

Carbon in Our Daily Lives

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Climate Mitigation Services
Snowmass, Colorado
7-Apr-09

Folio 1

Notes & to-do's:

Table 1

Elec CO2 factor (Aspen 2007)

Elec CO2 factor, US 2006

Table 2

Conversions

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	
110.0	lb CO2 per million Btu (Aspen)
1,214.8	lb CO2e per million Btu (Aspen)

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

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 bottles
1	HP =	0.746	kW

Table 3

Summary table of (partial) results: other calculations 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			
One Airbus A380		188	lb CO2 per mile			
One Cessna 182:	see box below	1.61	lb CO2 per mile	213		
One Hawker 900EX bizjet		15.1	lb CO2 per mile	7,830		
One Gulfstream IV bizjet		19.7	lb CO2 per mile	10,231		
Aspen ave personal vehicle (18.6 mpg)		1.02	lb CO2 per mile		61 (average)	0.77 lb CO2/mile at 60 mph
Snowmobile for an hour (excluding driving the infernal machine somewhere):		87	lb CO2/hr	520	87	Aspen Inventory
US household (single family)		26,028	lb/yr	71	3.0	0.05 Cool Citizens

Lovins: Make Fuel Efficiency Our Gulf Strategy, 1990

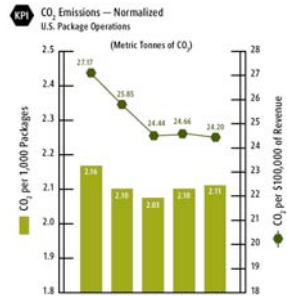
Aspen-specific estimates

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)		61	lb/hr	na	61.3	1.02		
All Aspen driving per day:	tons CO2/yr	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	lb CO2/yr	818,849	34,119	569	9.5	
All Aspen second homes	90,497	180,994,000	lb CO2/yr	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, elect)	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 Snc	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
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 c)	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
Desktop computer + CRT monitor (ofc)	1.354	603	816	2.24	0.09			AD Little 2002
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

	A	B	C	D	E	F	G	H	I	J	K	L	M
102													
103		Flying & Driving & Military											
104													
105													
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107		Private Aviation											
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121		Airbus A380											
122		One Airbus A380 188 lb CO2 per mile											
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126													
127													
128		Aircraft carrier fuel and emissions											
129													
130		One aircraft carrier: 8,086 lb CO2 per mile						Lovins "Make Fuel Efficiency Our Gulf Strategy" 1990					
131													
132													
133													
134													
135													
136		USS Independence, at 25 knots = 690.6 statute miles/day 5,654 lb CO2 per mile											
137		"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."											
138		"battleships ... consume 68 barrels per hour"											
139													
140		Midway & Independence	USS Independence	USS Independence	USS Kitty Hawk	USS Kitty Hawk	USS Kitty Hawk	unknown carrier					
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153		F-16 and F-18 fighter jets											
154													
155		Tom Shanker, Int Herald Tribune	When an F-16 lights up its afterburners, it consumes nearly 28 gallons of fuel per minute.										
156		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.										
157		Gar Smith	At peak thrust, F-15 fighters burn 25 gallons per minute.										
158		Gar Smith	A B-52 bomber gulps down 86 barrels per hour.										
159		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 (based										
160		www.f-16.net/f-16_forum_viewtopic-	F-16 on a "1.0 mission" uses abt 700-900 gallons of fuel										
161		www.f-16.net/f-16_forum_viewtopic-	F-16 1 hr mission: start with 12,000-12,300 lb and returns with ~3000-3500 lb, say uses ~										
162													
163													
164		See Gar Smith's article for data n Abrams tanks (~0.125 gpm)											
165													
166													
167													
168		www.mirage-jet.com/COMPAR_1/com	Mach 0.5 sea level	Mach 0.8 15,000 ft	Mach 1.4 36,000ft								
169			kg/min	kg/min	kg/min								
170													
171													
172													
173													
174													
175			lb/min	lb/min	lb/min								
176													
177													
178													
179													
180			lb CO2/hour	lb CO2/hour	lb CO2/hour								
181													
182													
183													
184													
185		F-15C sky flash	F-16	F-18 Hornet sky flash	F-18 afterburner on take-off								
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A	B	C	D	E	F	G	H	I	J	K	L	M
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197												
198		Private & Commercial Aviation compared: travel to Aspen								Folio 3		
199		example of one 1,000-mile trip, one way										
200									lb CO2/pax-mile	Flight distance		
201		First leg to DEN	2nd leg, DEN-ASE	First leg to DEN	2nd leg, DEN-ASE	trip emissions/pax	Short flight	0.720	0-120 miles			
202		miles	miles	lb CO2	lb CO2	lb CO2	Medium flight	0.560	121-800 miles			
203	Commercial air travel	880	120	370	86	456	Long flight	0.420	801-2500 miles			
204		same, using GEO r		343	77	420	Extended flight	0.360	2501-25000 miles			
205		same, using GEO & CMS data on ASE		343	117	460						
206												
207	Private aviation	Fuel rate	Fuel rate	Fuel consumption	Emissions	trip emissions/pax	Adopted by GEO	lb CO2/pax-mile	Flight distance			CMS recommendation
208	Hawker 400XP	gallons/nm	gallons/stat mile	gallons 1000 miles	lb CO2 1000 miles	assumes 4 pax	Short flight	0.640	0-250 miles	0.720		CMS
209		0.46	0.40	402	8,399	2,100	Medium flight	0.450	251-800 miles	0.520		Dec-08
210							Long flight	0.390	801-2500 miles	0.360		
211							Extended flight	0.390	2501-25000 miles	0.290		
212		Private / commercial air travel multiplier					5.00					
213												
214												
215		Driving										
216		gallons/hr	miles per hour	miles per gallon	lb CO2/hr	lb CO2 per mile						
217												
218												
219	Hummer H2	5.61	60	10.7	110	1.83						
220												
221	Average Aspen personal vehicle	3.13	60	19.15	61	1.02						
222												
223	Average commuting vehicle, Hershey I	2.63	60	22.8	52	0.86						
224												
225	Toyota Prius	1.47	60	40.8	29	0.48						
226												
227	Drive Aspen to Glenwood rt (miles, no	4.18	80	19.2	82	1.02						
228			miles, not mpg									
229	RFTA bus	7.60	40	5.3	164	4.09						
230					21.5	lb CO2/gallon B5 fuel						
231												
232												
233												
234												
235												
236												
237												
238		Driving and flying compared										
239	Driving:	mpg	distance (miles)	Fuel	lb CO2							
240	Aspen to Glenwood and back	18.63	80.00	4.29	84							
241												
242		MPG	Miles ASE-DEN	ASE-DEN-ASE	Gallons/vehicle	CO2/vehicle	Lb CO2, driver	Lb CO2, driver + pax				
243	Aspen to DIA and back	18.63	typical Aspen veh.	200	400	21.47	420	420	210			
244												
245												
246		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			
247	Flying ASE-DEN-ASE (13 CMS flights)	0.974	CRJ-700 & Dash-8	131	262	7.40	14.80	127.63	255			
248	(Pasted in case of lost link):	0.974		131		7.40						
249												
250												
251		CMS field rsrch on fuel per pax-mile ASE-DEN										
252		0.974 lb CO2/pax-mile										
253												
254												
255												
256												
257												
258		Aspen traffic congestion on a bad day										
259		# of vehicles	MPG	Gallons per hour	Dwell time minutes	Total Gal per hr	Total lb CO2/hr	Lb CO2/vehicle				
260	One hour of sitting in traffic jam	700	lite vehicles 4-5 p	18.63	0.80	15	140	3.91				
261	each vehicle stop & go for 15 minutes	240	medium trucks, var	14.00	1.00	15	60	5.24				
262		60	heavy trucks, buse	6.00	1.20	15	18	6.72				
263		1,000					218	4,400	4.40			
264		may be conservative										
265												
266												
267												
268												
269												
270												
271		One UPS package delivery										
272		2.11 tonnes CO2 per 1,000 packages										
273		means 2.11 kg CO2 per package, or 4.65 lb CO2 per package										
274												
275		water consumption (vehicle wash)	6.18	million cubic meter	1,633	million gallons						
276			264.17	gallons/m ³								
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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.

