City of Aspen / Canary Initiative — Summary

Greenhouse Gas Emissions Inventory, year 2007

Last Modified: 13 April 2009 — **Rick Heede** — Climate Mitigation Services

	Physical Units		Energy Units		GHG Emissions		CO_2 Equivalent		Percent of Total
Buildings: electricity			Million Btu						
Electricity: Aspen Municipal Utility	64,693,191	kWh	659,871	10^6 Btu	19,091	tons CO2	19,091	tons CO2	2.51%
Electricity (MEAN fugitive methane - coal mining)	8	tons CH4	322	10^6 Btu	8	tons CH4	207	tons CO2e	0.03%
Electricity: Holy Cross Energy	159,436,793	kWh	1,626,255	10^6 Btu	134,929	tons CO2	134,929	tons CO2	17.75%
Electricity (Xcel fugitive methane - coal mining)	87	tons CH4	3,365	10^6 Btu	87	tons CH4	2,165	tons CO2e	0.28%
Total electricity	224,129,984	kWh	**2,289,812**	10^6 Btu	**na**		156,392	**tons CO2e**	**20.57%**
Buildings: natural gas and propane									
Natural Gas (SourceGas)	1,497,844	Mcf	1,233,025	10^6 Btu	72,064	tons CO2	72,064	tons CO2	9.48%
Natural Gas (SourceGas - fugitive methane)	411	tons CH4	15,988	10^6 Btu	411	tons CH4	10,286	tons CO2e	1.35%
Natural Gas (AM Gas)	385,848	Mcf	317,630	10^6 Btu	18,564	tons CO2	18,564	tons CO2	2.44%
Natural Gas (AM Gas - fugitive methane)	106	tons CH4	4,119	10^6 Btu	106	tons CH4	2,650	tons CO2e	0.35%
Propane (AmeriGas, Ferrellgas, Cross, and Propane Svcs)	375,191	gallons	34,267	10^6 Btu	2,377	tons CO2	2,377	tons CO2	0.31%
Propane (fugitive methane)	5	tons CH4	201	10^6 Btu	5	tons CH4	129	tons CO2e	0.02%
Total natural gas & propane	1,883,692	Mcf	**1,605,230**	10^6 Btu	**na**		106,070	**tons CO2e**	**13.95%**
Buildings: other									
AVH Hospital (diesel generator)	1,200	gallons	166	10^6 Btu	13	tons CO2	13	tons CO2	0.002%
Refrigerants, halocarbons, CFCs, etc.	na		na	10^6 Btu		lbs CO2e	na	tons CO2e	
Total buildings	376,391	gallons	**3,895,209**	10^6 Btu	**na**	lbs CO2e	262,475	**tons CO2e**	**34.52%**
Transportation: highway, around town, buses									
Commuting via Hwy 82	11,778,838	gallons	1,473,191	10^6 Btu	117,242	tons CO2	117,242	tons CO2	15.42%
Driving around town	3,804,498	gallons	475,832	10^6 Btu	37,713	tons CO2	37,713	tons CO2	4.96%
Tourist road travel to & from Aspen	4,002,349	gallons	500,578	10^6 Btu	39,211	tons CO2	39,211	tons CO2	5.16%
Transit Buses (RFTA)	439,040	gallons	60,895	10^6 Btu	4,395	tons CO2	4,395	tons CO2	0.58%
School Buses (Aspen School District - diesel)	17,500	gallons	2,427	10^6 Btu	196	tons CO2	196	tons CO2	0.03%
Other School District vehicles - gasoline	12,500	gallons	1,563	10^6 Btu	122	tons CO2	122	tons CO2	0.02%
Out-of-school-district fuel (ExEd trips, away games, gasoline)	5,000	gallons	625	10^6 Btu	52	tons CO2	52	tons CO2	0.01%
Pitkin County Public Works heavy vehicles (diesel)	8,865	gals (*0.2	1,230	10^6 Btu	99	tons CO2	99	tons CO2	0.01%
Pitkin County Public Works - sheriff etc. (gasoline)	8,812	gals (*0.2	1,102	10^6 Btu	86	tons CO2	86	tons CO2	0.01%
City of Aspen equipment (diesel fuel)	57,611	gallons	7,991	10^6 Btu	645	tons CO2	645	tons CO2	0.08%
City of Aspen vehicles (gasoline)	37,823	gallons	4,731	10^6 Btu	371	tons CO2	371	tons CO2	0.05%
Aspen Skiing Company (diesel and gasoline consumption)	237,350	gallons	29,686	10^6 Btu	2,263	tons CO2	2,263	tons CO2	0.30%
Off-road fuel (construction, snowmobiles, lawn & snow widgets)	101,633	gallons	12,711	10^6 Btu	1,047	tons CO2	1,047	tons CO2	0.14%
Ambulances	2,588	gallons	324	10^6 Btu	29	tons CO2	29	tons CO2	0.00%
Total highway vehicles, around town, buses, & misc	**20,514,406**	**gallons**	**2,572,885**	10^6 Btu	203,471	tons CO2	203,471	**tons CO2**	**26.76%**
Transportation: commercial and private aviation									
Air Travel - Commercial via Pitkin County Airport	10,022,903	gallons	1,353,092	10^6 Btu	105,681	tons CO2e	105,681	tons CO2e	13.90%
Air Travel - Commercial at other airports	3,953,858	gallons	533,771	10^6 Btu	41,689	tons CO2e	41,689	tons CO2e	5.48%
Air Travel - General Aviation (jets)	11,598,066	gallons	1,565,739	10^6 Btu	122,289	tons CO2e	122,289	tons CO2e	16.09%
Air Travel - General Aviation (turboprops)	582,952	gallons	78,699	10^6 Btu	6,147	tons CO2e	6,147	tons CO2e	0.81%
Air Travel - General Aviation (piston aircraft)	112,489	gallons	13,520	10^6 Btu	1,032	tons CO2	1,032	tons CO2	0.14%
Air Travel - General Aviation (Air Ambulance flights)	6,909	gallons	830	10^6 Btu	69	tons CO2	69	tons CO2	0.01%
Total commercial and private aviation	**26,277,176**	**gallons**	**3,545,650**	10^6 Btu	276,907	tons CO2	276,907	**tons CO2e**	**36.42%**
Total transportation	**46,791,582**	**gallons**	**6,118,536**	10^6 Btu	480,378	tons CO2	480,378	**tons CO2**	**63.19%**
Landfill									
Landfill & Materials Recovery: electricity	153,511	kWh	1,566	10^6 Btu	66	tons CO2	66	tons CO2	0.01%
Landfill & Materials Recovery: diesel & gasoline fuel	6,826	gallons	947	10^6 Btu	38	tons CO2	38	tons CO2	0.00%
Landfill: fugitive methane	679	tons CH4	32,904	10^6 Btu	679	tons CH4	16,969	tons CO2e	2.23%
Total landfill	**various**		**35,416**	10^6 Btu		na	17,072	**tons CO2e**	**2.25%**
Nitrous Oxide sources									
Maroon Creek Club	3,458	kg N	na		108	kg N2O	35	tons CO2e	0.005%
Aspen Golf Course	4,051	kg N	na		126	kg N2O	41	tons CO2e	0.005%
City of Aspen parks and greenspaces	1,502	kg N	na		47	kg N2O	15	tons CO2e	0.002%
City of Aspen athletic fields	2,687	kg N	na		84	kg N2O	27	tons CO2e	0.004%
Private greenspace within city limits	15,078	kg N	na		470	kg N2O	153	tons CO2e	0.020%
Private greenspace within Urban Growth Boundary	6,883	kg N	na		215	kg N2O	70	tons CO2e	0.009%
Total nitrous oxide sources	**33,659**	kg N	na		1,050	kg N2O	343	**tons CO2e**	**0.05%**
Total	**various**	**units**	**10,049,161**	10^6 Btu	**various**	**units**	760,268	**tons CO2e**	**100%**
Methane and nitrous oxide of total emissions					1,291	tons CH4	**32,619**	**tons CO2e**	**4.29%**
Carbon dioxide of total emissions							**727,649**	**tons CO2**	**95.71%**

Total emissions 2004 (original estimate)	840,875	tons CO2e	Difference	**80,607**	tons CO2e	**Percent**	-9.59%
Total emissions 2004 (revised Feb09 estimate)	828,648	tons CO2e	Difference	**68,381**	tons CO2e	**Percent**	-8.25%

Cell: F8
Comment: Rick Heede:
CMS estimates the energy value of fugitive methane, although using Aspen's Btu value of 823.2 Btu per cubic foot rather than the standard value of 1,027 Btu per cf (standard temperature and pressure). See th Natural gas worksheet for details.

Cell: G8
Comment: Rick Heede:
Energy Information Administration (2008) Emissions of Greenhouse Gases in the United States 2007. GWP, methodolgoy, p 12: Methane. In its Fourth Assessment Report, the IPCC developed revised global warming potential factors (GWPs) for selected gases. The GWP for methane was revised from the previous value of 23 in the IPCC's Third Assessment Report to 25 in the Fourth Assessment Report. The revisedGWPfor methane is used in this report. In addition, this report incorporates an increase in the density of methane from 42.28 to 42.37 pounds per thousand cubic feet, in order to provide consistent temperature and pressure values for methane in all EIA data. Nitrous Oxide. The IPCC also updated the GWP for nitrous oxide in its Fourth Assessment Report, to 298, up from 296 in the IPCC's Third Assessment Report."

