.8 mpg.

Cell: E228
Comment: Rick Heede:
CMS 2007 data from Blankenship for Aspen Inventory 2007: fleet average mpg is now 5.26 mpg, 13.4 percnt biodiesel on average, 20.02 lb CO2 per average gallon of fuel

Cell: C246
Comment: Rick Heede:

CMS field research calculating specific flights ASE-DEN shows an average of 0.935 lb CO2 per passenger mile, ranging from 0.60 to 1.58 lb CO2/pax-mile for the eleven flights analyzed through Dec08. Variables include APU burn, miles flown (not always direct), and pax onboard (half full to full flights). See HeedeAirStats.xls in Aspen Canary folder.

Cell: F257
Comment: Rick Heede:
Pablo, 11Jan08: “Great observation. The Fiji water numbers are material intensity factors (like LCA) while the CE Delft numbers are more suitable as greenhouse gas inventory factors. Since the wine paper looked only at CO2e, not the full LCA, I chose to use the Delft numbers. Candidly, I trust their methodology a bit more anyway...”

CMS: Pablo used 17 g GHGs per tonne-km for Fiji example, vs CE Delft’s 52.1 g CO2/t-km for the French wine example.

Cell: B297
Comment: Rick Heede:
ASC (2006) Sustainability Report 2004-2006, 13 pp., www.aspensnowmass.com/environment/

Cell: B299
Comment: Rick Heede:
REC contract started in Jun06, hence not reflected in the last inventory covering 2004-2005. Electricity for all mountains totalled 24.594 million kWh = 21,956 tons CO2, less 1,032 tons CO2 for “non-REC windpower”. Auden declined to update CMS with current (post-REC contract) emissions per skier day.

Cell: D323
Comment: Rick Heede:
Three sources googled 15Feb08:
www.ccg-gcc.gc.ca/helicopter/carct_bell212_e.htm: Canadian Coast Guard Characteristics of the Bell 212 Helicopter Fuel Burn Rate 380 Litres/Hour

www.aoc.noaa.gov/aircraft_bell.htm NOAA Bell 212 Helicopter Type Engines: 2 Pratt & Whitney PT6T-3 Twinpac 1800 shaft horsepower, Service Ceiling: 12,500 feet, Fuel Burn Rate: 625 pounds/hour (~100 gallons/hour)

www.indopedia.org/Bell_212.html Bell 212, Type Engines: 2 Pratt & Whitney PT6T-3 Twinpac 1,800 shaft horsepower (1,300 kW), Service Ceiling: 12,500 ft (3,800 m), Fuel Burn Rate: 625 lb/h (283 kg/h) or about 100 US gałh (380 Łh), Fuel Load: 1430 lb (649 kg) or 220 US gallons (833 L) Standard, Type Fuel: Jet A, Jet B, JP4, JP8, Range (normal): 225 nautical miles (420 km) ~2.3 hours @100 knots (185 km/h)

Cell: D348
Comment: Rick Heede:
Piper Foster got preliminary estimate from front desk personnel that Club averages 500-600 visitors per day (personal communication, 21Jan08).

Cell: H364
Comment: Rick Heede:
Tim Anderson, Recreation Director tima@ci.aspen.co.us, 11March08:
“We have about 225,000 annual uses at the ARC. We arrive at that number through our computer counts as to pass holder uses and daily admissions. We also include in that number hand counts for such groups as jr. hockey who pay by the hour of ice used, the spectator counts for hockey games, and parents who sit in the lobby areas and watch their kids, as well as special events attended at the ARC.” CMS confirmed that 85 to 90 percent of total are actual users of the ARC; CMS computes emissions for actual facility users.

Cell: D365
Comment: Rick Heede:
This factor is used to generate results for individual homes and commercial buildings. (It takes the carbon emissions factor and adds the CO2-equivalent of the fugitive methane developed in Table 1 above. As such it adds to CO2 the methane factor shown in Table 2: Methane emissions rate as CO2-e, which in 2004 = 13.05 percent of CO2.)