	A	B	C	D	E	F	G	H	I	J	K	L	M
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290 **Skiing & recreation** Folio 4

Skiing for a day at Aspen

Compare Heli-skiing

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

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

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

Aspen Skiing Company CO₂ Emissions 1999-2005



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
lb per hr	liters per hr	gallons per hr	lb CO2 per hr	lb CO2 per day	lb CO2/pax (40)
625	380	100.4	2,096	16,768	419.2
gallons per day:		803			

Canadian Mountain Holidays (Monashees, Revelstoke, Gothics, etc)
Bell 212 helicopter
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

One day at a local athletic club (preliminary)
Large Red Mtn home

Basic data	
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	
\$ 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 (KM electricity (HCE)	Natural gas		Electricity		Gas + Elec		Visitors, 2007 estimated	lb CO2/visitor	lb CO2/million btu
	CCF	lb CO2-e/ccf	kwh	lb CO2/kWh (HCE)	Tons CO2e	Tons CO2e			
		11,392		1,731			16,406		1,214.8
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

	A	B	C	D	E	F	G	H	I	J	K	L	M
383													
384		Libations & Vittles											
385													
386													
387													
388		Aspen city water					Seawater desalination, reverse osmosis						
389													
390			tons CO2/gallon	lb CO2/1000 glns									
391		Water supply	0.0000063	1.26									
392		Wastewater treatment		11.62									
393		Total emissions per 1,000 gallons		12.88									
394		Emissions per gallon		0.01288	lb CO2/gallon								
395		Emissions per liter		0.00340	lb CO2/liter								
396			assumes that water is from Aspen Water Plant (data from ASC Sust Rpt),										
397			that water used is also flushed and treated by Aspen Sanitation,										
398			excludes emissions from pumping water up, say, Red Mtn.										
399													
400													
401													
402		Bottled water: Fiji Water, 1 liter											
403													
404		One bottle (1 liter) of Fiji Water											
405		Fiji water bottle (one liter) Fiji to Aspen											
406		Manufac. PET bottle (1 liter), 25 g	93.00	grams CO2									
407		Shipping blanks from China	4.30	grams CO2									
408		Shipping filled bottles to San Francisco	153.00	grams CO2									
409		Bottled water: 1 liter Fiji, del. San Fran	250.30	grams CO2		0.5518	lb CO2						
410													
411		Trucking one liter Fiji from SF to Aspe	191.22	grams CO2		0.4216	lb CO2						
412													
413		Total manuf., shipping 1 Fiji to Aspen	441.52	g CO2/liter Fiji		0.9734	lb CO2						
414													
415													
416													
417													
418		Comparative cargo emissions											
419		Container ship	52.1	g CO2e/tkm	CE Delft								
420		Refrigerated ship	67.1	g CO2e/tkm	CE Delft								
421		Train	200.0	g CO2e/tkm	WRI GHG Protocol								
422		Trucking emissions rate (Pablo)	252.0	g CO2e/tkm	WRI GHG Protocol								
423		Airplane	570.0	g CO2e/tkm	CE Delft								
424			www.onlineconversion.com/drivingdistance.htm										
425		Trucking distance SF to Denver	2,032	km									
426		Trucking distance Denver to Aspen	320	km									
427		Sum SF to Aspen	2,352	km									
428													
429													
430		One metric tonne of water trucked SF	592,704	g CO2e									
431			593	kg CO2e									
432		Thus, 1 liter trucked SF to Aspen	0.593	kg CO2e									
433		Thus, 1 liter trucked SF to Aspen	1.307	lb CO2e									
434													
435													
436													
437													
438		CMS re-calculation of trucking emissions, 15Jan08											
439		Trucking emissions rate (CMS)	81.3	g CO2 per tonne-km									
440													
441		One metric tonne of water trucked SF	191,218	g CO2e									
442		Thus, 1 liter trucked SF to Aspen	0.191	kg CO2e									
443		Thus, 1 liter trucked SF to Aspen	0.422	lb CO2e									
444													
445													
446													
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450													
451													
452		Cup of Joe: Starbucks Coffee					(Forbes article)						
453		One cup of coffee	40,000	cups at San Mateo Starbucks, one month									
454			4,900	lb carbon (store utils only)									
455			0.123	lb carbon per cup									
456			0.449	lb CO2 per cup									
457													
458													
459													
460			gallons/yr										
461		John Ryan: 2 cups per day	34	100	beans/cup	6,000	beans/tree						
462		700 cups per year	34	70,000	beans/yr	11.7	trees/yr						
463													
464		Starbucks CSR 2006	133	million kg coffee									
465			6.57	kWh per sf of retail space per month									
466			0.059	therms/sf-month									
467			12,440	worldwide stores									
468				average sf per store (NA)									
469			40,000	cups per month (San Mateo store only)									
470		Starbucks CSR 2006	Global coffee production 2005/06: 7 billion kg, of which St bought 133 million kg (p7),										
471			2003 inventory: electricity 81%, coffee roasting and natural gas 18%, company-owned vehicles and aircraft 1% (p. 16).										
472													
473													
474													

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

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.

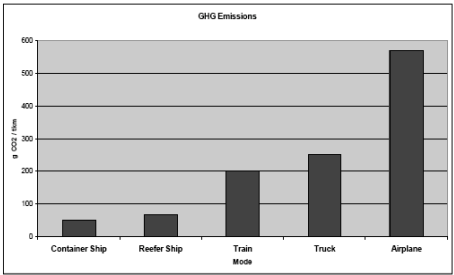
Bottled water: Fiji Water, 1 liter

One bottle (1 liter) of Fiji Water

Fiji water bottle (one liter) Fiji to Aspen			
Manufac. PET bottle (1 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 Fran	250.30	grams CO2	0.5518 lb CO2 Pablo Paster
Trucking one liter Fiji from SF to Aspe	191.22	grams CO2	0.4216 lb CO2
Total manuf., shipping 1 Fiji to Aspen	441.52	g CO2/liter Fiji	0.9734 lb CO2



Figure 1. Comparative cargo emissions



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

	MJ/ton-km	mt CO2e/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.