Greenhouse Gas Emissions Inventory 2004

Revised Apr09

Last modified: 15 April 2009

	Physical Units		Energy Units		GHG Emissions		CO2 Equivalent		Percent of Total	lb CO2e per million Btu
			Million	Btu						
Buildings: electricity										
Electricity (Aspen Municipal Utility/Aspen Elec Dp	62,872,609	kWh	641,301	10^6 Btu	39,571	tons CO2	39,571	tons CO2	4.8%	123
Electricity (MEAN fugitive methane - coal mines)	8	tons CH4	391	10^6 Btu	8	tons CH4	185	tons CO2e	0.0%	947
Electricity (Holy Cross)	141,283,859	kWh	1,441,095	10^6 Btu	125,036	tons CO2	125,036	tons CO2	15.1%	174
Electricity (Xcel fugitive methane - coal mines)	77	tons CH4	3,727	10^6 Btu	77	tons CH4	1,764	tons CO2e	0.2%	947
Total electricity	**204,156,553**	**kWh**	**2,086,514**	**10^6 Btu**	**na**		**166,557**	**tons CO2e**	**20.1%**	160
Buildings: natural gas and propane										
Natural Gas (Kinder Morgan)	14,527,438	ccf	1,252,365	10^6 Btu	73,194	tons CO2	73,194	tons CO2	8.8%	117
Natural Gas (Kinder Morgan - fugitive methane)	415	tons CH4	20,170	10^6 Btu	415	tons CH4	9,549	tons CO2e	1.2%	947
Natural Gas (AM Gas)	3,631,860	ccf	313,091	10^6 Btu	18,299	tons CO2	18,299	tons CO2	2.2%	117
Natural Gas (AM Gas - fugitive methane)	104	tons CH4	5,043	10^6 Btu	104	tons CH4	2,387	tons CO2e	0.3%	947
Propane (AmeriGas)	250,137	gallons	22,846	10^6 Btu	1,662	tons CO2	1,662	tons CO2	0.2%	146
Propane (Ferrellgas)	250,137	gallons	22,846	10^6 Btu	1,662	tons CO2	1,662	tons CO2	0.2%	146
Total natural gas & propane	**1,815,930**	**Mcf**	**1,636,361**	**10^6 Btu**	**na**		**106,754**	**tons CO2e**	**12.9%**	130
Buildings: other										
AVH Hospital (diesel generator)	1,200	gallons	166	10^6 Btu			13	tons CO2	0.0%	161
Refrigerants, halocarbons, CFCs, etc.	na		na	10^6 Btu		lbs CO2-e	na	tons CO2e		
Total buildings	**501,474**	**gallons**	**3,723,041**	**10^6 Btu**		**na**	**273,324**	**tons CO2e**	**33.0%**	147
Transportation: highway, around town, buses										
Highway vehicles, driving Hwy 82	12,635,963	gallons	1,580,393	10^6 Btu	125,714	tons CO2	125,714	tons CO2	15.2%	159
Highway vehicles, around town	3,698,454	gallons	462,569	10^6 Btu	36,720	tons CO2	36,720	tons CO2	4.4%	159
Tourist road travel to & from Aspen	4,117,548	gallons	514,986	10^6 Btu	40,340	tons CO2	40,340	tons CO2	4.9%	157
Transit Buses (RFTA)	291,989	gallons	40,499	10^6 Btu	3,139	tons CO2	3,139	tons CO2	0.4%	155
School Buses (Aspen School District)	17,420	gallons	2,416	10^6 Btu	195	tons CO2	195	tons CO2	0.0%	161
Other School District vehicles	13,380	gallons	1,673	10^6 Btu	131	tons CO2	131	tons CO2	0.0%	157
Out-of-school-district fuel (ExEd trips, away game	5,352	gallons	669	10^6 Btu	56	tons CO2	56	tons CO2	0.0%	168
Pitkin County Public Works - sheriff etc. (gasoline	11,870	gals (*0.2	1,485	10^6 Btu	116	tons CO2	116	tons CO2	0.0%	157
Pitkin County Public Works heavy vehicles (diesel)	7,581	gals (*0.2	1,051	10^6 Btu	85	tons CO2	85	tons CO2	0.0%	161
City of Aspen equipment (diesel fuel)	33,588	gallons	4,659	10^6 Btu	376	tons CO2	376	tons CO2	0.0%	161
City of Aspen vehicles (gasoline)	62,590	gallons	7,828	10^6 Btu	613	tons CO2	613	tons CO2	0.1%	157
Aspen Skiing Company (diesel and gasoline consu	210,468	gallons	26,323	10^6 Btu	2,007	tons CO2	2,007	tons CO2	0.2%	152
Off-road (construction equip., snowmobiles, gas v	150,440	gallons	18,816	10^6 Btu	1,654	tons CO2	1,654	tons CO2	0.2%	176
Ambulances	2,588	gallons	324	10^6 Btu	29	tons CO2	29	tons CO2	0.0%	179
Total highway vehicles, around town, buses, & mi	**21,259,230**	**gallons**	**2,663,691**	**10^6 Btu**	**211,175**	**tons CO2**	**211,175**	**tons CO2**	**25.5%**	159
Transportation: commercial and private aviation										
Air Travel - Commercial at Pitkin County Airport	12,983,681	gallons	1,752,797	10^6 Btu	195,637	tons CO2	136,946	tons CO2	16.5%	156
Air Travel - Commercial at other airports	4,710,566	gallons	635,926	10^6 Btu	70,978	tons CO2	49,685	tons CO2	6.0%	156
Air Travel - General Aviation (jets)	13,027,830	gallons	1,758,757	10^6 Btu	196,301	tons CO2	137,411	tons CO2	16.6%	156
Air Travel - General Aviation (turboprops)	662,942	gallons	89,497	10^6 Btu	9,989	tons CO2	6,992	tons CO2	0.8%	156
Air Travel - General Aviation (piston aircraft)	123,648	gallons	14,861	10^6 Btu	1,621	tons CO2	1,135	tons CO2	0.1%	153
Air Travel - General Aviation (Air Ambulance flight	7,413	gallons	891	10^6 Btu	112	tons CO2	78	tons CO2	0.0%	176
Total commercial and private aviation	**31,516,080**	**gallons**	**4,252,730**	**10^6 Btu**	**474,638**	**tons CO2**	**332,247**	**tons CO2**	**40.1%**	156
Total transportation	**53,276,784**	**gallons**	**6,916,421**	**10^6 Btu**		**tons CO2**	**543,422**	**tons CO2**	**65.6%**	157
Landfill										
Landfill & Materials Recovery: electricity	110,476	kWh	1,127	10^6 Btu	50	tons CO2	50	tons CO2	0.0%	88
Landfill & Materials Recovery: diesel fuel	4,849	gallons	673	10^6 Btu		tons CO2	27	tons CO2	0.0%	81
Landfill: fugitive methane	500	tons CH4	24,291	10^6 Btu	500	tons CH4	11,500	tons CO2e	1.4%	947
Total landfill	**various**		**26,090**	**10^6 Btu**		**na**	**11,577**	**tons CO2e**	**1.4%**	887
Nitrous Oxide sources										
Maroon Creek Club	3,285	kg N	na		102	kg N2O	33	tons CO2e	0.0%	
Aspen Golf Course	4,888	kg N	na		153	kg N2O	50	tons CO2e	0.0%	
City of Aspen Parks & athletic fields	1,806	kg N	na		56	kg N2O	18	tons CO2e	0.0%	
Private greenspace within city limits	15,078	kg N	na		470	kg N2O	153	tons CO2e	0.0%	
Private greenspace within Urban Growth Boundary	6,888	kg N	na		215	kg N2O	70	tons CO2e	0.0%	
Total nitrous oxide sources	**31,945**	**kg N**	**na**		**997**	**kg N2O**	**325**	**tons CO2e**	**0.0%**	
Total	**various**	**units**	**10,665,552**	**10^6 Btu**	**various**	**units**	**828,648**	**tons CO2e**	**100.0%**	155
Methane and nitrous oxide of total emissions					1,104	tons CH4	25,711	tons CO2e	3.1%	
Carbon dioxide of total emissions							802,937	tons CO2	96.9%	

Original total:	840,888	12,240	tons, net revision GA jets

2004

Greenhouse Gas Emissions Inventory 2007

Last modified: 15 April 2009

	Physical Units		Energy Units		GHG Emissions		CO2 Equivalent		Percent of Total	lb CO2e per million Btu
Buildings: electricity			Million	Btu						
Electricity: Aspen Municipal Utility	64,693,191	kWh	659,871	10^6 Btu	19,091	tons CO2	19,091	tons CO2	2.5%	58
Electricity (MEAN fugitive methane - coal mining)	8	tons CH4	322	10^6 Btu	8	tons CH4	207	tons CO2e	0.0%	1,287
Electricity: Holy Cross Energy	159,436,793	kWh	1,626,255	10^6 Btu	134,929	tons CO2	134,929	tons CO2	17.7%	166
Electricity (Xcel fugitive methane - coal mining)	87	tons CH4	3,365	10^6 Btu	87	tons CH4	2,165	tons CO2e	0.3%	1,287
Total electricity	**224,129,984**	**kWh**	**2,289,812**	**10^6 Btu**	**na**		**156,392**	**tons CO2e**	**20.6%**	137
Buildings: natural gas and propane										
Natural Gas (SourceGas)	1,497,844	Mcf	1,233,025	10^6 Btu	72,064	tons CO2	72,064	tons CO2	9.5%	117
Natural Gas (SourceGas - fugitive methane)	411	tons CH4	15,988	10^6 Btu	411	tons CH4	10,286	tons CO2e	1.4%	1,287
Natural Gas (AM Gas)	385,848	Mcf	317,630	10^6 Btu	18,564	tons CO2	18,564	tons CO2	2.4%	117
Natural Gas (AM Gas - fugitive methane)	106	tons CH4	4,119	10^6 Btu	106	tons CH4	2,650	tons CO2e	0.3%	1,287
Propane (AmeriGas, Ferrellgas, Cross, and Propan	375,191	gallons	34,267	10^6 Btu	2,377	tons CO2	2,377	tons CO2	0.3%	139
Propane (fugitive methane)	5	tons CH4	201	10^6 Btu	5	tons CH4	129	tons CO2e	0.0%	1,287
Total natural gas & propane	**1,883,692**	**Mcf**	**1,605,230**	**10^6 Btu**	**na**		**106,070**	**tons CO2e**	**14.0%**	132
Buildings: other										
AVH Hospital (diesel generator)	1,200	gallons	166	10^6 Btu	13	tons CO2	13	tons CO2	0.0%	161
Refrigerants, halocarbons, CFCs, etc.	na		na	10^6 Btu		lbs CO2e	na	tons CO2e	0.0%	
Total buildings	**376,391**	**gallons**	**3,895,209**	**10^6 Btu**		**lbs CO2e**	**262,475**	**tons CO2e**	**34.5%**	135
Transportation: highway, around town, buses										
Commuting via Hwy 82	11,778,838	gallons	1,473,191	10^6 Btu	117,242	tons CO2	117,242	tons CO2	15.4%	159
Driving around town	3,804,498	gallons	475,832	10^6 Btu	37,713	tons CO2	37,713	tons CO2	5.0%	159
Tourist road travel to & from Aspen	4,002,349	gallons	500,578	10^6 Btu	39,211	tons CO2	39,211	tons CO2	5.2%	157
Transit Buses (RFTA)	439,040	gallons	60,895	10^6 Btu	4,395	tons CO2	4,395	tons CO2	0.6%	144
School Buses (Aspen School District - diesel)	17,500	gallons	2,427	10^6 Btu	196	tons CO2	196	tons CO2	0.0%	161
Other School District vehicles - gasoline	12,500	gallons	1,563	10^6 Btu	122	tons CO2	122	tons CO2	0.0%	157
Out-of-school-district fuel (ExEd trips, away game	5,000	gallons	625	10^6 Btu	52	tons CO2	52	tons CO2	0.0%	168
Pitkin County Public Works heavy vehicles (diesel)	8,865	gals (*0.2)	1,230	10^6 Btu	99	tons CO2	99	tons CO2	0.0%	161
Pitkin County Public Works - sheriff etc. (gasoline	8,812	gals (*0.2)	1,102	10^6 Btu	86	tons CO2	86	tons CO2	0.0%	157
City of Aspen equipment (diesel fuel)	57,611	gallons	7,991	10^6 Btu	645	tons CO2	645	tons CO2	0.1%	161
City of Aspen vehicles (gasoline)	37,823	gallons	4,731	10^6 Btu	371	tons CO2	371	tons CO2	0.0%	157
Aspen Skiing Company (diesel and gasoline consu	237,350	gallons	29,686	10^6 Btu	2,263	tons CO2	2,263	tons CO2	0.3%	152
Off-road fuel (construction, snowmobiles, lawn &	101,633	gallons	12,711	10^6 Btu	1,047	tons CO2	1,047	tons CO2	0.1%	165
Ambulances	2,588	gallons	324	10^6 Btu	29	tons CO2	29	tons CO2	0.0%	179
Total highway vehicles, around town, buses, & mi	**20,514,406**	**gallons**	**2,572,885**	**10^6 Btu**	**203,471**	**tons CO2**	**203,471**	**tons CO2**	**26.8%**	158
Transportation: commercial and private aviation										
Air Travel - Commercial via Pitkin County Airport	10,022,903	gallons	1,353,092	10^6 Btu	105,681	tons CO2e	105,681	tons CO2e	13.9%	156
Air Travel - Commercial at other airports	3,953,858	gallons	533,771	10^6 Btu	41,689	tons CO2e	41,689	tons CO2e	5.5%	156
Air Travel - General Aviation (jets)	11,598,066	gallons	1,565,739	10^6 Btu	122,289	tons CO2e	122,289	tons CO2e	16.1%	156
Air Travel - General Aviation (turboprops)	582,952	gallons	78,699	10^6 Btu	6,147	tons CO2e	6,147	tons CO2e	0.8%	156
Air Travel - General Aviation (piston aircraft)	112,489	gallons	13,520	10^6 Btu	1,032	tons CO2	1,032	tons CO2	0.1%	153
Air Travel - General Aviation (Air Ambulance flight	6,909	gallons	830	10^6 Btu	69	tons CO2	69	tons CO2	0.0%	166
Total commercial and private aviation	**26,277,176**	**gallons**	**3,545,650**	**10^6 Btu**	**276,907**	**tons CO2**	**276,907**	**tons CO2e**	**36.4%**	156
Total transportation	**46,791,582**	**gallons**	**6,118,536**	**10^6 Btu**	**480,378**	**tons CO2**	**480,378**	**tons CO2**	**63.2%**	157
Landfill										
Landfill & Materials Recovery: electricity	153,511	kWh	1,566	10^6 Btu	66	tons CO2	66	tons CO2	0.0%	84
Landfill & Materials Recovery: diesel & gasoline fu	6,826	gallons	947	10^6 Btu	38	tons CO2	38	tons CO2	0.0%	79
Landfill: fugitive methane	679	tons CH4	32,904	10^6 Btu	679	tons CH4	16,969	tons CO2e	2.2%	1,031
Total landfill	**various**		**35,416**	**10^6 Btu**		**na**	**17,072**	**tons CO2e**	**2.2%**	964
Nitrous Oxide sources										
Maroon Creek Club	3,458	kg N	na		108	kg N2O	35	tons CO2e	0.0%	
Aspen Golf Course	4,051	kg N	na		126	kg N2O	41	tons CO2e	0.0%	
City of Aspen parks and greenspaces	1,502	kg N	na		47	kg N2O	15	tons CO2e	0.0%	
City of Aspen athletic fields	2,687	kg N	na		84	kg N2O	27	tons CO2e	0.0%	
Private greenspace within city limits	15,078	kg N	na		470	kg N2O	153	tons CO2e	0.0%	
Private greenspace within Urban Growth Boundary	6,883	kg N	na		215	kg N2O	70	tons CO2e	0.0%	
Total nitrous oxide sources	**33,659**	**kg N**	**na**		**1,050**	**kg N2O**	**343**	**tons CO2e**	**0.0%**	
Total	**various**	**units**	**10,049,161**	**10^6 Btu**	**various**	**units**	**760,268**	**tons CO2**	**100.0%**	151
Methane and nitrous oxide of total emissions					1,291	tons CH4	32,619	tons CO2e	4.3%	
Carbon dioxide of total emissions							727,649	tons CO2	95.7%	