Cell: C390
Comment: Rick Heede:
Datum from ASC (2006) Sust Rpt, page 6.

Cell: G408
Comment: Rick Heede:
Pablo calc GHG per 1 liter Fiji bottle delivered to SF in US: 1 l uses ~25g PET bottle, manuf bottle emits 93g, shipping PET blanks from China to Fiji = 4.3g, shipping filled one liter bottle to SF emits 153g; Pablo assumes fixed costs (bottling plant, HQ, utilities) are zero; total emissions = 250 g GHG (presumably CO2).

Cell: D417
Comment: Rick Heede:
Dr Vino & Pablo Paster (2007), page 8: “The greatest climate impact from the wine supply chain comes from transportation. This transportation impact begins with the delivery of agrichemicals, barrels, and bottles, but is primarily accumulated during the final product shipment to the customer. While unrefrigerated container shipping is most efficient, it also takes a long time. And air cargo, which can deliver product to virtually any destination around the world in a matter of hours, has an emissions factor of over 11 times that of container shipping. Emissions factors for cargo are in terms of g · t-1 · km-1, or grams of CO2e per ton of cargo per km transported. The emissions factor applied for container shipping is 52.1 g · t-1 · km-1 (CE Delft 2006). The trucking emissions factor used is 252 g · t-1 · km-1, and trains emit 200 g · t-1 · km-1(GHG Protocol).4 The emissions factor used for refrigerated container shipping is 67.1 g · t-1 · km-1 (2003). Finally, we use 570 g · t-1 · km-1 for air cargo (CE Delft 2006).”

Cell: F451
Comment: Rick Heede:
Forbes mag (3Aug07), Sonia Narang, Carbon with that Latte?: “In its shop in downtown San Mateo, Calif., for instance, baristas serve up about 40,000 cups of coffee drinks every month. Just based on utility bills alone, that means Starbucks is serving up about 4,900 pounds of carbon with its drinks--or about two ounces per cup.” No mention of natural gas in stores, or shipping and roasting coffee, or growing and processing.

Cell: B459
Comment: Rick Heede:
Ryan,John (1997) Stuff: The Secret Lives of Everyday Things, p. 6.

Cell: C483
Comment: Rick Heede:
Nicolas Theisen, New Belgium, 19De07: “24 lbs CO2 per barrel (31 gallons)- this is production CO2 per barrel which includes CO2 from combustion and CO2 from fermentation. It does not include CO2 from coal produced electricity - because we purchase wind power through the Fort Collins Wind program. “

Cell: I512
Comment: Rick Heede:

Email to DrVino 14Dec07. Quote: "Assuming average greenhouse gas emissions of 2 kg per liter and a global production volume of 2,668,300,000 liters in 2001,9 the global GHG emissions from wine production and distribution are 5,336,600 tons."

Colman, Tyler, & Pablo Päster (2007) Red, White, and "Green": the Cost of Carbon in the Global Wine Trade, American Association of Wine Economists Working Paper #9, by Tyler Colman New York University & Pablo Päster Sustainable Solutions Group, URS Corporation, 20 pp., www.wine-economics.org/workingpapers/AAWE_WP09.pdf

Cell: F514
Comment: Rick Heede:
Pablo Paster replied to email from CMS, Dec07: Here are the emissions from production and transportation, per bottle, to Aspen:
France: 2804 g CO2e; Napa: 2492 g CO2e; Australia: 3086 g CO2e.

Cell: B532
Comment: Rick Heede:
Weber, Christopher L., & H. Scott Matthews (2008) "Food-Miles and the Relative Climate Impacts of Food Choices in the United States," Environmental Science & Technology, vol. 42:3508-3513, 6 pp. Used 22.1 kg CO2 per kg red meat, Weber Fig. 2 caption. Heede interpolated emission rates for each food category from their Figure 2 as a percent of their benchmark of red meat: 22.1 kg CO2 per kg.