One bottle of 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, refrigerat	1.0632	lb CO2/gallon	
	0.0997	lb CO2/bottle (12 oz)	

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, Raw materials		853	Brewing ops (gas) Corp	123	Distribution	
Climate Consultancy (2008) The Carbon Footprint of Fat Tire Amber Ale for New Belgium Brewery		678	Waste disposal	46	Retail	897	
				4	Use	262	
					Waste	50	
Per six-pack (grams CO2e)		1,531.3		172.9		1,485	3,189
Percent of total		48.0%		5.4%		46.6%	100.0%
Per bottle (grams CO2e)		255		29		247	531
Per six-pack (lb CO2e)		3.38		0.38		3.27	7.03
Per bottle (lb CO2e)		0.56		0.06		0.55	1.172

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 lb CO2/glass
	kg CO2 / 750 mL	lb CO2/bottle	kg CO2 / 750 mL	lb CO2/bottle	
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

See also: Fiala, Nathan (2009) "The Greenhouse Burger," *Scientific American*, Feb, pp. 72-75:

beef 14.8 lb CO2e/lb, pork 3.8 lb CO2e, chicken 1.1 lb CO2e/lb, potatoes 0.26 lb CO2e/lb, apples 0.3 lb CO2e/lb, asparagus 0.4 lb CO2e/lb

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"

	Emissions per year tons CO2e/yr	Emissions per day lb CO2e/d	Emissions per meal 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 Store	not estimated		
Driving 2 miles RT to pick up milk	955	2.105	32.80%
Total milk supply chain		2,911	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)



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Cheeseburger cheeseburger		
final estimate (with methane)		
low	high	unit
2.85	3.10	kg CO2e/burger
6.28	6.83	lb CO2e/burger
6.56 lb CO2e 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_cheeseburger.html

One banana	
energy CO2, methane, and nitrous oxide (?)	

Folio 7

MIT estimate		Dole Food Company estimate	
segment	g CO2e/banana	segment	g CO2e/kg banana / g CO2e/banana
growing the banan:	15	Farming & packin	228.7
electricity & ripenir	2	Transport to port	16.4
packaging	20	Operations & Log	39.4
ship & truck transp	43	Ocean shipping to	97.8
disposal	18	Disposal	ne
Total	98	Total	382.3
Total (in US lb)	0.2161	Total (in US lb)	0.8428

Carbon Footprint Estimate 2007, Bananas Grams of CO2e

Concept	To Freeport	To San Diego
Farming and Packing	228.7	228.7
Transportation to Port of Export	16.4	16.4
Operations and Logistics	39.4	39.4
Ocean Shipping to US: Port	97.8	167.8
Total Per Kg. of Bananas	382.3	452.4
Total Per Banana	63.7	75.4

Residential calculations

Heated driveway	
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

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

766															
767		Pond circulating pump										Folio 9			
768															
769		1.354 lb CO2 per delivered kWh, 2006				see cell E17		1 HP		0.746 kW					
770		1.731 lb CO2e, HCE (2007, est.)													
771															
772		Typical large pond system specs													
773		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					
774		25	550	7.50	5.60	8,760	49,012	\$ 4,411	84,863	42.43					
775															
776		If system runs half the year													
777		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					
778		33,000	9.17	1.2254	76.50	4,380	24,506	\$ 2,206	42,431	21.22					
779		Water conversions													
780		1 gallon =		0.1337	cubic feet										
781		1 gallon =		8.3453	lb H2O	144,540,000	19,322,188	1,206,229,662	603,115						
782		1 CF =		7.4805	gallons										
783		1 CF =		62.43	lb H2O										

Aspen: Primary & Second Homes: emissions per occupied day
 Heede, 2007, Anybody Home? Aspen Second Homes Energy Study, Sopris Fdn.

Table 9	Primary		Second		Factor of Second/Primary	
	Emissions per occ. day		Emissions per occ. day		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