2007

Comparing 2004 and 2007: Fuel & Energy

Last modified: 15 April 2009

Fuel and energy comparisons

		2004	2007	Change
Table 1	title:	Electricity: comparing 2004 to 2007		
	x-axis legend items:	kWh	kWh	Change
	Aspen Electric	62,872,609	64,693,191	2.90%
	Holy Cross	141,283,859	159,436,793	12.8%
	Total	204,156,553	224,129,984	9.78%
Table 2	title:	Natural gas: comparing 2004 to 2007		
	x-axis legend items:	Mcf	Mcf	Change
	SourceGas	1,452,744	1,497,844	3.10%
	AM Gas	363,186	385,848	6.24%
	Total	1,815,930	1,883,692	3.73%
Table 3	title:	Propane: comparing 2004 to 2007		
	x-axis legend items:	gallons	gallons	Change
	Propane vendors	1,815,930	375,191	-79.34%

		2004	2007	
Table 4	title:	Ground transportation: comparing 2004 to 2007		
	x-axis legend items:	gallons	gallons	Change
	Commuting	12,635,963	11,778,838	-6.78%
	Around town	3,698,454	3,804,498	2.87%
	Tourist driving	4,117,548	4,002,349	-2.80%
	RFTA	291,989	439,040	50.36%
	School buses	17,420	17,500	0.46%
	ASD vehicles	13,380	12,500	-6.58%
	Out-of-town ASD	5,352	5,000	-6.58%
	Pitkin County diesel	11,870	8,865	-25.32%
	Pitkin County gasoline	7,581	8,812	16.24%
	City of Aspen diesel	33,588	57,611	71.52%
	City of Aspen gasoline	62,590	37,823	-39.57%
	SkiCo diesel & gasoline	210,468	237,350	12.77%
	Off-road fuel	150,440	101,633	-32.44%
	Ambulances	2,588	2,588	0.00%
	Total ground fuel	21,259,230	20,514,406	-3.50%
	RFTA		(147,051)	gallons
	Total ground		744,825	gallons
Table 5	title:	Air travel & aviation: comparing 2004 to 2007		
	x-axis legend items:	gallons	gallons	Change
	Air travel via Aspen	12,983,681	10,022,903	-22.80%
	Air travel via other airports	4,710,566	3,953,858	-16.06%
	GA: jets	13,027,830	11,598,066	-10.97%
	GA: turboprops	662,942	582,952	-12.07%
	GA: piston	123,648	112,489	-9.03%
	GA: air ambulance	7,413	6,909	-6.80%
	Total air travel & aviation	31,516,080	26,277,176	-16.62%
	GA fuel	13,821,833	12,300,415	-11.01%
	Total transportation	53,276,784	46,791,582	-12.17%
			6,485,203	gallons
Table 6	title:	Landfill energy & methane: comparing 2004 to 2007		
	x-axis legend items:	various	various	Change
	Electricity	110,476	153,511	38.95%
	Diesel & gasoline	4,849	6,826	40.77%
	Fugitive methane	500	679	35.75%
Table 7	title:	Nitrous oxide: comparing 2004 to 2007		
	x-axis legend items:	kg N	kg N	Change
	Golf courses	8,173	7,509	-8.13%
	City parks & fields	1,806	4,189	131.94%
	Private greenspaces	21,966	21,961	-0.02%
	Total nitrous oxide	31,945	33,659	5.36%
	Total	various	various	na
Table 4.2	Commuting	12,635,963	11,778,838	
	Around town	3,698,454	3,804,498	
	Tourist driving	4,117,548	4,002,349	
	RFTA	291,989	439,040	
	SkiCo diesel & gasoline	210,468	237,350	
	Off-road fuel	150,440	101,633	

Btu comparisons

		2004	2007	Change
Table 8	title:	Building energy sources: comparing 2004 to 2007		
	x-axis legend items:	million Btu	million Btu	Change
	Aspen Electric	641,301	659,871	2.90%
	Holy Cross	1,441,095	1,626,255	12.85%
	SourceGas	1,252,365	1,233,025	-1.54%
	AM Gas	313,091	317,630	1.45%
	Propane vendors	45,692	34,267	-25.00%
	Total energy in buildings	3,693,544	3,871,048	4.81%
Table 9	title:	Total building energy: comparing 2004 to 2007		
	x-axis legend items:	million Btu	million Btu	Change
	Electricity	2,082,396	2,286,126	9.78%
	Natural gas	1,565,457	1,550,655	-0.95%
	Propane	45,692	34,267	-25.00%
	Methane: elec, gas, & propan	29,330	23,994	-18.19%
	AVH diesel	166	166	0.00%
12	Total buildings	3,723,041	3,895,209	4.62%

		2004	2007	
Table 10	title:	Ground transportation: comparing 2004 to 2007		
	x-axis legend items:	million Btu	million Btu	Change
	Commuting	1,580,393	1,473,191	-6.78%
	Around town	462,569	475,832	2.87%
	Tourist driving	514,986	500,578	-2.80%
	RFTA	40,499	60,895	50.36%
	School buses	2,416	2,427	0.46%
	ASD vehicles	1,673	1,563	-6.58%
	Out-of-town ASD	669	625	-6.58%
	Pitkin County diesel	1,485	1,230	-17.18%
	Pitkin County gasoline	1,051	1,102	4.82%
	City of Aspen diesel	4,659	7,991	71.52%
	City of Aspen gasoline	7,828	4,731	-39.57%
	SkiCo diesel & gasoline	26,323	29,686	12.77%
	Off-road fuel	18,816	12,711	-32.44%
	Ambulances	324	324	0.00%
	Total ground fuel	2,663,691	2,572,885	-3.41%
	RFTA			
	Total ground			
Table 11	title:	Air travel & aviation: comparing 2004 to 2007		
	x-axis legend items:	million Btu	million Btu	Change
	Air travel via Aspen	1,752,797	1,353,092	-22.80%
	Air travel via other airports	635,926	533,771	-16.06%
	GA: jets	1,758,757	1,565,739	-10.97%
	GA: turboprops	89,497	78,699	-12.07%
	GA: piston	14,861	13,520	-9.03%
	GA: air ambulance	891	830	-6.80%
	Total air travel & aviation	4,252,730	3,545,650	-16.63%
Table 11b	Total transportation	6,916,421	6,118,536	-11.54%
Table 12	title:	Landfill energy & methane: comparing 2004 to 2007		
	x-axis legend items:	million Btu	million Btu	Change
	Electricity	1,127	1,566	38.95%
	Diesel & gasoline	673	947	40.77%
	Fugitive methane	24,291	32,904	35.46%
Table 13	title:	Nitrous oxide: comparing 2004 to 2007		
	x-axis legend items:	million Btu	million Btu	Change
	Golf courses	not applicable		
	City parks & fields			
	Private greenspaces			
	Total nitrous oxide			
Table 14	title:	Total energy (in Btu): comparing 2004 to 2007		
	x-axis legend items:	million Btu	million Btu	Change
	Total	10,665,552	10,049,161	-5.78%

Comparing 2004 and 2007: Greenhouse Gas Emissions

Last modified: 15 April 2009

GHG emissions comparisons

	2004	2007	Change
Total GHG	828,648	760,268	-8.25%
		68,381	2,680.54 homes

Table 15 natural gas, and propane emissions: comparing 2004 to

	tons CO2e	tons CO2e	Change
Aspen Electric	39,756	19,298	-51.46%
Holy Cross	126,801	137,094	8.12%
SourceGas	82,744	82,350	-0.48%
AM Gas	20,686	21,214	2.55%
Propane vendors	3,325	2,506	-24.63%
Total energy in buildings	273,324	262,475	-3.97%
Total Gas & Propane (& AVI	106,768	106,083	-0.64%

Table 16 Total building emissions: comparing 2004 to 2007

	tons CO2e	tons CO2e	Change
Electricity	166,557	156,392	-6.10%
Natural gas	103,430	103,564	0.13%
Propane	3,325	2,506	-24.63%
Methane: elec, gas, & propan	incl above	incl above	
AVH diesel	13	13	0.00%
Total buildings	273,324	262,475	-3.97%
		10,849	tons CO2

	2004	2007

Table 17 und transportation emissions: comparing 2004 to 2007

	tons CO2e	tons CO2e	Change
Commuting	125,714	117,242	-6.74%
Around town	36,720	37,713	2.70%
Tourist driving	40,340	39,211	-2.80%
RFTA	3,139	4,395	40.01%
School buses	195	196	0.46%
ASD vehicles	131	122	-6.58%
Out-of-town ASD	56	52	-6.58%
Pitkin County diesel	116	99	-14.69%
Pitkin County gasoline	85	86	1.75%
City of Aspen diesel	376	645	71.52%
City of Aspen gasoline	613	371	-39.57%
SkiCo diesel & gasoline	2,007	2,263	12.75%
Off-road fuel	1,654	1,047	-36.69%
Ambulances	29	29	0.00%
Ground transportation	211,175	203,471	-3.6%
		7,704	tons CO2
RFTA		(1,256)	

Table 18 r Travel & General Aviation: Comparing 2004 to 2007

	tons CO2e	tons CO2e	Change		
2004 Air Trav	Air travel via Aspen	136,946	105,681	-22.83%	38%
186,631	Air travel via other airports	49,685	41,689	-16.09%	15%
	GA: jets	137,411	122,289	-11.00%	44%
2007 Air Trav	GA: turboprops	6,992	6,147	-12.10%	2%
147,370	GA: piston	1,135	1,032	-9.03%	0%
Change	GA: air ambulance	78	69	-12.01%	0%
21.0%	Total air travel & aviation	332,247	276,907	-16.66%	
			55,340	change, tons	
Table 18.2	Total transportation	543,422	480,378	-11.60%	
			63,044	2,471	Aspen homes @2

Table 19 ll energy & methane emissions: comparing 2004 to 2007

	tons CO2e	tons CO2e	Change
Electricity	50	66	32.16%
Diesel & gasoline	27	38	38.53%
Fugitive methane	11,500	16,969	47.55%
(5,495) Total landfill	11,577	17,072	47.46%