Cell: D532
Comment: Rick Heede:
Weber, Christopher L., & H. Scott Matthews (2008) "Food-Miles and the Relative Climate Impacts of Food Choices in the United States," Environmental Science & Technology, vol. 42:3508-3513, 6 pp. Used 22.1 kg CO2 per kg red meat, Weber Fig. 2 caption. CMS inferred total supply chain emissions of chicken from Figure 2. Their estimates are based on a comprehensive input/output model of the U.S., and includes meat production, fertilizer inputs, transportation, processing, refrigeration, methane from eructation and manure, and N2O from fertilizer.

The milk emission rate is from Heede (2007).

Note: Weber and Matthews's emission factor for dairy products is approximately 4.18 kg CO2e per kg of milk, or, ~16.3 kg CO2e per gallon of milk, or roughly 8 times the CMS estimate.

Cell: B570
Comment: Rick Heede:
Cascio, Jamais (2006) Carbon footprint of a Cheese Burger, www.openthefuture.com/2006/12/the_footprint_of_a_cheeseburge.html

Camais' estimate is based on Univ Stockholm research -- which includes energy inputs to fertilizers, agriculture, pickle and cheese and beef production, and cooking the burger -- and he converts original energy inputs in MJ into fuel and emissions. At first he concludes 127 to 426 grams of carbon per served. But he updated this first estimate by adding cattle methane: "Dividing the methane total by the number of burgers, then, we get about 2.6 CO2-equivalent kilograms of additional greenhouse gas emissions from methane, per burger, or about 5-10 times more greenhouse gas produced from cow burps than from all of the energy used to raise, feed or produce all of the components of a completed cheeseburger!" His final number: "At 2.85-3.1 kg of CO2 (equiv) per burger, then, that's 428-465 kg of greenhouse gas per year for an average American's burger consumption." (@3 burgers per week, on average).

Carlsson-Kanyama, Annika, & Mireille Faist (2004?) Energy Use in the Food Sector: A data survey, Environmental Strategies Research Group, Dept of Systems Ecology, Stockholm University, 36 pp.

CMS note: This calculation needs to be verified from beginning to end. Prelim: the methane component sounds too high.

Cell: F600
Comment: Rick Heede:
CMS uses the EIA 1605b emission factor of 120.59 lb CO2 per Mcf for natural gas (applied to driveway heating and showers). This does not account for methane from natural gas systems; see Table 1 at top of worksheet for details. At STP this value equates to 117.08 lb CO2 per million Btu.

Cell: E612
Comment: Rick Heede:
CMS callled John Klein Property Management 4Dec08 970-948-7898 (ref from Reese at Aspen Snow Removal) regarding snowmelt systems duty cycles. Auto on for even trace snows, most systems kick on at 36 F (ie, nearly every night) for a 4-hr cycle, his Highlands system was on nearly 100 percent of last winter due to heavy snows. He suggested, when pressed, that 4 hours per day (17 percent) is a good but likely conservative starting assumption.
4 hr/day over 22-week winter (ski season plus 2 weeks) equals 4 hr/d * 154 days = 616 hours per winter.

Cell: E618
Comment: Rick Heede:
called Stephen Kanipe 429-2766
called Jeff Dickinson 963-0114

Cell: I631
Comment: Rick Heede:
REMP fee calculation, p. 3-20: Spa Example (Spa 100 sq. ft. year around use) (430000(BTU per sq. ft. per year) / .87 (efficiency rating of boiler))*100 (spa area)= 49,425,287 (BTU/yr) / 3412 (BTU per kWh)= 14,485.72 (kWh/yr)* 20 (years)* .07/kWh =$20,280 REMP fee will be $20,280

Cell: I637
Comment: Rick Heede:
Aspen inventory, 2004. Linked to conversion factors, cell C18.