Daily Carbon

	A	B	C	D	E	F	G	H	I	J	K	L	M
861													
862		Climate Zone¹									Folio 10		
863		Less than 2,000 CDD and--											
864		Greater than 7,000 HDD.....	10.9	106	602	1,317	9,721	131,770,791		12.1	24,178	66.2	2.8
865		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
866		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
867		Fewer than 4,000 HDD.....	24.0	262	789	Q	10,932	233,666,503		9.7	19,472	53.3	2.2
868		2000 CDD or More and--											
869		Less than 4,000 HDD.....	22.8	357	383	Q	15,632	268,562,230		11.8	23,558	64.5	2.7
870													
871		Type of Housing Unit											
872		Single-Family Detached.....	72.1	951	3,376	4,622	13,204	929,603,856		12.9	25,787	70.6	2.9
873		Single-Family Attached.....	7.6	70	403	Q	9,263	71,681,640		9.4	18,864	51.7	2.2
874		Apartments in 2-4 Unit Buildings.....	7.8	59	365	545	7,579	68,044,246		8.7	17,447	47.8	2.0
875		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
876		Mobile Homes.....	6.9	85	118	114	12,214	71,394,275		10.3	20,694	56.7	2.4
877													
878		Ownership of Housing Unit											
879		Owned.....	78.1	996	3,541	4,753	12,749	974,424,421		12.5	24,953	68.4	2.8
880		Single-Family Detached.....	64.1	855	3,038	4,222	13,355	837,419,940		13.1	26,129	71.6	3.0
881		Single-Family Attached.....	4.2	38	238	Q	9,209	40,072,306		9.5	19,082	52.3	2.2
882		Apartments in 2-4 Unit Buildings.....	1.8	14	122	187	7,658	18,925,507		10.5	21,028	57.6	2.4
883		Apartments in 5 or More Unit Buildings.....	2.3	17	50	Q	7,381	14,521,919		6.3	12,628	34.6	1.4
884		Mobile Homes.....	5.7	71	94	73	12,340	59,237,149		10.4	20,785	56.9	2.4
885		Rented.....	33.0	290	1,091	1,483	8,781	282,675,767		8.6	17,132	46.9	2.0
886		Single-Family Detached.....	8.0	96	338	401	11,997	92,098,191		11.5	23,025	63.1	2.6
887		Single-Family Attached.....	3.4	32	166	Q	9,328	31,669,631		9.3	18,629	51.0	2.1
888		Apartments in 2-4 Unit Buildings.....	5.9	45	244	358	7,555	49,179,036		8.3	16,671	45.7	1.9
889		Apartments in 5 or More Unit Buildings.....	14.4	103	319	655	7,137	97,114,613		6.7	13,488	37.0	1.5
890		Mobile Homes.....	1.2	14	24	Q	11,608	11,601,338		9.7	19,336	53.0	2.2
891													
892		Year of Construction											
893		Before 1940.....	14.7	135	876	2,146	9,176	173,543,673		11.8	23,611	64.7	2.7
894		1940 to 1949.....	7.4	63	389	709	8,546	76,884,927		10.4	20,780	56.9	2.4
895		1950 to 1959.....	12.5	121	614	1,046	9,663	132,855,724		10.6	21,257	58.2	2.4
896		1960 to 1969.....	12.5	133	580	760	10,671	135,784,396		10.9	21,726	59.5	2.5
897		1970 to 1979.....	18.9	216	624	778	11,445	198,085,382		10.5	20,961	57.4	2.4
898		1980 to 1989.....	18.6	234	576	364	12,602	203,197,101		10.9	21,849	59.9	2.5
899		1990 to 1999.....	17.3	253	638	304	14,565	220,877,592		12.8	25,535	70.0	2.9
900		2000 to 2005.....	9.2	131	334	128	14,179	115,659,914		12.6	25,143	68.9	2.9
901													
902		Total Floorspace (Square Feet)											
903		Fewer than 500.....	3.1	18	85	Q	5,915	17,803,275		5.7	11,486	31.5	1.3
904		500 to 999.....	22.2	174	542	968	7,850	165,290,114		7.4	14,891	40.8	1.7
905		1,000 to 1,499.....	19.1	196	687	520	10,290	185,763,460		9.7	19,452	53.3	2.2
906		1,500 to 1,999.....	14.4	171	613	426	11,897	162,900,967		11.3	22,625	62.0	2.6
907		2,000 to 2,499.....	12.8	161	551	646	12,623	153,423,084		12.0	23,972	65.7	2.7
908		2,500 to 2,999.....	10.1	124	502	714	12,302	125,735,011		12.4	24,898	68.2	2.8
909		3,000 to 3,499.....	8.2	105	388	683	12,869	105,571,041		12.9	25,749	70.5	2.9
910		3,500 to 3,999.....	5.7	77	311	698	13,467	80,705,298		14.2	28,318	77.6	3.2
911		4,000 or More.....	15.7	259	953	1,477	16,489	257,782,666		16.4	32,839	90.0	3.7
912													
913		Household Size											
914		1 Person.....	30.0	229	1,022	1,480	7,625	240,439,263		8.0	16,029	43.9	1.8
915		2 Persons.....	34.8	411	1,393	2,153	11,810	401,154,212		11.5	23,055	63.2	2.6
916		3 Persons.....	18.4	243	793	1,222	13,229	231,758,898		12.6	25,191	69.0	2.9
917		4 Persons.....	15.9	221	754	823	13,920	209,993,183		13.2	26,414	72.4	3.0
918		5 Persons.....	7.9	119	416	417	15,031	112,643,829		14.3	28,517	78.1	3.3
919		6 or More Persons.....	4.1	62	252	143	15,289	59,997,449		14.6	29,267	80.2	3.3
920													
921		2005 Household Income Category											
922		Less than \$10,000.....	9.9	79	337	503	8,015	81,824,413		8.3	16,530	45.3	1.9
923		\$10,000 to \$14,999.....	8.5	73	274	580	8,659	74,831,886		8.8	17,608	48.2	2.0
924		\$15,000 to \$19,999.....	8.4	81	275	532	9,632	79,612,346		9.5	18,955	51.9	2.2
925		\$20,000 to \$29,999.....	15.1	151	615	598	10,006	149,614,899		9.9	19,817	54.3	2.3
926		\$30,000 to \$39,999.....	13.6	156	484	679	11,425	146,583,489		10.8	21,556	59.1	2.5
927		\$40,000 to \$49,999.....	11.0	130	457	603	11,810	126,106,733		11.5	22,928	62.8	2.6
928		\$50,000 to \$74,999.....	19.8	247	831	987	12,451	235,673,214		11.9	23,805	65.2	2.7
929		\$75,000 to \$99,999.....	10.6	146	508	923	13,759	143,580,831		13.5	27,091	74.2	3.1
930		\$100,000 or More.....	14.2	222	851	832	15,700	217,829,448		15.3	30,680	84.1	3.5
931													
932		Income Relative to Poverty Line											
933		Below 100 Percent.....	16.6	152	593	906	9,127	153,773,679		9.3	18,527	50.8	2.1
934		100 to 150 Percent.....	12.9	135	450	586	10,451	128,487,354		10.0	19,921	54.6	2.3
935		Above 150 Percent.....	81.5	999	3,588	4,745	12,247	974,977,549		12.0	23,926	65.6	2.7
936													
937		Eligible for Federal Assistance²											
938		Yes.....	38.6	375	1,430	2,262	9,722	375,808,689		9.7	19,472	53.3	2.2
939		No.....	72.5	910	3,201	3,975	12,554	880,759,340		12.1	24,297	66.6	2.8
940													
941		Payment Method for Utilities											
942		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
943		Some Paid, Some in Rent.....	4.7	34	166	345	7,373	36,884,646		7.8	15,696	43.0	1.8
944		All Included in Rent.....	7.6	51	283	737	6,760	61,233,619		8.1	16,114	44.1	1.8
945		Other Method.....	1.3	17	49	Q	13,185	14,461,622		11.1	22,249	61.0	2.5
946													
947		Ethnic Origin of Householder											
948		Hispanic Descent.....	14.8	144	533	765	9,735	141,434,034		9.6	19,113	52.4	2.2
949		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
950													
951		Race of Householder³											
952		White.....	79.1	953	3,307	4,842	12,041	930,351,478		11.8	23,523	64.4	2.7
953		Hispanic.....	5.0	50	152	175	9,869	46,665,707		9.3	18,666	51.1	2.1
954		Non-Hispanic.....	74.1	903	3,155	4,667	12,189	883,692,105		11.9	23,851	65.3	

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 (CD)	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>

Rank & Nation	CO2 per capita tonnes C/yr	CO2 per capita lb CO2/yr	CO2 per capita lb CO2/day
1 Qatar	21.63	174,729	479
2 Kuwait	10.13	81,831	224
3 UAE	9.32	75,288	206
4 Aruba	8.25	66,644	183
5 Luxembourg	6.81	55,012	151
6 Trinidad & Tobago	6.80	54,931	150
7 Brunei	6.56	52,992	145
8 Bahrain	6.53	52,750	145
9 USA	5.61	45,318	124
10 Canada	5.46	44,106	121
11 Norway	5.22	42,168	116
13 Australia	4.41	35,624	98
18 Saudi Arabia	3.71	29,970	82
28 Russian Federation	2.89	23,346	64
33 Japan	2.69	21,730	60
36 Germany	2.67	21,568	59
52 Spain	2.08	16,802	46
85 Romania	1.14	9,209	25
92 China, PRC	1.05	8,482	23
## India	0.34	2,747	8
## Albania	0.32	2,585	7
## Bhutan	0.05	404	1
## Afghanistan	0.01	81	0

United Nations Statistics Division

Greenhouse Gas Emissions (industrial CO2, methane, and N2O)

http://unstats.un.org/unsd/environment/air_greenhouse_emissions.htm

	CO2e per capita tonnes CO2e/yr	CO2e per capita lb CO2e/yr	CO2e per capita lb CO2e/day
Qatar	na		
Kuwait	na		
UAE	na		
Aruba	na		
Luxembourg	27.71	61,089	167
Trinidad & Tobago	13.49	29,740	81
Brunei	na		
Bahrain	34.34	75,706	207
USA	23.92	52,734	144
2004 Canada	23.72	52,293	143
2004 Norway	11.95	26,345	72
2004 Australia	26.54	58,510	160
Saudi Arabia	na		
Russian Federation	na		
Japan	10.59	23,347	64
Germany	12.28	27,072	74
Spain	10.03	22,112	61
Romania	7.10	15,653	43
China, PRC	3.36	7,407	20
India	1.33	2,932	8
Albania	1.72	3,792	10
Bhutan	0.72	1,587	4
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