Table 20 Nitrous oxide emissions: comparing 2004 to 2007

	tons CO2e	tons CO2e	Change
Golf courses	83	76	-8.13%
City parks & fields	18	43	131.94%
Private greenspaces	224	224	-0.02%
Total nitrous oxide	325	343	5.36%
	11,902	17,414	46.31%

Table 21 Total Aspen emissions: comparing 2004 to 2007

	tons CO2e	tons CO2e	Change
Total	828,648	760,268	-8.25%

Table 22 Emissions by GHG gas: comparing 2004 to 2007

	tons CO2e	tons CO2e	Change
Carbon dioxide	802,937	727,649	-9.38%
Methane	25,386	32,276	27.14%
Nitrous Oxide	325	343	5.36%
Total GHG	828,648	760,268	-8.25%

GHG emissions comparisons

	2004	2007	Change
Total GHG	828,648	760,268	-8.25%

Table 23 Major emissions sources: comparing 2004 to 2007

	tons CO2e	tons CO2e	Change
Electricity	166,557	156,392	-6.10%
Natural gas	103,430	103,564	0.13%
Commuting	125,714	117,242	-6.74%
Around town	36,720	37,713	2.70%
Tourist driving	40,340	39,211	-2.80%
Air travel via Aspen	136,946	105,681	-22.83%
Air travel via other airports	49,685	41,689	-16.09%
GA: jets	137,411	122,289	-11.00%
Landfill methane	11,500	16,969	47.55%
Subtotal, 9 major sources	808,302	740,749	-8.36%
Major sources, percent of tot	97.54%	97.43%	
Natural Gas (alt adjust NOT ma	103,430	107,429	3,865 tons

Table 24 ound travel, and air travel emissions: comparing 2004 t

	tons CO2e	tons CO2e	Change
Total buildings	273,324	262,475	-3.97%
Ground transportation	211,175	203,471	-3.65%
Total air travel & aviation	332,247	276,907	-16.66%
Subtotal, 3 major sources	816,746	742,853	-9.05%
Major sources, percent of tot	98.56%	97.71%	

Table 17.2 ajor ground transportation: comparing 2004 to 2007

	tons CO2e	tons CO2e	Change
Commuting	125,714	117,242	-6.74%
Around town	36,720	37,713	2.70%
Tourist driving	40,340	39,211	-2.80%
RFTA	3,139	4,395	40.01%
SkiCo diesel & gasoline	2,007	2,263	12.75%
Off-road fuel	1,654	1,047	-36.69%

Table 25 Major sources: comparing 2004 to 2007

	tons CO2e	tons CO2e	Change
Buildings	273,324	262,475	-3.97%
Transportation	543,422	480,378	-11.60%
Other sources	11,902	17,414	46.31%
Total	828,648	760,268	correct sum

Table 26 Major sources: comparing 2004 to 2007

	tons CO2e	tons CO2e	Change	
	Electricity	166,557	156,392	-6.10%	
53.2%	Natural gas & propane	106,754	106,070	-0.64%	
	Ground transportation	211,175	203,471	-3.65%	
	Air travel & aviation	332,247	276,907	-16.66%	
	Landfill	11,577	17,072	47.46%	
	Nitrous oxide	325	343	5.36%	
	Total	828,635	760,254		only excl AVH diesel

Table 27 nd ground transportation emissions: comparing 2004 t

	tons CO2e	tons CO2e	Change
Commuting	125,714	117,242	-6.74%
Around town	36,720	37,713	2.70%
Tourist driving	40,340	39,211	-2.80%
Air travel via Aspen	136,946	105,681	-22.83%
Air travel via other airports	49,685	41,689	-16.09%
GA: jets	137,411	122,289	-11.00%

Table 28 GA Jets & Turboprops: comparing 2004 to 2007

	tons CO2e	tons CO2e	Change
General Aviation: Jets	137,411	122,289	-11.00%
General Aviation: Turboprop	6,992	6,147	-12.10%
Total	144,403	128,436	-11.06%
All GA Total	145,616	129,537	-11.04%

Table 29 GA Jets & Turboprops: comparing 2004 to 2007

	tons CO2e	tons CO2e	Change
Air travel via Aspen	136,946	105,681	-22.83%
Air travel via other airports	49,685	41,689	-16.09%
Total commercial Air Travel	186,631	147,370	-21.04%

Comparing 2004 and 2007: Energy Costs, & Miscellaneous

Last modified: 15 April 2009

Emissions, Energy Cost, and electricity EF comparisons

Table 30 — Electricity consumption & emissions: comparing 2004 to 2007

tons CO2e	2004 kWh	2007 kWh	2004 tons CO2e	2007 tons CO2e
Aspen Electric	62,872,609	64,693,191	39,756	19,298
Holy Cross	141,283,859	159,436,793	126,801	137,094

linked to "ElectricityCarbon2007.xls"

	Aspen Muni	Holy Cross Energy
CO2 per kWh generated	0.5509	1.5800
CO2 per kWh delivered	0.5902	1.6926
Methane (as CO2e)	0.0064	0.0272
Total CO2e/kWh	0.5966	1.7197
Compare 2004:	1.2646	1.7950
Percent change:	52.8%	4.2%

Table 31 — Highway 82 & commuting emissions: comparing 2004 to 2007

x-axis legend items:	2004 tons CO2e	2007 tons CO2e	Change
Passenger cars (sedans, cabriolets, etc)	24,542	24,491	-0.21%
Small SUVs and small pick-up trucks	13,841	26,446	91.07%
Medium/Large SUVs and large "light" trucks	66,513	46,463	-30.14%
2-axle medium-duty trucks, RVs	5,357	4,967	-7.27%
3-axle trucks, dump trucks, etc	11,927	7,613	-36.17%
Semis, combination trucks	3,474	7,185	106.85%
Motorcycles	61	77	24.59%
excludes			
RFTA	3,139	4,395	
School buses	195	196	

Table 34 — ectricity emission factors: comparing 2004 to 2007

x-axis legend it	2004 lb CO2/kWh	2007 lb CO2/kWh	Change
Aspen Electric Dept	1.2646	0.5966	52.8%
Holy Cross Energy	1.7950	1.7197	4.2%
Sales weighted average		1.3955	
Simple average	1.5298	1.1582	

Table 35 — RFTA: Travel & General Aviation: Comparing 2004 to 2007

x-axis legend items:	2004 tons CO2e	2007 tons CO2e	Change
Total Air Travel	186,631	147,370	-21.04%
Total General Aviation	145,616	129,537	-11.04%
Total	332,247	276,907	-16.66%
Air Travel change		39,260	1,539 home
GA change		16,079	630 home

Table 32 — Vehicle type survey, August 2008

	# of vehicles	Percent
Passenger cars	1,844	26.8%
Light trucks & SUVs	1,820	26.5%
Med&Hvy trucks/SUVs	2,691	39.1%
Large 2-axle trucks	176	2.6%
Large 3-axle trucks	168	2.4%
Semis	50	0.7%
Buses (RFTA)	88	1.3%
Motor cycles * 0.5	44	0.6%
Total	6,881	100.0%

Table 33 — Cost of energy: comparing 2004 to 2007

x-axis legend items:	2004 commodity	2004 units	2004 cost per unit	2004 cost	2007 commodity	2007 units	2007 cost per unit	2007 cost
Aspen Electric	62,872,609	kWh	$ 0.08	$ 4,715,446	64,693,191	kWh	$ 0.09	$ 5,822,387
Holy Cross	141,283,859	kWh	$ 0.08	$ 11,302,709	159,436,793	kWh	$ 0.08	$ 13,233,254
SourceGas	1,452,744	Mcf	$ 10.75	$ 15,616,996	1,497,844	Mcf	$ 13.06	$ 19,561,838
AM Gas	363,186	Mcf	$ 9.43	$ 3,424,844	385,848	Mcf	$ 11.32	$ 4,367,802
Propane vendors	1,815,930	gallons	$ 1.31	$ 2,373,420	375,191	gallons	$ 1.89	$ 709,110
Commuting	12,635,963	gallons	$ 1.42	$ 17,980,975	11,778,838	gallons	$ 2.34	$ 27,527,144
Around town	3,698,454	gallons	$ 1.43	$ 5,288,789	3,804,498	gallons	$ 2.34	$ 8,891,112
Tourist driving	4,117,548	gallons	$ 1.43	$ 5,888,093	4,002,349	gallons	$ 2.34	$ 9,353,489
RFTA	291,989	gallons	$ 1.32	$ 384,257	439,040	gallons	$ 2.35	$ 1,030,865
School buses	17,420	gallons	$ 1.32	$ 22,925	17,500	gallons	$ 2.35	$ 41,090
ASD vehicles	13,380	gallons	$ 1.32	$ 17,608	12,500	gallons	$ 2.35	$ 29,350
Out-of-town ASD	5,352	gallons	$ 1.32	$ 7,043	5,000	gallons	$ 2.35	$ 11,740
Pitkin County diesel	11,870	gallons	$ 1.32	$ 15,621	8,865	gallons	$ 2.35	$ 20,814
Pitkin County gasoline	7,581	gallons	$ 1.32	$ 9,977	8,812	gallons	$ 2.35	$ 20,691
City of Aspen diesel	33,588	gallons	$ 1.32	$ 44,202	57,611	gallons	$ 2.35	$ 135,271
City of Aspen gasoline	62,590	gallons	$ 1.32	$ 82,368	37,823	gallons	$ 2.35	$ 88,808
SkiCo diesel & gasoline	210,468	gallons	$ 1.32	$ 276,976	237,350	gallons	$ 2.35	$ 557,298
Off-road fuel	150,440	gallons	$ 1.32	$ 197,979	101,633	gallons	$ 2.35	$ 238,634
Ambulances	2,588	gallons	$ 1.32	$ 3,406	2,588	gallons	$ 2.35	$ 6,077
Air travel via Aspen	12,983,681	gallons	$ 1.21	$ 15,671,303	10,022,903	gallons	$ 2.00	$ 20,045,806
Air travel via other airports	4,710,566	gallons	$ 1.21	$ 5,685,653	3,953,858	gallons	$ 2.00	$ 7,907,715
GA: jets	13,027,830	gallons	$ 2.83	$ 36,874,166	11,598,066	gallons	$ 4.69	$ 54,394,928
GA: turboprops	662,942	gallons	$ 2.83	$ 1,876,401	582,952	gallons	$ 4.69	$ 2,734,045
GA: piston	123,648	gallons	$ 2.83	$ 349,975	112,489	gallons	$ 4.69	$ 527,572
GA: air ambulance	7,413	gallons	$ 2.83	$ 20,982	6,909	gallons	$ 4.69	$ 32,403
			Total 2004	$ 128,132,114			Total 2007	$ 177,289,243

Table 33.2 — Cost of energy: comparing 2004 to 2007

x-axis legend items:	2004 commodity	2004 units	2004 cost per unit	2004 cost	2007 commodity	2007 units	2007 cost per unit	2007 cost	Change
Electricity	204,156,468	kWh		$ 16,018,154	224,129,984	kWh		$ 19,055,641	19.0%
Natural gas	1,815,930	Mcf		$ 19,041,840	1,883,692	Mcf		$ 23,929,640	25.7%
Propane	1,815,930	gallons		$ 2,373,420	375,191	gallons		$ 709,110	-70.1%
Ground transportation	21,259,230	gallons		$ 30,220,220	20,514,406	gallons		$ 47,952,382	58.7%
Aviation	31,516,080	gallons		$ 60,478,480	26,277,176	gallons		$ 85,642,469	41.6%
			Total 2004	$ 128,132,114			Total 2007	$ 177,289,243	38.4%

Cell: BE38
Comment: Rick Heede:
CMS reduces the number of motorcycles in the survey (done in Aug08) by half to better reflect annual averages.

Cell: BM44
Comment: Rick Heede:
Cost for residential customers. Coml customers paid 14.5 cents per kWh; not reflected in costs.