Cell: C642
Comment: Rick Heede:
Pitkin Energy Code Guidelines, Chapter 3 (CMS, Feb08): 307.1.3 Snowmelt Energy Use (not a budget). Snowmelt energy use shall be the consumption of snowmelt system and equipment energy from depletable sources used for melting snow. Snowmelt energy use for dwelling units is 34,425BTU/yr/sq.ft. at 100% equipment efficiency. Snowmelt energy use shall be adjusted for efficiency of the boiler and shall be added to the subtotal source energy consumption calculated as per the requirements of Section 307.2.2.2.
Page 3-19: Snowmelt Example (Snowmelt requested 500 sq. ft.) (34,425(BTU per sq. ft. per year) / .87 (efficiency rating of boiler))*500 (snowmelt area)= 19,784,482 (BTU/yr) / 3412 (BTU per kWh)= 5798.5 (kWh/yr)* 20 (years)* .07/kWh =$8,117.90 REMP fee will be $8,117.90

Cell: F642
Comment: Rick Heede:
REMP fee calculation, p. 3-19: Pool Example (Pool year around outdoor use 600 sq. ft.) (332000(BTU per sq. ft. per year) / .87 (efficiency rating of boiler))*600 (pool area)= 228,965,520 (BTU/yr) / 3412 (BTU per kWh)= 67,105.95 (kWh/yr)* 20 (years)* .07/kWh =$93,948 REMP fee will be $93,948

Cell: I642

Comment: Rick Heede:
REMP fee calculation, p. 3-20: Pool Example (Pool summer use only 600 sq. ft.)(29000(BTU per sq. ft. per year) / .87 (efficiency rating of boiler))*600 (pool area)= 20,000,000 (BTU/yr) / 3412 (BTU per kWh)= 5861.66 (kWh/yr)* 20 (years)* .07/kWh =$8,206 REMP fee will be $8,206

Cell: K654
Comment: Rick Heede:
Reese, Aspen Snow Removal, 4Dec08: 30-40 driveways 18 gallon tank for 3-6 inch dump, larger storms >6 inches require larger loader using 40-50 gallons for 30-40 driveways. Light dumps: new bobcat skid loader. Larger dumps use bob cat wheel loaders 930G Caterpillar 60 gallons per 12 hr shift.

Cell: I696
Comment: Rick Heede:
CMS uses the EIA 1605b emission factor of 120.59 lb CO2 per Mcf for natural gas (applied to driveway heating and showers). This does not account for methane from natural gas systems; see Table 1 at top of worksheet for details. At STP this value equates to 117.08 lb CO2 per million Btu.

Cell: F817
Comment: Rick Heede:
EIA RECS 2005, Table HC1.2.2 Living Space Characteristics by Average Floorspace, shows total sf per housing unit “4,000 or more” as 5,740 sf. Also shows US average household of all 111.1 millin units as 2,033 sf, not 2,171 sf as above. Also from RECS 2005 somewhere).

Cell: G1015
Comment: Rick Heede:
EIA (2008) Emissions of Greenhouse Gases in the United States, 2007, Dec08, p. 1. Total 2007P CO2: 6,021.8 MtCO2, methane: 699.9 MtCO2e, Nitrous: 383.9 MtCO2e, High-GWP gases: 176.9 MtCO2e, Total 7,282.4 MtCO2e.

Cell: B1025
Comment: Rick Heede:
US Bureau of the Census: pop est for 2007: 301, 621,157

Cell: F1030
Comment: Rick Heede:
EIA website, climate data, per capita: Table H.1cco2 World Per Capita Carbon Dioxide Emissions from the Consumption and Flaring of Fossil Fuels, 1980-2005 (Metric Tons of Carbon Dioxide).

Cell: B1048
Comment: Rick Heede:
Monbiot, George (2007) Heat: how to stop the planet from burning, 304 pp.