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

2050 CO2 emissions per capita per day

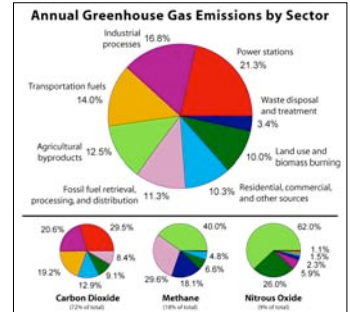
If applied to each region or country: Monbiot & GCI

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

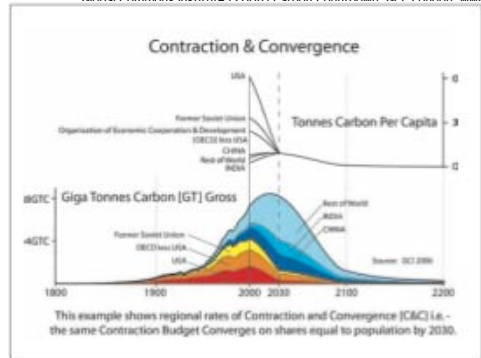
GCI: Contraction and Convergence	World by 2050	397	kg C/capita-yr
Global Commons Institute, London		1,456	kg CO2/cap-yr
		3,211	lb CO2/cap-yr
		8.80	lb CO2/cap-day
			kg carbon/yr
			lb CO2/day
	Germany by 2050	382	8.45
	USA by 2050	374	8.29
	China by 2050	394	8.72

Unadjusted to actual 2007 data (see cell ~K1124)

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



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



Daily Carbon

	A	B	C	D	E	F	G	H	I	J	K	L	M
1062													
1063													
1064													Folio 12
1065		World & selected country per capita emissions of industrial, from Global Commons Institute Contraction & Convergence model											
1066		Global Commons Institute, London, A campaign for Contraction & Convergence. www.gci.org.uk/ CMS revision to 2007 actual											
1067			World CO2	World per capita	China per capita	Germany per cap	US per capita	US per capita	US per capita	US per capita			
1068		World	tonnes carbon	kg carbon	kg carbon	kg carbon	kg carbon/yr	kg CO2/yr	lb CO2/yr	lb CO2/day			
1069													
1070		1990		1,379	592	3,440	5,177	18,969	41,819	115			
1071		1991		1,372	612	3,110	5,111	18,726	41,284	113			
1072		1992		1,328	633	3,002	5,057	18,530	40,852	112			
1073		1993		1,307	657	2,924	5,289	19,379	42,724	117			
1074		1994		1,315	688	2,893	5,322	19,501	42,991	118			
1075		1995	0.02913	1,320	733	2,830	5,263	19,286	42,517	116			
1076		1996		1,326	756	2,919	5,289	19,381	42,727	117			
1077		1997	0.20466	1,324	735	2,816	5,421	19,862	43,788	120			
1078		1998		1,302	687	2,773	5,384	19,728	43,492	119			
1079		1999		1,257	615	2,650	5,337	19,555	43,110	118			
1080		2000	6,594,400,000	1,257	613	2,637	5,389	19,746	43,532	119			
1081		2001	6,686,594,753	1,258	624	2,636	5,317	19,482	42,951	118			
1082		2002	6,765,685,136	1,253	636	2,617	5,214	19,106	42,120	115			
1083		2003	6,832,172,600	1,246	644	2,594	5,102	18,693	41,211	113			
1084		2004	6,886,550,950	1,237	652	2,564	4,980	18,249	40,232	110			
1085		2005	6,929,306,344	1,226	658	2,530	4,852	17,778	39,194	107			
1086		2006	6,960,917,293	1,215	664	2,492	4,718	17,288	38,113	104	US CO2 2007		
1087		2007	6,981,854,663	1,202	668	2,449	4,579	16,778	36,988	101	120.6	1.1900	
1088		2008	6,992,581,871	1,187	672	2,403	4,435	16,251	35,828	98	116.8	1.1900	
1089		2009	6,993,553,889	1,172	674	2,353	4,288	15,712	34,639	95	112.9	1.1900	
1090		2010	6,985,219,242	1,155	676	2,300	4,138	15,163	33,428	92	109.0	1.1900	
1091		2011	6,968,018,009	1,138	676	2,246	3,987	14,610	32,209	88	105.0	1.1900	
1092		2012	6,942,382,821	1,120	677	2,188	3,835	14,052	30,980	85	101.0	1.1900	
1093		2013	6,908,738,663	1,102	675	2,129	3,683	13,492	29,743	81	97.0	1.1900	
1094		2014	6,867,502,874	1,082	674	2,068	3,529	12,930	28,505	78	92.9	1.1900	
1095		2015	6,819,085,146	1,059	672	1,998	3,365	12,329	27,181	74	88.6	1.1900	
1096		2016	6,763,887,524	1,042	670	1,941	3,222	11,808	26,031	71	84.9	1.1900	
1097		2017	6,702,304,407	1,022	667	1,876	3,070	11,251	24,803	68	80.9	1.1900	
1098		2018	6,634,722,546	1,001	664	1,810	2,920	10,700	23,590	65	76.9	1.1900	
1099		2019	6,561,521,048	980	660	1,744	2,772	10,158	22,394	61	73.0	1.1900	
1100		2020	6,483,071,371	959	656	1,677	2,627	9,625	21,218	58	69.2	1.1900	
1101		2021	6,399,737,328	938	651	1,612	2,486	9,109	20,082	55	65.5	1.1900	
1102		2022	6,311,875,083	917	647	1,546	2,348	8,603	18,967	52	61.8	1.1900	
1103		2023	6,219,833,156	896	641	1,481	2,213	8,109	17,877	49	58.3	1.1900	
1104		2024	6,123,952,420	874	635	1,416	2,081	7,626	16,812	46	54.8	1.1900	
1105		2025	6,024,566,100	851	629	1,349	1,949	7,143	15,748	43	51.3	1.1900	
1106		2026	5,921,999,775	832	623	1,286	1,829	6,701	14,772	40	48.2	1.1900	
1107		2027	5,816,571,377	811	616	1,221	1,708	6,259	13,798	38	45.0	1.1900	
1108		2028	5,708,591,194	790	610	1,158	1,591	5,831	12,854	35	41.9	1.1900	
1109		2029	5,598,361,863	769	603	1,095	1,478	5,416	11,941	33	38.9	1.1900	
1110		2030	5,486,178,379	749	596	1,034	1,369	5,016	11,059	30	36.1	1.1900	
1111		2031	5,372,328,086	729	588	975	1,265	4,634	10,217	28	33.3	1.1900	
1112		2032	5,257,090,684	709	581	917	1,164	4,266	9,405	26	30.7	1.1900	
1113		2033	5,140,738,226	689	573	861	1,068	3,912	8,625	24	28.1	1.1900	
1114		2034	5,023,535,119	669	565	806	975	3,573	7,877	22	25.7	1.1900	
1115		2035	4,905,738,121	649	556	753	886	3,248	7,159	20	23.3	1.1900	
1116		2036	4,787,596,347	630	548	702	802	2,939	6,479	18	21.1	1.1900	
1117		2037	4,669,351,262	612	539	652	721	2,644	5,828	16	19.0	1.1900	
1118		2038	4,551,236,685	593	530	604	645	2,362	5,208	14	17.0	1.1900	
1119		2039	4,433,478,792	575	521	557	572	2,094	4,617	13	15.1	1.1900	
1120		2040	4,316,296,106	557	512	512	502	1,839	4,055	11	13.2	1.1900	
1121		2041	4,199,899,510	539	498	498	488	1,790	3,946	11	12.9	1.1900	
1122		2042	4,084,492,236	522	485	485	475	1,741	3,837	11	12.5	1.1900	
1123		2043	3,970,269,870	505	471	471	462	1,692	3,730	10	12.2	1.1900	
1124		2044	3,857,420,353	489	458	458	449	1,644	3,624	10	11.8	1.1900	
1125		2045	3,746,123,979	473	445	444	436	1,596	3,520	10	11.5	1.1900	
1126		2046	3,636,553,393	457	431	431	423	1,550	3,417	9	11.1	1.1900	
1127		2047	3,528,873,597	442	419	419	410	1,504	3,315	9	10.8	1.1900	
1128		2048	3,423,241,944	427	406	406	398	1,459	3,216	9	10.5	1.1900	
1129		2049	3,319,808,141	413	394	394	386	1,415	3,119	9	10.2	1.1900	
1130		2050	3,218,714,248	397	382	382	374	1,372	3,024	8.29	9.9	1.1900	
1131		2051	3,120,094,679	385	370	370	363	1,330	2,931	8	9.6	1.1900	
1132		2052	3,024,076,202	373	359	359	352	1,289	2,841	8	9.3	1.1900	
1133		2053	2,930,777,936	361	348	348	341	1,249	2,754	8	9.0	1.1900	
1134		2054	2,840,311,356	349	337	337	330	1,210	2,669	7	8.7	1.1900	
1135		2055	2,752,780,290	338	327	327	320	1,173	2,586	7	8.4	1.1900	
1136		2056	2,668,280,917	327	317	317	310	1,137	2,507	7	8.2	1.1900	
1137		2057	2,586,901,772	316	307	307	301	1,102	2,430	7	7.9	1.1900	
1138		2058	2,508,723,742	306	298	298	292	1,069	2,357	6	7.7	1.1900	
1139		2059	2,433,820,069	296	289	289	283	1,037	2,287	6	7.5	1.1900	
1140		2060	2,362,256,346	287	280	280	275	1,007	2,219	6	7.2	1.1900	
1141		2061	2,294,090,521	278	272	272	267	978	2,155	6	7.0	1.1900	
1142		2062	2,229,372,895	269	265	265	259	950	2,095	6	6.8	1.1900	
1143		2063	2,168,146,123	261	257	257	252	924	2,037	6	6.6	1.1900	
1144		2064	2,110,445,212	253	250	250	245	899	1,983	5	6.5	1.1900	
1145		2065	2,056,297,524	245	244	244	239	876	1,932	5	6.3	1.1900	
1146		2066	2,005,722,772	238	238	238	233	855	1,884	5	6.1	1.1900	
1147		2067	1,958,733,026	231	232	232	228	835	1,840	5	6.0	1.190	