Cell: BH46
Comment: Rick Heede:
EIA natuarl gas, 2004, resl & coml.

Cell: BM46
Comment: Rick Heede:
EIA, Natural Gas Prices, 2007, Residential $13.06 and commercial $11.32.
http://tonto.eia.doe.gov/dnav/ng/ng_pri_sum_dcu_nus_a.htm

Cell: BH48
Comment: Rick Heede:
EIA (2008) AER 2007, Table 5.23: Sales Prices to End Users (for motor gasoline, diesel fuel, and propane).

Cell: BH63
Comment: Rick Heede:
EIA (2005) AER 2004, Table 5.22: Sales prices to end users; lists Jet fuel, motor gasoline, diesel, and propane prices.

Cell: BH65
Comment: Rick Heede:
CMS uses the 2007 multiple for Jet Fuel (air carrier) in AER to BC&A nationwide average Jet Fuel costs for private and business aviation for 2004.

Cell: BM65
Comment: Rick Heede:
Business & Commercial Aviation 2007 Operations Planning Guide, Aug07, p. 84: $4.69 average nationwide.

Cell: J78
Comment: Rick Heede:
The original 2004 summary worksheet missed adding in the 13 tons of diesel emissions from AVH. The 2004 total should therefore have been 840,888 tons CO2.

Aspen Emissions Inventory: Electricity, 2007

Future inventorists need to update electricity sales by each utility and to check the carbon dioxide and methane emissions factors for each utility's sources of purchased electricity. Note: this is calculated at the "ElectricityCarbon.xls" worksheet. All calculations are linked and automatically updated all the way to the AspenSum2007.xls worksheet and its derived charts.

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started: 2 October 2008
Last Modified: 13 April 2009

Data provided by:
Phil Overeynder
Director
City of Aspen Electric Dept.
970-920-5111
philo@ci.aspen.co.us

Data provided by:
Steve Casey
Member Svcs Supervisor
Holy Cross Energy
970-947-5430
scasey@holycross.com

Emissions of carbon dioxide from the combustion of fossil fuels at power plants supplying electricity to Xcel Energy (via Holy Cross Energy) and to Municipal Energy Agency of Nebraska (MEAN, via Aspen Electric Dept). Zero-carbon renewable sources are accounted for (see note under "Emission factor"). Methane emissions from coal mines supplying power plant fuel are also included (see note under "Methane" below and the "ElectricityCarbon.xls" worksheet).

City of Aspen Electric Dept if 2004 factors		
2004 EF:	1.2646	lb CO2/kWh
tons CO2	Methane, tons CO2e	Total, tons
40,907	443	41,350
	Savings w. 2007 EF	**22,053**

2007	Electricity		Carbon dioxide	Emissions				
	Consumption	Consumption	Emission factor	Carbon Dioxide	Methane	Methane	Total	Total
	kWh	MWh	CO2/kWh	tons CO2	tons CH4	tons CO2e	tons CO2+CH4	tonnes C-eq
			lb CO2/kWh (delivered)		lb CH4/MWh	25xCO2	lb CO2-equiv/kWh	kg C-eq/kWh
City of Aspen Electric Dept.			0.5902		0.2558	25	0.5966	0.074
Residential: single-family households	17,401,131	17,401		5,135	2.2	56	5,191	1,285
Residential: multi-family 2-4 households	1,812,227	1,812		535	0.2	6	541	134
Residential: multi-family 5+ households	5,079,241	5,079		1,499	0.6	16	1,515	375
Residential: Total	**24,292,599**	**24,293**		**7,169**	**3.1**	**78**	**7,246**	**1,794**
Commercial	**36,063,009**	**36,063**		**10,642**	**4.6**	**115**	**10,757**	**2,663**
Industrial	-	-		-	-	-	-	-
Municipal	**4,249,339**	**4,249**		**1,254**	**0.5**	**14**	**1,268**	**314**
Other (irrigation pumps)	**88,244**	**88**		**26**	**0.0**	**0**	**26**	**7**
Total, Aspen Electric Dept.	**64,693,191**	**64,693**		**19,091**	**8.3**	**207**	**19,298**	**4,778**

City Electric + Holy Cross Energy, sectors									
	Residential usage	113,201,055	kWh	Commercial usage	106,587,946	kWh	Irrigation	91,644
				Muncipal usage	4,249,339	kWh	Total	224,129,984

	Consumption	Consumption	Emission factor	Carbon Dioxide	Methane	Methane	Total	Total
	kWh	MWh	CO2/kWh	tons CO2	tons CH4	tons CO2e	tons CO2+CH4	tonnes C-eq
			lb CO2/kWh (delivered)		lb CH4/MWh	25xCO2	lb CO2-equiv/kWh	kg C-eq/kWh
Holy Cross Energy			1.6926		1.086	25	1.7197	0.213
Residential	**88,908,456**	**88,908**		**75,242**	**48.3**	**1,207**	**76,449**	18,929
Commercial	**70,524,937**	**70,525**		**59,684**	**38.3**	**958**	**60,642**	15,015
Irrigation	**3,400**	**3**		**3**	**0.0**	**0**	**3**	1
Municipal		-		-	-	-	-	-
Total, Holy Cross Energy	**159,436,793**	159,437		**134,929**	**87**	**2,165**	**137,094**	**33,944**

	Residential emissions	83,696	tons CO2e	Commercial emissions	71,399	tons CO2e	Municipal & Other	1,297
							Total	156,392

	Consumption	Weighted factor	Weighted factor	Carbon Dioxide	Methane	Methane	Total	Total
	kWh	CO2/kWh	CO2e/kWh	tons CO2	tons CH4	tons CO2e	tons CO2+CH4	tonnes C-eq
Total, Aspen Electric + Holy Cross Energy	**224,129,984**	**1.374**	**1.396**	**154,020**	**95**	**2,372**	**156,392**	**38,722**

Cell: E19

Comment: Rick Heede (Feb09):

Aspen's own generation at Ruedi increased from 11 to 17 million kWh (2004 vs 2007), new wind resources, and other low-carbon inititatives lowered Aspen's estimated carbon factor from 1.26 lb CO2 per kWh delivered in 2004 to 0.588 lb CO2 per kWh delivered in 2007. See "ElectricityCarbon2007.xls" for details.

Rick Heede (2005):

The carbon factors -- the amount of carbon dioxide per average kWh delivered to customers -- varies depending on the fuel mix of each of the electricity providers serving Aspen. *

Aspen Electric Dept purchased two-thirds of its power from the Nebraska Municipal Power Pool (NMPP) in Lincoln, Nebraska in 2004. Data from NMPP on the amount of fossil generation by type (coal- or gas-fired) are used to calculate the average emission of carbon dioxide per kWh generated. NMPP's own renewable generation (~4 percent) is factored in, as was a factor for the electricity lost in the transmission grid from Nebraska to Aspen (4.6 percent).

Holy Cross Energy estimated the carbon factor for its electricity based on data from Xcel Energy (from which Holy Cross buys most its power). A small grid-loss factor is also applied in order to estimate the amount of carbon dioxide associated with the CONSUMPTION of an average kWh of electricity, and, conversely, how much CO2 is avoided per kWh saved. The Holy Cross/Xcel datum of 1.67 lb CO2/kWh x 1.06 = 1.77 lb CO2/kWh consumed. **

* This simplified version excludes the complexities of power generation and delivery in the United States, such as the time of day, electricity "wheeled in" from other generators, peak power times, base loads, availability of hydro and wind power, maintenance schedules, and so forth. Nonetheless, an average carbon factor can be estimated for each utility. For carbon reduction purposes, the argument can be made that a kWh of electricity saved at night, when coal-fired power plants are providing base load capacity, keeps more carbon in the ground than during peak times (which is roughly breakfast and dinner time in Aspen), when more of the natural gas plants are supplying a larger proportion of the power generated.

** The Energy Information Administration estimates average US T&D losses "between the point of generation and delivery to the customer" at nine percent of gross generation EIA 2005, Annual Energy Review 2004, p. 223. We have reduced this factor to six percent (1.06) to account for the relative proximity of Xcel's power plants to Holy Cross's service area. Losses also occur in local grids, powerlines, and transformers.

Cell: G20

Comment: Rick Heede (Dec08):

Prelim: If we take "MEAN's resource mix (of own generation plus WAPA power purchases) was 82.9 percent coal-fired in 2004, this means a methane factor of 0.3086 lb CH4/MWh x 0.829 = 0.25583 lb CH4/MWh, or 0.25583 x 25 = 6.39574 lb CO2-equivalent per MWh, or 0.00639574 lb CO2e/kWh" and apply it to 2007.

Rick Heede (2005):

We develop a fugitive methane emissions factors for Holy Cross and MEAN-supplied electricity (each utility uses coal from different regions with varying methane emissions factors).

MEAN purchases and/or generates most of its power from plants burning coal from the Great Northern Plains coal basin. These are typically surface mines with methane emissions factors of 14 ft^3 per short ton produced. Since the net generation of electricity requires -- on average (power plants have widely different heat rates or conversion efficiencies) -- 1.04 lbs of coal per kWh (or 0.96 kWh per lb), then one ton of coal generates 1.92 MWh, or 0.521 tons of coal required per MWh. Great Northern Plains coal emits 14 ft^3 of methane per ton mined, thus for each MWh of electricity supplied by MEAN 0.521x 14 ft^3 CH4 = 7.3 ft^3 of methane for its coal-based generation. To convert to lb of methane: 7.3 ft^3 methane x 0.04228 lb/ft^3 = 0.3086 lb methane per MWh.

A similar calculation for Holy Cross electricity -- supplied by Xcel Energy, which uses Piceance Basin coals. These are primarily surface mines generating 77 ft^3 of methane per ton of coal (if underground mines, then 196 ft^3 per ton in situ), which equals 40.15 ft^3 per MWh of coal-based electricity supplied. To convert to lb of methane: 40.15 ft^3 methane x 0.04228 lb/ft^3 = 1.698 lb methane per MWh.

Note 1: we dilute the above factors by gas-fired generation in the resource mix of both MEAN and Xcel.

In the case of Xcel, 63.97 percent of its generation is by coal, hence we multiply 1.698 lb CH4/MWh x 0.6397 = 1.0862 lb CH4 per MWh of total Xcel generation. Since methane is 25 times as powerful a greenhouse gas as carbon dioxide, this equals 27.155 lb CO2-equivalent per MWh, or 0.027155 lb CO2-equiv per kWh.

MEAN's resource mix (of own generation plus WAPA power purchases) was 82.9 percent coal-fired in 2004, this means a methane factor of 0.3086 lb CH/MWh x 0.829 = 0.25583 lb CH4/MWh, or 0.25583 x 25 = 6.3957 lb CO2-equivalent per MWh, or 0.0063957 lb CO2e/kWh (updated to 25xCO2 in Feb09).

Principal sources (2005):

US Dept of Energy (2005) Voluntary Reporting of Greenhouse Gases (1605b Program: Draft Technical Guidelines, DOE Office of Policy and International Affairs, section 1.E.4.2.1. Coal mining, p. 105-106. The above source reports (on p. 105) an erroneous conversion factor for lb methane per cubic foot (now corrected in this comment and all fugitive methane calculations from 0.418 to 0.04228 lb/cf). This error was confirmed with DOE VRGG technical staff, personal communication, 26Sep05.

Personal communication with MEAN and WAPA staff.

EPA eGRID web-accessible database on utility carbon/MWh; www.epa.gov/cleanenergy/egrid

Note 2: Calculation of Methane emissions per ton of coal consumed (national average method, not used)

Methane emitted from surface mining plus underground mining plus post-mining activities plus CH4 vented less CH4 recovered in 2003 equals 2.87 million tonnes CH4 = 6,327 million lb CH4 (EIA Emissions 2003, p. 43);

Coal production in 2003 totaled 1,071.8 million tons (AER 2003, p. 205);

US national average methane emissions: 5.77879 lb CH4 per ton produced.