Cell: K1063
Comment: Rick Heede:
CMS uses data from Global Commons Institute’s Contraction & Convergence model, downloaded Dec08, www.gci.org.uk. The scenarios are developed from actual emissions per region and per country, based on actual emissions of industrial CO2 emissions and converging toward equal per capita emissions in the year 2100 or so.

CMS pasted in per capita emissions for World, German, China, and the United States from 1990 to 2100, in kg carbon per capita per year.

Cell: K1064
Comment: Rick Heede:
While CMS uses shorthand to revise and update the GCI model for the US -- given that 2007 CO2 emissions were 120.6 lb CO2 per capita per day rather than the modeled 101 lb CO2 per cap/d -- by simply multiplying each subsequent GCI year by the 2007 differential factor of 1.19, this does not represent an internally consistent revision. It is not based on revised per capita assignment for the US, reviwed global CO2 emissions through 2007, or any other factor is the sophisticated GCI model. It is merely shorthand to get a slightly better answer than parroting the GCI result for the US for any year after 2008, such as 2020 or 2050.

Cell: D1188
Comment: Rick Heede:
2004 emissions from Aspen Inventory. Projection to 2050 based on the Canary Initiative (and City Council endorsed) target of reducing emissions by 30 percent or 2004 by 2020 and to 80 percent of 2004 by 2050. CMS (2007) Aspen Emissions Scenarios. Data imported from CMS files, indexed to 2004, peak assumed in 2008, and declining to targets in 2020 and 2050.

Cell: E1188
Comment: Rick Heede:
CMS developed several ways to estimate Aspen’s population pertinent to the emissions sources included in the inventory: resident population in City plus UGB (8,202), residents plus visitors of ~0.575 million visitor-days (Tomcich, personal communication 2005) equals 1,575 souls per day, on average totals 9,777 folks), and residents plus visitors plus workers and ski bums etc based on wastewater treatment plant effluent treated per day: 16.963 folks in town on the average day. CMS adopted the latter method in the inventory to estimate per capita emissions in 2004.

In 2008, CMS assumes a one percent perannum increase in total population (16,963), thus 19,890 in 2020 and 26,809 in 2050.

Cell: I1188
Comment: Rick Heede:
Aubrey Meyer of Global Commons Institute in London has recommended “Contraction and convergence” for years relying on a global agreement for equitabel distribution of per capita rigts to emit GHG. CMS: get current target, etc.

Meanwhile, Chancellor Angela Merkel has recommended a 2 metric tonne CO2 per capita target (CMS: Get specifics, includes all GHGs?, target year, etc.)

CMS here assumes a per capita target of 2,000 kg, or 4,409 lb CO2e and the target year as 2050. The percentage below is a measure of each year’s per capita emissions above that numeric target.

Cell: K1191
Comment: Rick Heede:
Heede (2006) Aspen GHG Inventory estimates that 96.94 percent of total emissions (total 840,875 tons CO2e) is CO2, and 3.06 percent (25,711 tons CO2e) is methane and nitrous oxide.

Cell: D1294
Comment: Rick Heede:
Waste, Recycling, and Climate Change Frank Ackerman, Director or the Research and Policy Division of GDAE, Tufts University, Medford MA, USA. See www.tufts.edu/tuftsrecycles/energy.htm

Abstract: Waste management has at least five types of impacts on climate change, attributable to (1) landfill methane emissions, (2) reduction in industrial energy use and emissions due to recycling and waste reduction, (3) energy recovery from waste, (4) carbon sequestration in forests due to decreased demand for virgin paper, and (5) energy used in long-distance transport of waste. A recent

U.S. EPA study provides estimates of overall per-ton greenhouse gas reductions due to recycling. Calculations using these estimates suggest that the U.S. could realize substantial greenhouse gas reductions through increased recycling, particularly of paper.

Cell: G1294
Comment: Rick Heede:
We allocate 50 percent of the savings from recycled materials to Aspen.