Daily Carbon

	A	B	C	D	E	F	G	H	I	J	K	L	M
1165		2085	1,544,189,913	173	183	183	180	658	1,451	4	4.7	1.900	
1166		2086	1,529,306,114	171	181	181	178	652	1,437	4	4.7	1.900	
1167		2087	1,514,719,992	169	180	180	176	646	1,423	4	4.6	1.900	
1168		2088	1,500,425,592	168	178	178	175	639	1,410	4	4.6	1.900	
1169		2089	1,486,417,080	166	176	176	173	633	1,397	4	4.6	1.900	
1170		2090	1,472,688,739	165	175	175	171	628	1,384	4	4.5	1.900	
1171		2091	1,459,234,964	163	173	173	170	622	1,371	4	4.5	1.900	
1172		2092	1,446,050,265	162	172	172	168	616	1,359	4	4.4	1.900	
1173		2093	1,433,129,259	160	170	170	167	611	1,346	4	4.4	1.900	
1174		2094	1,420,466,674	159	169	169	165	605	1,335	4	4.4	1.900	
1175		2095	1,408,057,341	158	167	167	164	600	1,323	4	4.3	1.900	
1176		2096	1,395,896,194	156	166	166	162	595	1,311	4	4.3	1.900	
1177		2097	1,383,978,270	155	164	164	161	590	1,300	4	4.2	1.900	
1178		2098	1,372,298,705	154	163	163	160	585	1,289	4	4.2	1.900	
1179		2099	1,360,852,730	152	161	161	158	580	1,279	4	4.2	1.900	
1180		2100	1,349,635,676	151	160	160	157	575	1,268	3	4.1	1.900	

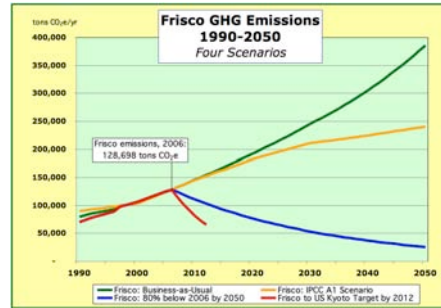
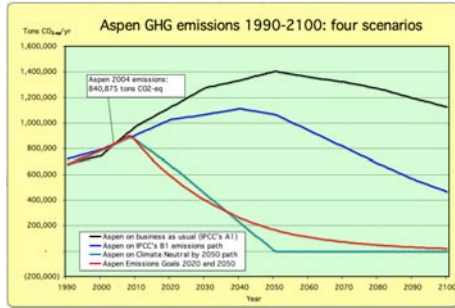
Folio 13

Aspen per capita emissions

"Aspen Emissions Goals 2020 and 2050"

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

	A	B	C	D	E	F	G	H	I	J	K	L	M
1268		2074	7.44%	62,545	34,041	1.84	3,675	0.42	83%				#
1269		2075	7.14%	60,044	34,381	1.75	3,493	0.40	79%				#
1270		2076	6.85%	57,642	34,725	1.66	3,320	0.38	75%				#
1271		2077	6.58%	55,336	35,072	1.58	3,156	0.36	72%				#
1272		2078	6.32%	53,123	35,423	1.50	2,999	0.34	68%				#
1273		2079	6.06%	50,998	35,777	1.43	2,851	0.33	65%				#
1274		2080	5.82%	48,958	36,135	1.35	2,710	0.31	61%				#



Folio 14

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)
	tonnes	tonnes CO2-eq/tonne	tons CO2-eq	Percent	sh tons CO2-eq/yr	tonnes carbon (C-eq)
Pitkin County Landfill: Savings from Recycl						
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
Commingle 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

	tonnes CO2e/tonne	CO2e savings (Ackermann & CMI data, CMS calcs)						
		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
Ackermann: CO2 saved per tonne alum	15.7							
Can Manufacturers Institute		34.2	75.4	13.3	75,419	15.7	0.208	0.459