This method is not used, since the emissions from the coal mining regions of MEAN and Xcel production is more relevant to our emissions survey and affords greater opportunities for credits and savings than does a national average.

Cell: H20
Comment: Rick Heede:
Fugitive methane emissions of coals mined for each utility's coal-fired power plants diluted by coal-fired percentage of total generation and specific to each utility's coal-mining regions. This column converts tons of methane into tons of CO2-equivalent by multiplying by methane's conversion factor of 25xCO2 (100 hundred year horizon, mole basis), per IPCC Fourth Assessment Report.

Cell: E22
Comment: Rick Heede (27Feb09:
CMS finalized Aspen's total resource, including MEAN's (and WAPA's Upper Great Plains gas-fired spot market purchases of 48 percent gas-fired power & 52 percent hydro from federal dams). See "ElectricityCarbon2007.xls" for details.

Marta Darby:
14Nov08: Aspen Electric's carbon factor "verified via letter dated 4/1/08 from Phil Overeynder, City of Aspen Public Works Director."

Cell: I22
Comment: Rick Heede:
This value calculates the CO2-equivalent factor for each utility's carbon dioxide and methane emissions per average kWh and accounts for all carbon and non-carbon inputs to its resource mix. This factor also accounts for T&D losses from generation to delivery. While the factor has accounted for coal and natural gas fuel inputs (chiefly coal with respect to Aspen's non-renewable sources) as well as fugitve methane from coal mining, this estimate stops at the mine and power plant gates and does not include the energy and emissions arising from transportation of coal, nor the manufacture of loaders and draglines nor the diesel fuel to run the mining and transportation modes. See the Boundary definition in the final report for details.

Cell: B23
Comment: Rick Heede:
2004 summary of sales by sector and purchased electricity (WAPA, MEAN) plus generation sources from Phil Overeynder, Director City of Aspen Electric Dept, 15Aug05.

Cell: B42
Comment: Rick Heede:
HCE electricity sales within the inventory geographic area in 2004 provided by Bob Gardner and Steve Casey of Holy Cross Energy. Holy Cross supplies electricity within City Limits (outside the City Electric Dept's service territory) as well as buildings and facilities outside City Limits yet within our defined geographic areas-- chiefly contiguous to city limits.

Holy Cross intends to develop a data acquisition protocol based upon the regions within the utility's Township and Range maps. The relevant sectors were identified in a meeting between Bob Gardner and Steve Casey of HCE and Rick Heede of Climate Mitigation Services in Aug05.

Holy Cross Energy supplied data for residential and commercial sales only. We have assumed that "commercial" includes sales to the City of Aspen's buildings, pumps, and facilities and have deducted the 4.57 million kWh from the HCE provided for this study in order to avoid double-counting. See "Municipal" below.

Cell: E42
Comment: Rick Heede:
Marta Darby:
According to HC letter dated April 17, 2008. HCE carbon factor verified via letter dated 4/17/08 from Stephen Casey, HCE Member Services and Marketing Administrator.

See note under "Carbon factor" above. In sum, we have adjusted Holy Cross/Xcel Energy's estimated carbon factor up from 1.67 lb CO2/kWh generated to 1.77 lb CO2/kWh consumed by accounting for T&D losses of six percent (although averages nine percent in US).

Cell: G42
Comment: Rick Heede:
See discussion of fugitive methane per ton of coal mined in Xcel's service territory (chiefly Piceance Creek Basin) at cell G15 above.

Cell: B48

Comment: Rick Heede:

Holy Cross Energy did not disagggregate electricity sales to the City of Aspen's buildings, facilities, street lights, and miscellaneous. HCE did supply Lee Cassin of the City Env Health Dept for a separate accounting, in which a total of 4.57 million kWh supplied by Holy Cross Energy for the City's buildings and facilities outside its own utility's service territory such as Truscott Place, the ARC (1.74 million kWh), the golf course pumps and buildings (404,600 kWh).

Thus, in our account, we DEDUCT the 4.57 million kWh listed under municipal uses herein from the HCE data supplied for this study listed under "Commercial" above so as to avoid double-counting these sales.

Our purpose is simply to more fully account for all municipal energy uses.

Aspen Emissions Inventory: Electricity carbon factors, 2007

MEAN's resource mix must updated for future inventories; average emissions rates per MWh from coal and natural gas power plants should be updated with EIA data; Aspen Electric Dept's electricity supply by source must also be updated. Aspen's Phil Overeynder calculates carbon emissions from its generation sources, plus total procurement and total sales. Holy Cross also estimates its carbon factor each year.

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started 10 September 2008
Last Modified: 3 March 2009

Randy Wilkerson, Public Affairs, Western Area Power Administration
720-962-7056, <Wilkerson@wapa.gov>

Data supplied by

Phil Overeynder, City of Aspen Electric Dept
philo@ci.aspen.co.us, 970-920-5111
Jill Jones, jjones@nmppenergy.org, 402-474-4759
Municipal Energy Agency of Nebraska, MEAN/NMPP

US EPA eGRID database	Steve Casey, Holy Cross	EIA *Annual Energy Review*
epa.gov/cleanenergy/egrid	scasey@holycross.com	www.eia.doe.gov
	970-947-5430	

Table 1: Calculation of MEAN carbon factor for electricity sold to Aspen Electric Dept.

2007	MEAN	US power sector	US power sector	US power sector	US power sector	MEAN	MEAN	MEAN
	MEAN GenMix 2007	Emissions by source	Emissions by source	Electric generation	Elec emissions rate	Total emissions	Emissions rate	Generation by source
	MWh	Million tonnes CO2	Million sh tons CO2	Billion kWh	lb CO2/kWh gen	short tons CO2	lb CO2/kWh (gen)	percent
Coal	15,730	1,918	2,115	1,970	2.147	16,887	2.147	58.63%
Wind	529							1.97%
WAPA (2007: 1/2 UGP + 1/2 LAP)	4,341				0.521	1,131	0.521	16.18%
Oil & Natural Gas (50/50 per MEAN)	1,416	196	216	397	1.516	1,073	1.516	5.28%
Nuclear	4,813							17.94%
Total, and average	**26,829**			**3,721**		**19,091**	**1.4231**	100.00%

Table 1B. WAPA fossil vs hydro, 2007	market purchases (MWh)	total sales (MWh)	Percent market (fossil)	Average
WAPA Upper Great Plains (UGP)			48.0%	40.4%
WAPA Loveland Area Projects (LAP)	829,139	2,527,072	32.8%	50% UGP & 50% LAP

MEAN factor/*deliv.* kWh	MEAN fossil percentage
1.5245	**70.45%**

Table 2: Aspen Electric Dept carbon factor 2007

Sources	Generation sources	Emissions rate	Total emissions	Emissions rate	
	kWh (2007)	lb CO2/kWh (gen)	short tons CO2	lb CO2/kWh (del)	
MEAN	26,829,000	**1.4231**	19,091		
WAPA (direct)	4,992,000	near zero	near zero		
Ruedi Hydro	17,145,000	zero	zero		
Maroon Creek	2,262,000	zero	zero		
Windpower	18,074,534	zero	zero		
Total Gen/Gross Purch.	**69,302,534**			**0.55094**	CO2/kWh generated
Total Sold	**64,693,191**		19,091	**0.59019**	CO2/kWh delivered
T&D losses & unacc	4,609,343				
Percent losses & unacc	6.65%				

Table 3. Aspen Muni: Renewables and non-carbon fractions

2007	Renewables fraction	Non-carbon fraction
Renewables source	Aspen Electric, kWh	Aspen Electric, kWh
MEAN wind, hydro /nuclear	3,116,013	7,929,013
WAPA/CRSP direct hydro	4,992,000	4,992,000
Ruedi hydro	17,145,000	17,145,000
Maroon hydro	2,262,000	2,262,000
Aspen wind contract	18,074,534	18,074,534
Total renewables	**45,589,547**	**50,402,547**
Total generation	**69,302,534**	**69,302,534**
Percent renew/non-carbon	**65.78%**	**72.73%**

Table 4: US emissions by generating source 2006 (EIA *Annual Energy Review*)

2006	Emissions	Emissions	Generation	Elec emissions rate
	million tonnes CO2	million tons CO2	billion kWh	lb CO2/kWh gen
Table 12.7a All Sectors	Table 12.7a		Table 8.2a	
Gas	403.0	444.2	813.0	1.093
Coal	1,974.1	2,176.1	1,990.9	2.186
Total fossil	2,444.4	2,694.5	2,884.4	1.868
Nuclear & renewables	15.4	17.0	1,180.3	0.029
Total Generation	2,459.8	2,711.4	4,064.7	1.334
Electric Power Sector	Table 12.7b		Table 8.2b	
Gas	337.9	372.5	734.4	1.014
Coal	1,918.4	2,114.7	1,969.8	2.147
Petroleum	54.8	60.4	59.9	2.017
Total fossil	2,322.9	2,560.5	2,768.1	1.850
Nuclear & renewables	na	na	1,140.0	
Total Generation	2,322.9	2,560.5	3,908.1	1.310
Commercial & Industrial Sectors	Table 12.7c		Table 8.2d	
Gas	65.1	71.8	78.6	1.826
Coal	55.7	61.4	21.2	5.792
Total fossil	137.0	151.0	116.3	2.597
Nuclear & renewables	na	na	40.4	
Total Generation	137.0	151.0	156.7	1.927

Table 5. Emissions factors (CO2e/kWh consumed), 2007

	Aspen Muni	Holy Cross Energy
CO2 per kWh generated	0.5509	1.5800
CO2 per kWh delivered	0.5902	1.6926
Methane (as CO2e)	0.0064	0.0272
Total CO2e/kWh	0.5966	1.7197
Compare 2004:	1.2646	1.7950
Percent change:	52.8%	4.2%

Table 6. Holy Cross carbon emissions (system-wide)

2007	Percent of generation	Tons CO2
Coal	63.97%	728,586
Natural Gas	25.18%	117,338
Renewables	7.51%	-
"Imported - unknown"	3.34%	20,769
Percent renew/non-carbon	**100%**	**866,694**

Table 7: US EPA data on utility emissions (generation)

eGRID: US ave, 2005	Colorado average 2005	Xcel Energy 2005
lb CO2/kWh	lb CO2/kWh	lb CO2/kWh
1.329	1.911	1.692

Cell: B13
Comment: Rick Heede:
Jill Jones sent account of MEAN Overall Mix and Aspen procurement, in MWh, for 2008.

Cell: C13
Comment: :
KP sent email to Jill Jones on 9/10/08 asking for data

Cell: C14
Comment: Rick Heede:
MEAN's resource mix by fuel type for 2004 from Jill Jones, MEAN Planning Analyst, 22Aug05. Jones data column in kWh -- which is an error and must mean MWh.

Overall, MEAN data suggest a renewable fract on 3.79 to 4.22 percent for its three Service Schedules. In FY 2004/05, 56.50 GWh were classified as renewable ("includes WAPA hydro, Kimball Wind, and NPPD Wind") of total sales of 1,337.54 GWh. This agrees with our finding that WAPA is far less than 100 percent hydro generation, or the cited mix would be WAPA 169 GWh of 1,981 GWh total, or 8.6 percent, plus the 31.6 GWh wind line item = 1.6 percent.

Cell: D14
Comment: Rick Heede:
U.S. emissions from the electric power sector in EIA (2005) Annual Energy Review 2004, Table 12.7b. Emissions from commercial or industrial CHP units are not included.

Cell: F14
Comment: Rick Heede:
EIA (2005) Annual Energy Review 2004, Table 8.2b Electricity Net Generation: Electric Power Sector, p. 229. Utility-owned plants only (no industrial or commercial CHPs). Data for 2003.

Cell: B18
Comment: Rick Heede (2Mar09):
Randy Wilkerson (WAPA Loveland Area Projects) provided hydro generation by WAPA (BuRec dams) and market power from steam generators to cover shortage of own generation. CMS assumes that the market purchases from LAP have Xcel Energy's emission factor (1.692 lb CO2/kWh [gen]), and that LAP and UGP each contribute 50 percent of MEAN's total WAPA procurement in 2007. UGP (see note below) 52% hydro + 48% gas-fired. For LAP the percent market purchase was 32.8 percent in 2007 (829,139 MWh / 2,527,072 MWh).