Cell: B1295
Comment: Rick Heede:
Fuel and electricity consumption in 2004 from Chris Hoofnagle, Solid Waste Manager, personal communication, 17Aug05. Tel. 923-3487, chrisho@co.pitkin.co.us.

Cell: B1299
Comment: Rick Heede:
Commingled recycled materials sold in 2004: 1,174.7 metric tonnes (2.590 million lb). Data from Hoofnagle, 17Aug05.

Chris Hoofnagle estimated commingled fractions as follows: “Ratios of the commingle pile are probably more like 65% glass, 18% steel, 8% plastic, and 4% aluminum; by weight.” (28Sep05)

Cell: B1300
Comment: Rick Heede:
Ackerman (see ref above) estimates savings for HDPE as 1.5 tonne CO2-eq saved per tonne recycled, LDPE as 2.0 tonne CO2-eq saved per tonne recycled, and PET as 2.5 tonne CO2-eq saved per tonne recycled. We average to 2.0 tonne CO2-eq saved per tonne recycled.

Cell: B1301
Comment: Rick Heede:
The aluminum recycling rate in Aspen is ~11.2 lb/cap-yr (76 tonnes/yr in commingled recyclables divided by Aspen’s population within the UGB of 8,993 = 5.1 kg/cap-yr). This compares favorably to Seattle (4.1 kg/cap-yr), Bergen County 6.8 kg/cap-yr) and the U.S. average (3.5 kg/cap-yr); 1996 data from EPA/Ackerman; www.tufts.edu/tuftsrecycles/energy.htm, Table 2.

Cell: B1302
Comment: Rick Heede:
Aspen’s glass recycling rate is low compared to Waiheke Island (off Auckland, NZ) whose 8,000 permanent residents recycle 100 tonnes per month vs Aspen’s 8,993 residents (residents within city limits plus within Aspen’s Urban Growth Boundary) who recycle 763 tonnes in 2004, 60 percent of which is attributed to Aspen UGB. Waiheke Island residents thus recycle 150 kg of glass per capita vs Aspen’s residents 51 kg per year.

Aspen’s glass recycling rate compares better to Seattle (25 kg/cap-yr), Bergen County (26 kg/cap-yr) and the U.S. average (11 kg/cap-yr); 1996 data from EPA/Ackerman; www.tufts.edu/tuftsrecycles/energy.htm, Table 2.

Cell: C1315
Comment: Rick Heede:
“How many aluminum beverage cans are in a pound? There are 34.21 cans per pound. In 1972 one pound of aluminum yielded 21.75 cans.”
Can Manufacurers Institute, www.cancentral.com

Cell: B1366
Comment: Rick Heede:
Delucchi (2003) Lifecycle emissions model (LEM), table 56 “Upstream fuel cycle emissions as a percentage of end use emissions, by pollutant amd feedstock/fuel combination,” shows 27 percent for conventional gasoline and 19 percent for diesel.

Since the gasoline/diesel output ratio is roughly 6.7 million bbl per week (gasoline) and 2.3 million bbl per week (diesel), CMS uses this blended average to estimate average fuel cycle emissions per gallon, i.e., (27 percent * 6.7 + 19 percent * 2.3) / (6.7 + 2.3) = (180.9 + 43.7) / 9.0 = 24.96 percent on average.
Cal gasoline and diesel refining data: www.energy.ca.gov/gasoline/quarterly/index.html

Delucchi (2003), page 95: “In Table H.6 of DeLuchi (1993), refineries consumed 0.145 BTUs of process energy to produce 1.0 BTU of conventional gasoline.” Note: gasoline requires much higher refinery energy inputs than does diesel fuel (0.039 to 0.072). Note: refinery inputs only, excluding production, pipeline, and distribution energy and emissions. Since this does not include other refinery emissions sources, CMS uses above emissions calculations instead.

Cell: B1427
Comment: Rick Heede:
Worldwatch (2008) Vital Signs.