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



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/aspern/index.shtml
 - 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

1362	A	B	C	D	E	F	G	H	I	J	K	L	M			
1363	Fuel cycle emissions: diesel and gasoline										Folio 15					
1364																
1365	lb CO2 per gallon										From Heede (2008) Paredon Oil & Gas Project					
1366	Gasoline	19.564											Estimated refinery or fuel cycle energy inputs and emission factors			
1367	Gasoline fuel cycle adder	5.282											UCS/Wang	22.8	5.4	23.7%
1368	Total gasoline fuel cycle emissions	24.846											Heede (2003)	15.5%		
1369											ANL GREET model	5,156	1,245	24.1%		
1370	Diesel	22.384											FEIR cites GM	averages FEIR citation: 13 to 17%		
1371	Diesel fuel cycle adder	4.253											Delucchi (2003)	25.0%		
1372	Total diesel fuel cycle emissions	26.637											Simple average of above upstream estimates 20.7%			
1373											ie, specific to California gasoline/diesel mix (esp Delucchi)					
1374																
1375																
1376																
1377																
1378	Volumetric CO2 calculations															
1379																
1380	International Carbon Bank & Exchange	Volume calculation of one ton CO ₂														
1381	one cubic meter = 1,000 liters															
1382	one liter = .03531 cubic feet															
1383	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)															
1384	one tonne contains 22,730 moles of CO ₂ (1,000,000g / 44.0g per mole)															
1385	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 L/mole = 556,200 L = 556.2 m ³															
1386	One tonne of CO ₂ occupies 556.2 m ³ of volume.															
1387	1 m ³ CO ₂ = 0.0017979 tonne = 1.7979 kg.															
1388	1 ft ³ CO ₂ = 1.7979 kg m ³ / 35.31 m ³ ft ³ = 0.050918 kg = 0.112253 lbs CO ₂ .															
1389											CMS calculations					
1390																
1391																
1392	www.eia.doe.gov/oiaf/1605/archive/	1 thousand cubic feet carbon dioxide = 115.97 pounds		1000 cf CO2 weighs		115.970 lb, thus:										
1393		1 thousand cubic feet of methane = 42.28 pounds		1 cf CO2 weighs		0.116 lb, thus:										
1394				1 lb CO2 equals:		8.623 cubic foot										
1395				1 ounce CO2 equals		0.539 cubic foot										
1396				1 cubic foot weighs		1.856 ounces										
1397																
1398																
1399	http://hypertextbook.com/facts/200	party balloons of radius 0.1143 m		1 cubic meter equal		35.3147 cf										
1400		The volume of the balloon is 0.00625m ³		0.00625 m ³		0.2207 cf										
1401																
1402																
1403																
1404											CMS calculations					
1405																
1406	therefore it would take	39.07 balloons to equal		1.00 lb CO2												
1407	and	1.00 balloon contains		0.03 lb CO2												
1408		1.00 balloon contains		0.41 ounces CO2												
1409		1.00 ounce CO2 takes		2.44 balloons												
1410																
1411																
1412	CO2-filled ballons per year, day, hour, minute, second															
1413		tons CO2e/yr	lb CO2e/yr	lb CO2e/day	lb CO2e/hour	lb CO2e/minute	lb CO2e/second									
1414	Aspen total emissions, 2004	840,875	1,681,750,000	4,607,534	191,981	3,200	53.3									
1415	Average Aspen residence		50,800	139.18	5.80	0.10	0.00									
1416		balloons per year	balloons per day	balloons per hour	balloons/minute	balloons/second										
1417	Aspen total emissions, 2004	65,702,324,146	180,006,368	7,500,265	125,004	2,083										
1418	Average Aspen residence	1,984,646	5,437	226.6	3.78	0.06										
1419																
1420	/www.physlink.com/education/askexp	1 cubic foot of air at standard temperature and pressure assuming average composition weighs approximately 0.0807 lbs.														
1421																
1422	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 CO ₂ = 2.13 Gt of carbon.														
1423																
1424																
1425	Global CO2 emissions converted into lb CO2, cubic feet CO2, and CO2-filled balloons per year, day, hour, minute, second															
1426	conversions by CMS from Worldwatch datum on industrial CO2 emissions in 2005															
1427	Global CO2 emissions, 2005															
1428		7.56 GtC														
1429		27.70 billion tonnes CO2														
1430		30.54 billion tons CO2														
1431		83,657,878 tons CO2/day	167,315,755,118 lb CO2/day	1.44275E+12 cf CO2/day	6.54E+12 balloons/day											
1432		3,485,745 tons CO2/hr	6,971,489,797 lb CO2/hr	6.01E+10 cf CO2/hr	2.72E+11 balloons/hr											
1433		58,096 tons CO2/minute	116,191,497 lb CO2/min	1,001,909,947 cf CO2/min	4.54E+09 balloons/min											
1434		968 tons CO2/sec	1,936,525 lb CO2/sec	16,698,499 cf CO2/sec	75,655,828 balloons/sec											
1435																
1436																
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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 electric 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 mgnt, 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 CO₂e = 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 CO ₂	lb CO ₂	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 Store	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 Copyright CMS, 2009

checked for accuracy and boundary.

Cell: B30

Comment: Rick Heede:

Overeinderand 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 include 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: B35

Comment: Rick Heede:

Aspen commuter vehicles averaged an estimated 18.61 mpg in 2004 (note: improved to 19.15 mpg in 2007). This is based on a vehicle type survey conducted in Aug05, and averaging each vehicle type's EPA fuel economy. CMS conducted a similar survey of 183 commuters and their specific vehicle makes and models for the Milton Hershey School in Pennsylvania, in which EPA fuel economy averaged 22.77 mpg (vs 23.85 mpg estimated by drivers).

Note also that fuel and emission rates vary with load, altitude, driving habits, tuning, and speed, and consequently the average Aspen commuting vehicle only averages 1.022 lb CO₂ per mile. Fuel economy also includes acceleration, stop & go traffic, auxiliary power demand (such as AC and fans), high-speed and low-speed driving, etc. A 1997 study of fuel consumption of nine vehicles (1988-1997 model years) by driving speed -- in which the EPA City/Hwy fuel economy averaged 23.0 mpg (19.6 mpg City and 26.4 mpg Hwy) -- averaged 31.4 mpg at 60 mph (and 31.0 mpg at 40 mph and 24.8 mpg at 75 mph). Sources: TEBD 2008, Tables 4.22 - 4.24, and West, B.H. et al (1998) Development and Verification of Light-Duty Modal Emissions and Fuel Consumption Values for Traffic Models.

Cell: H35

Comment: Rick Heede:

CMS and assumes 18.61 mpg and 1.022 lb CO₂ per average mile driven (see note above). Steady speed at 60 mph, however, would likely be ~36 percent better than its City/Hwy average, or roughly 25.4 mpg. At this fuel rate over 60 miles a vehicle would burn 2.36 gallons, emit 46.3 lb CO₂, and thus 0.77 lb CO₂ per mile rather than the 1.022 lb CO₂ per mile shown in this simple averaged computation.