Wilkerson provided Loveland Area Projects data for WAPA via MEAN to Aspen for 2007 inventory:
FY 2004 Total Energy Sales - 2,717,357 MWh Total Purchased Power - 1,212,754 MWh;
FY 2007 Total Energy Sales - 2,527,072 MWh Total Purchased Power - 829,139 MWh.

3March09 note: CMS formula is "0.5*(F53*E24)+0.5*(J64*E25)", which accounts (a) for WAPA being mostly hydro from federal dams, (b) the CMS assumption that WAPA buys its purchased power half from LAP and half from UGP, and (c) that LAP's 32.8 percent purchased power has an emission factor equal to Xcel Energy's EF (1,692 lb CO2/MWh) and UGP's 48 percent purchased power has an emission factor equal to gas-fired generation (see Table 4 below) of 1,014 lb CO2/MWh.

Rick Heede (Feb09):
Jill Jones: "MEAN's overall mix of WAPA is a combination of LAP, SLCA and UGP. LAP is Loveland Area Projects (also referred to as RMR-Rocky Mountain Region), and SLCA is Salt Lake Area City Area Projects (also referred to as CRSP-Colorado River Storage Projects)." CMS called WAPA Upper Great Plains (UGP: Radecki & Stonebarger) and RMR in Montrose (Otto) for resource mix. As Radecki confirmed, "we know it isn't zero" carbon, but don't know what it is. Stonebarger for UGP: 52% hydro + 48% gas-fired in 2007. Need RMR data, since UGP only provides some or none of power wired to Aspen.

Tentatively (27Feb): CMS calculates MEAN's WAPA component as 52 percent hydro (zero carbon) and 48 percent gas-fired generation. May be revised with RMR resource mix. The result (0.487 lb CO2/kWh) compares to BuRec's own generation in 2005 (eGRID PRCO05: 0.222 lb CO2/kWh), and WAPA UGP (eGRID PCAL05: 1.840 lb CO2/kWh), and WAPA Lower Colorado (eGRID PCAL05: 0.883 lb CO2/kWh).

Rick Heede (2005):
Western Area Power Administration (WAPA) is typically hydro-power, but WAPA Upper Great Plains (eastern) region is ~70 percent coal and ~30 percent gas; zero hydro is shown. This power has a carbon content of 1,594.96 lb CO2/MWh generated.

Note 1: WAPA carbon content varies by region: Upper Great Plains (west) is all hydro, hence no carbon/kWh. WAPA Rocky Mountain region emitted 1,884.23 lb CO2/MWh generated.

Source: EPA eGRID emissions database; www.epa.gov/cleanenergy/egrid/index.html (See Owner-Based Power Control Area file, worksheet "EGRDPCAO00".)

Note 2: a telephone conversation with John Stonebarger, WAPA Energy Mgmt and Marketing official, tel 605-882-7560 (ref from Sam Miller, WAPA in Billings, 406-247-7466, csmiller@wapa.gov): WAPA owns hydro generation assets along the Missouri River (with zero carbon), but does market power generated by several privately-owned steam plants. We estimate MEAN's emissions (and thus Aspen Electric Dept's) on the basis of carbon-content of purchased power, which in this case includes the fossil plants not owned but marketed with WAPA's own generation, i.e., 1.595 lb CO2/kWh.

Cell: B19
Comment: Rick Heede:
Jones, 24Feb09: "Assumes market purchases are 50% natural gas, 50% coal." CMS therefore averages the Electric Power Sector emission factors of natural gas and petroleum generation, US 2006.

Cell: B23
Comment: Rick Heede (2Mar09):
CMS gathered this data for 2007 from MEAN/NMPP (Jill Jones), Stonebarger and Radecki at WAPA UGP and Wilkerson at WAPA LAP in order to trace fossil-fueled carbon emissions back to WAPA market power purchases. See WAPA note above for details and sources.
Wilkerson sent details on the sources of LAP 2007 power purchases, e.g., total of 828 GWh, of which 204 GWh from Cargill-Alliant LLC, 144 GWh from Platte River Power Authority (mostly coal-fired gen), 119 GWh from Xcel Energy (also coal and gas, ave 1.692 lb CO2/kWh), Aquila Inc, etc. While CMS has not reviewed the portfolios of every power source, CMS' assumption that LAP purchased power averages Xcel Energy's gas and coal-fired generation seems reasonable. See note above, under MEAN's WAPA, for details.

Cell: I29
Comment: Rick Heede:
CMS estimates the Aspen Electric Dept renewables fraction as follows:

MEAN is 4 percent renewable (ie, 4 percent of 44.141 GWh). Source: Jill Jones, MEAN, Aug05, to CMS via Phil Overeynder; this renewables fraction combines MEAN's Service Schedules J, K, and M (individual breakdowns were not listed; Aspen gets class M).
.
Aspen Muni purchases power from Colorado River Storage Project via WAPA and/or US Bureau of Recretion's mostly hydropower facilities on the Colorado and the Colorado Plateau, e.g., Flaming Gorge on the Green River. "WAPA direct" is 0.986 lb CO2/kWh CRSP emissions divided by coal generation emissions (US average) of 2.15 lb CO2/kWh = 45.86 percent "non-fossil". This equivalence assigns (100. percent - 45.86 percent) 54.14 percent of "WAPA direct" to Aspen Muni's renewable power column, or 5.08 GWh times 0.5414 = 2.751 GWh renewable. This formula may be followed in future years in which Aspen Muni may opt in to additional (non-hydro) power purchases.
Correction, 16Dec05: CMS has determined that WAPA's CRSP delivered only hydropower to Aspen Muni in 2004; Muni opted out of additional power purchases from coal-fired plants in 2004 that were made available via WAPA/CSRP to make up for hydropower shortfalls in drought years.

Ruedi, Maroon Creek, and Windpower are, of course, all renewable.

MEAN's nuclear generation is not entered in this renewable electricity column, even though some proponents and government agencies do preposterously consider nuclear to be a renewable electricity source. The column on the right estimates "non-carbon fraction," and does include MEAN's nuclear generation.

Cell: J29
Comment: Rick Heede:
This is the same calculation as the "renewable fraction" column, but adds MEAN's nuclear generation as follows:

MEAN's nuclear generation is factored into this column, as nuclear is typically considered a zero-carbon source of electricity.** MEAN's nuclear component can be considered non-fossil but not renewable. Then Aspen could add 12.63 percent of MEAN's power supply, or 44.141 GWh times 0.1263 = 5.575 GWh, which would bump Aspen's "non-fossil" from 32.15 percent to 40.61 percent. The nuclear generation does, of course, reduce Aspen's emissions through nuclear's dilution of fossil generation by MEAN, and thus reduces Aspen's average carbon emissions per kWh sold to its customers.

** Zero-carbon electric generation only if one ignores the relatively small but non-zero emissions from uranium mining, coal-fired enrichment services, plant construction, decommissioning, waste storage, transportation, and ultimate waste disposal: Nuclear Energy Agency (2002) estimates 2.5 to 5.7 gC-e/kWh.
Heede (2004) "Black Hydrogen: An Assessement of the U.S. Department of Energy's Plans for Nucler Hydrogen Production," p. 24.

Cell: B31
Comment: Rick Heede:
MEAN's 2004 generation mix is listed in Table 1.

Cell: H31
Comment: Rick Heede:
CMS calculates MEAN's resource mix in Table 1. MEAN's net renewable (accounting for MEAN's WAPA UGP and LAP purchased power fossil-fuel generation in Table 1B) plus wind. MEAN's Non-Carbon fraction adds nuclear to its renewable portfolio.

Cell: B32
Comment: Heede (Feb09):
CMS again adopts the 2004 decision to not count WAPA's CRSP emission rate (eGRID suggests 883.5 lb CO2/MWh for Lower Colorado; no data for CRSP only) in lieu of the City of Aspen's non-participation in optional power purchases.

Rick Heede:

16Dec05 note: Phil Overeynder to Rick Heede, CMS: "It is true that in aggregate, WAPA purchased coal fired energy to make up part of the difference between their contract obligations and available hydropower. These purchases were at the request of individual CRSP customers and are tracked and billed separately. Each quarter we are given the choice of whether or not to participate in these additional purchases and generally we decline in favor of making up the difference in the contract by purchasing MEAN's available resources. I can quantify this by looking back at the records if you wish to pursue. At any rate, I would argue that close to 100% of our WAPA-CRSP resources are hydroelectric power since Aspen does not generally participate in these optional purchases." CMS has thus eliminated carbon emissions from Aspen Muni's direct power contract with WAPA; that is, from 0.9857 lb CO2/kWh (gen) to 0.0 lb, reducing emissions for the Muni's procurement of 5.08 GWh from 2,504 tons CO2 to zero tons.

Pre-Dec05 comments:
CMS initially considered Aspen Muni's direct WAPA contract to be with WAPA's Rocky Mountain Region (1,884.23 lb CO2/MWh) or with WAPA's Phoenix PCA (690.427 lb/MWh). Phil Overeynder says the Aspen contract is with WAPA's Colorado River Storage Project, NOT the Rocky Mountain region.

CSRP is either US Bureau of Reclamationa (BuRec) Upper Colorado or Lower Colorado Region. The latter is most likely: BuRec Upper Colorado is primarily hydro through its many large and medium-sized dams and powerplants such as Glen Canyon, Flaming Gorge, Blue Mesa, Collbran, etc. However, according to the EPA power plant emissions database, EGRID lists BuRec's Upper Colorado as 985.653 lb CO2 per MWh. Source: EPA eGRID2000 EGRDECO worksheet line #1795, parent name = BuRec, power control area = WAPA - Rocky Mtn Region. www.epa.gov/cleanenergy/egrid/index.html

Cell: F43
Comment: Rick Heede:
This analysis uses US average carbon emissions per kWh generated by source (gas and coal, re: MEAN's two fossil sources). We calculate emissions for three classes of power plants (utility-owned "power sector", CHP owned by commercial and industrial sectors), and combined power sector + CHP). Since MEAN procures power from utility-owned power plants, we use the utility only carbon factor for each gas and coal-fired plants, which are highlighted in red on the worksheet. These factors are then used in Table 1 to estimate MEAN's total carbon emissions.

Cell: C44
Comment: Rick Heede:
Energy information Administration (2008) Annual Energy Review 2007. Tables as cited below.

Cell: J44
Comment: Rick Heede (13Feb09):
Steve Casey provided the 2007 carbon intensity: 1.58 lb CO2 per kWh.

Rick Heede (2005):
Holy Cross Energy's carbon coefficient is taken from HCE published data ("New Carbon Report Card," Consumer Connection, Sep04. That datum -- 1.67 lb CO2/kWh -- is adjusted upwards by 6 percent to account for transmission and distribution losses. This US average T&D factor is 9 percent, which CMS arbitrarily reduced to 6 percent in view of Xcel's generation assets being located in Colorado and not requiring long transmissions distances.

Cell: J53
Comment: Rick Heede:
Holy Cross data for system-wide power procurement, chiefly from Xcel Energy, in 2004. Source: Holy Cross Energy (2004) The Consumer Connection, vol 19(3), September.

Note: CMS has relied on HCE data and has not independently calculated the utility's carbon emissions.

Cell: H54
Comment: Rick Heede:
Four percent of MEAN's total resource mix is renewable. In 2004, Aspen Muni's purchase of 44.1 GWh * 0.04 = 1.77 GWh.

Cell: H57
Comment: Rick Heede:
Holy Cross appears to have used a carbon factor for this unknown generation source at 75 percent of the natural gas emissions rate -- ~0.675 lb CO2/kWh. Estimated from HCA data.