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 for emissions 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 CO_{2e} total = 6,496,000 lb CO_{2e} 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: C64

Comment: Rick Heede:

CMS calculations of emissions factors for US average electricity, in units of lb CO₂ and CO_{2e} per delivered kWh. Based on Energy Information Administration (2008) Annual Energy Review 2007, DOE. Copyright CMS, 2009

Daily Carbon

CO2 and CO2 + methane emissions per delivered kWh of electricity (retail sales). See Table 1 above for details

Cell: K64

Comment: Rick Heede:
Sources:

RECS: US EIA (2003) Residential Energy Consumption Survey 2001.

ECOS: Ecos Consulting (Durango, CO, www.ecosconsulting.com).

ACE3: Amann, Jennifer Thorne, Alex Wilson, & Katie Ackerly (2007) Consumer Guide to Home Energy Savings, Ninth edition, American Council for an Energy-Efficient Economy, Washington, 239 pp., www.aceee.org.

Heede (1995) Homemade Money: How to Save Energy and Dollars in Your Home, Brick House & Rocky Mountain Institute, Snowmass CO, 258 pp.

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:

CMS assumes average speed of 40 mph. City routes will be lower, and hybrid buses on Hwy 82 Valley routes somewhat higher.

Cell: B75

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: K95

Comment: Rick Heede:

Desktop annual energy consumption (AEC) in commercial office buildings in Table 5-7 shows PC at 297 kWh/yr (vs laptop of 32 kWh/yr) based on 2000 data and 55 W active on 5,131 hrs/yr + suspend at 25 W and 375 hrs + off at 1.5 W for 3,254 hrs/yr. (This seems nutty: on 20 hrs per work-day?) PLUS the average CRT monitor at 306 kWh/yr (calc from CRT commercial stock of 61 million units consuming 18.7 TWh/yr = 306 kWh/yr).

A D Little (2002) "Energy Consumption by Office and Telecommunications Equipment in Commercial Building, Vol.1".

Cell: E219

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: E225

Comment: Rick Heede:

Motor Trend 2004 Prius: Average test mpg of 40.8 mpg.

Cell: E229

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: C247

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: B298

Comment: Rick Heede:

ASC (2006) Sustainability Report 2004-2006, 13 pp., www.aspensnowmass.com/environment/

Cell: B300

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: D324

Comment: Rick Heede:

Three sources googled 15Feb08:

www.cg-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 gal/h (380 L/h), 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: D349

Comment: Rick Heede:

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

Cell: H365

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DailyCarbonCalcsApr09.xls

www.climate.mitigation.com

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: D366**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: C391**Comment:** Rick Heede:

Datum from ASC (2006) Sust Rpt, page 6.

Cell: B408**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: G409**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: D418**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: B460**Comment:** Rick Heede:

Ryan,John (1997) Stuff: The Secret Lives of Everyday Things, p. 6.

Cell: C493**Comment:** Rick Heede:

Glass 690 g CO₂e, Paper 74 g, Cardboard 47.7, Steel (bottle caps) 17.4 g, Wood (for pallets) 16 g, Adhesive 7.6 g, and Plastic 0.5 g CO₂e.

Cell: E493**Comment:** Rick Heede:

Entity emissions 173.0 g CO₂e. Brewing Ops 123.0 g, of which electricity (5.77 GWh) is zero due to NB's participation in City of Ft Collins Green ENERgy Program; Natural gas (50.5 Tjoules) 123.0 g CO₂e.

Interestingly, the report includes upstream emissions of methane and CO₂ from natural gas production to distribution: 12.4 percent of total, combustion 87.6 percent, total 123.0 g CO₂e per six-pack.

Cell: G493**Comment:** Rick Heede:

Distribution 276.2 gCO₂e, of which transport fuel 266.4 g, fugitive R-134a is 1.6 g; and Storage 8.2 g.

Cell: C494**Comment:** Rick Heede:

Consumable Materials: 678.0 g CO₂e per six-pack of Fat Tire beer.
Malt 593.9 g (fertilizer, water, harvesting, planting, tillage fuel etc for barley ag (394.1 g of malt total);
Hops 5.7 g; Water 3.2 g; CO₂ for FT carbonation 72.5 g CO₂.

Cell: E494**Comment:** Rick Heede:

Corporate Behavior: 45.7 g CO₂e, of which flights 15.3 g, fleet 17.3 g, fleet fugitive R-134a is 0.4 g CO₂e, employee commuting 12.7 g.

Cell: G494**Comment:** Rick Heede:

Retail 896.6 g CO₂, of which in-store refrigeration is 829.8 g, lighting etc 50 g, fugitive refrigerants 16.8 g.

Cell: G495**Comment:** Rick Heede:

Product Use: 261.5 g CO₂e, of which resl fridge (one week = 8.6 kWh divided by one six-pack being 1/40th of fridge, two week storage) = 260.9 g CO₂e, plus 0.6 g CO₂e fugitive R-134a.

Cell: G496**Comment:** Rick Heede:

Waste Disposal at end of life: 50.3 g, of which landfilling is 31.9 g, recycling 18.4 g.

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."

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Colman, Tyler, & Pablo Páster (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 Páster Sustainable Solutions Group, URS Corporation, 20 pp., www.wine-economics.org/workingpapers/AAWE_WP09.pdf

Cell: B571

Comment: Rick Heede:

Cascio, Jamais (2006) Carbon footprint of a Cheese Burger, www.openthefuture.com/2006/12/the_footprint_of_a_cheeseburger.html

Camaia's 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: F601

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: E619

Comment: Rick Heede:

called Stephen Kanipe 429-2766
called Jeff Dickinson 963-0114

Cell: I632

Comment: Rick Heede:

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

Cell: I638

Comment: Rick Heede:

Aspen inventory, 2004. Linked to conversion factors, cell C18.

Cell: C643

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 34,425 BTU/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.) $(34,425 \text{ BTU per sq. ft. per year} / .87 \text{ (efficiency rating of boiler)}) * 500 \text{ (snowmelt area)} = 19,784,482 \text{ (BTU/yr)} / 3412 \text{ (BTU per kWh)} = 5798.5 \text{ (kWh/yr)} * 20 \text{ (years)} * .07/\text{kWh} = \$8,117.90$ REMP fee will be \$8,117.90

Cell: F643

Comment: Rick Heede:

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

Cell: I643

Comment: Rick Heede:

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

Cell: I697

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: G1016

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: B1026

Comment: Rick Heede:

US Bureau of the Census: pop est for 2007: 301, 621,157

Cell: B1049

Comment: Rick Heede:

Mombiot, George (2007) Heat: how to stop the planet from burning, 304 pp.

Cell: D1190

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: E1190

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 Copyright CMS, 2009

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 per annum increase in total population (16,963), thus 19,890 in 2020 and 26,809 in 2050.

Cell: I1190

Comment: Rick Heede:

Aubrey Meyer of Global Commons Institute in London has recommended "Contraction and convergence" for years relying on a global agreement for equitable distribution of per capita rights 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: K1193

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: D1298

Comment: Rick Heede:

Waste, Recycling, and Climate Change Frank Ackerman, Director of 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: G1298

Comment: Rick Heede:

We allocate 50 percent of the savings from recycled materials to Aspen.

Cell: B1299

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: B1303

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: B1304

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: B1305

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: B1306

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: C1318

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 Manufacturers 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 and 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.