Cell: J61
Comment: Rick Heede:
US EPA eGRID database for 2005 (Jan09), US average emission rate: 1,329.3 lb CO2/MWh. CMS also lists State of Colorado, and Xcel Energy emission rates. Additional emissions from methane and nitrous oxide; see eGRID. www.epa.gov/cleanenergy/egrid/index.html

Cell: J62
Comment: Rick Heede:
EPA eGRID shows Xcel as 1,763 lb CO2/MWh. CMS instead uses Xcel Energy's 2006 emission factor (direct from Xcel staff for CMS' Town of Frisco project) at 1,692 lb CO2/MWh (gen).

Aspen Emissions Inventory for 2007: Natural Gas

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started 11 August 2005
Last Modified: 6 January 2009

Future inventorists must update annual sales from SourceGas. SourceGas data include natural gas transported for AM Gas. SourceGas started reporting "Aspen," "Snowmass Village," and "Woody Creek" separately based on billing address zip code of each jurisdiction. SourceGas also provided a conversion factor based on altitude of each jurisdiction. CMS adopts this local billing pressure adjustment and Btu to colume conversion.

Data provided by:
Jerrad Hammer
Manager, Regulatory Affairs
Source Gas
303-243-3496
Jerrad.Hammer@sourcegas.com

Data provided by:
Bart Levine, President
AM Gas, 970-925-2901
Jeff Grebe, President
MechTric Engineering
970-928-9687

Table 1	Natural Gas		Emissions factor	Emissions				
	Consumption	Consumption		Carbon Dioxide	Methane	Methane	Total	Total
2007	Thousand cf (Mcf)	Billion Btu (10^9)	carbon per btu	short tons CO2	short tons CH4	tons CO2e	tons CO2e	tonnes C-eq
	cubic feet/million btu	Btu per cubic foot (adj)	tonnes C/billion Btu	tons CO2/billion Btu	tons CH4/ton CO2	tons CO2e/ton CO2	tons CO2e/billlion Btu	tonnes C-e/billlion Btu
SourceGas	1,215	823.20	14.47	58.44	0.00571	0.14274	66.79	16.54
Residential	956,705	788		46,029	262.8	6,570	52,599	13,023
Commercial	541,138	445		26,035	148.7	3,716	29,751	7,366
Municipal (included above)		-			-	-	-	-
Total, SourceGas	**1,497,844**	**1,233**		**72,064**	**411**	**10,286**	**82,350**	**20,389**

	Consumption	Consumption	Emissions factor	Carbon Dioxide	Methane	Methane	Total	Total
	Mcf	Billion Btu (10^9)	carbon per btu	short tons CO2	short tons CH4	tons CO2-eq	tons CO2-e	tonnes C-eq
AM Gas, Inc.	1,215							
Residential		-			-	-	-	-
Commercial & Institutional	385,848	318		18,564	106.0	2,650	21,214	5,252
Total, AM Gas	**385,848**	**318**		**18,564**	**106**	**2,650**	**21,214**	**5,252**

Table 2	Consumption	Consumption	Emissions factor	Carbon Dioxide	Methane	Methane	Total	Total
2007	Mcf	Billion Btu (10^9)	carbon per btu	short tons CO2	short tons CH4	tons CO2-eq	tons CO2-e	tonnes C-eq
SourceGas + AM Gas	**1,883,692**	**1,551**		**90,628**	**517**	**12,936**	**103,564**	**25,641**

Residential emissions	52,599	tons CO2e	
	50.79%		
Commercial & Institution	50,965	tons CO2e	
	49.21%		

Table 2
Calculation of methane emissions rate for the natural gas industry

Methane from natural gas industry:	**7.1**	million tonnes CH4
CO2 from natural gas consumption:	**1,237**	million tonnes CO2
Methane emissions rate as CH4	**0.00571**	kg CH4/kg CO2
Methane emissions rate as CO2e	**0.14274**	kg CO2e/kg CO2
CO2 plus methane emissions rate (short tons)	**66.787**	tons CO2e/billlion Btu
Carbon plus methane emissions rate (metric)	**16.535**	tonnes C-e/billlion Btu

EIA 2008, methane GWP
25xCO2

Table 3
Carbon factors (Aspen)

116.89	lb CO2/million Btu
133.57	lb CO2e/million Btu
0.0962	lb CO2/cf
0.1100	lb CO2e/cf
9.622	lb CO2/ccf
10.996	lb CO2e/ccf
96.22	lb CO2/Mcf
109.96	lb CO2e/Mcf
1,215	cubic feet/million Btu
823.2	Btu/cubic foot
58.44	tons CO2/billion Btu

Standard conversions
1 tonne = 1.1023 tons
1 tonne = 1,000 kg
1 kg = 2.2046 lb

Table 4
Carbon factors (Standard sea level)

117.08	lb CO2/million Btu (sea level)
0.121	lb CO2/cf (sea level)
120.59	lb CO2/Mcf (sea level)
973.7	cubic feet/million Btu (sea lev
1,027.0	Btu/cubic foot
58.44	tons CO2/billion Btu

Cell: J7
Comment: Rick Heede:
Jeff Grebe reviewed our pressure altitude adjustments, informed our research on Kinder Morgan's PUC filings, and provided helpful background the natural gas measurement protocols at altitude.

Cell: E14
Comment: Rick Heede:
Kinder Morgan supplied natural gas sales data in million Btus per month. Emissions from the combustion of natural gas varies slightly (+/- 3 percent) by its heating value. We use the national average heating value of 14.47 milligrams/Btu or, as it is usually reported, Tg/QBtu (teragrams/quadrillion Btu); in normal parlance this factor equals 14.47 kg of carbon per million Btu, which, at average heating value, equals ~974 cubic feet of gas. Our calculation sidesteps the issue of how many ccf Kinder Morgan sold in 2004 since the data is reported in units of million Btu. Low-heating value natural gas (say below 950 Btu/cf) is typically due to high CO2 content in the supplied gas.

Factors reported in this column include:

14.47 kg C per million Btu.
Source: U.S. Environmental Protection Agency (2005) Inventory of U.S. Emissions and Sinks: 1990-2003, Annex B: Methodology for Estimating the Carbon Content of Fossil Fuels, http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2003.html

Tonnes CO2 per billion Btu simply multiplies C by 3.664191 -- the isotopically accurate conversion factor -- to convert carbon to CO2, assuming full combustion of the natural gas.

* While the energy content of a cubic foot of natural gas is highly dependent on the pressure altitude at which it is delivered, the carbon content per million Btu, which is the method we employ here, only varies slightly, as mentioned above. At normal sea level pressure and energy value, one cubic foot of natural gas has a heating value of 1,027 Btu (but can vary from 950 - 1,100 Btu/cf).

At sea level, one hundred cubic feet (ccf) emits 12.0953 lb CO2 upon combustion. At altitude, both the energy content and the carbon emissions will far less per ccf. A controversy over the tariffs charged Aspen customers has arisen between the City of Aspen and Kinder Morgan: the City contends that the altitude adjustment made by the gas suppliers over-charges local customers for the lowered energy content of the gas supplied. The argument is over a fair price for the energy rather than the volume of gas delivered: it's as if popcorn buyers are being charged extra for the inflated air in the bag rather than the weight of popcorn, or electric customers are charged for a kilowatt-hour but only get 930 watt-hours.

See the cell comment at C15 for our calculation of conversion factor (1,160 cubic feet per million Btu, = 862 Btu per cubic foot). This also means: 14.47 kg of C per million Btu = 116.89 lb CO2 per million Btu also equals (per my calculation) 1,160 cf, then 100 cf = 116.89/11.6 = 10.077 lb CO2 per 100 cf, or 16.44 percent less CO2/cf than at sea level.

Also, the Btu content varies by contract and even by season. Kinder Morgan is required by the Colorado Public Utilities Commission (PUC) to deliver gas with a minimum Btu content of 950 Btu/cf (national average is 1,027 Bt/cf).

Cell: F15
Comment: Rick Heede:
Carbon dioxide emissions are a product of natural gas sales in billion Btu times the carbon emissions factor in column "E."

Cell: G15
Comment: Rick Heede:
See notes in Table 2 below for methodology used to estimate fugitive methane emissions rate applied to Aspen's consumption of natural gas.

Cell: C17
Comment: John Eisler (Sep08) & Heede (Dec08): Jerrad Hammer (Source Gas Manager of Regulatory Affairs, 303-243-3496, jerrad.hammer@sourcegas.com), the Pressure Base for the volumes supplied are at 14.73 psia. The gas averaged 1,070 Btu/cf for the period of time.

SourceGas calculated a thermal conversion factor in its 2008 Rate Case of 823.2 Btu per cf, or 1,215 cf per million Btu, in Aspen. Woody Creek: 1,198 cf/million Btu, adn Snowmass Village: 1,232 cf/million Btu.

Rick Heede:
At sea level 1 cubic foot (cf) of natural gas contains, on average, 1,027 Btu. Kinder Morgan's gas averaged 1,070 Btu/cf in 2004.(*) Kinder Morgan's "local billing pressure" (LBP) is 11.87 psi (vs 14.73 at sea level); 11.87/14.73 = 0.80584 altitude adjustment factor. Therefore, 1 cf at 1,070 Btu*0.80584 = 862.3 Btu; conversely, 1 million Btu = 1,160 cf. This is the conversion factor used here.

However, the City of Aspen has pointed out that Aspen's pressure altitude is 11.04 psi, not KMI's LBP of 11.87 psi. If so, then 11.04/14.73 = 0.7495, or: 1 cf at 1,070 Btu*0.7495 = 802 Btu; conversely, 1 million Btu = 1,247 cf. The City of Aspen argues that Aspen consumers are paying for 862.3 Btu when the actual Btu content of 1 cubic foot is 802 Btu, which means an excess charge of 862.3/802 = 1.0752, or 7.52 percent.

Regardless of the merits of this argument vs KMI's zonal pressure adjustments, we apply Kinder Morgan's altitude cubic foot (ACF) factor: 1 million Btu = 1,160 ACF, and 1 ACF = 862.3 Btu.

(*) Brad Van Dyke, KMI, personal communication, 4Oct05.

Cell: B18
Comment: John: Information on the worksheet "2007 Natural Gas Volume Totals for Aspen.xls" seperated gas flows by Aspen, Snowmass and Woody Creek. Therefore all numbers here reflect only the values provided for Aspen and surrounding areas, not Woody Creek or Snowmass. 9/16/08

Rick Heede:
Data from Brad Van Dyke and Scott Emerson of Kinder Morgan, 29Sep05.

Van Dyke: "Attached is a file that provides the total amount of gas that flowed through the Aspen/Snowmass and Woody Creek town border stations in 2004. As noted in the file the estimated portion of the gas related to the Aspen area that flows through the Aspen/Snowmass town border station is about two-thirds. The estimated portion of gas related to residential and commercial in the Aspen area is approximately 50/50. There are no customers classified as industrial."

Emerson is Dir of Retail Business Development & Transportation Svcs., KM, PO Box 281304, Lakewood, CO 80228-8304, scott_emerson@kindermorgan.com, 303-763-3597

Brad_VanDyke@kindermorgan.com

Note 1: CMS apportioned KMI sales to Aspen plus Snowmass Village at the Woody Creek TBS on the relative populations of each area rather than on KMI's estimated "about two-thirds." Our methodology is as follows: Aspen population plus Urban Growth Boundary population plus ToSV plus ToSV UGB factor: Aspen 6,455 pop plus 1,186 UGB = 7,641 total Aspen area population with the emissions boundary as a fractoin of ToSV 2,317 pop plus ToSV UGB pop of 426: Aspen / Aspen plus ToSV = 7,641 / (7,641 + 2,743) = 7,641/10,384 = 73.6 percent. This percentage is applied to KM's total sales (excluding Woody Creek itself) as measured at the Woody Creek TBS, namely 2,127 billion Btu x 0.736 = 1,565 billion Btu, of which 80 percent is estimated as KM sales (1,251 billion Btu) and 20 percent as transported AM Gas (313 billion Btu).

Note 2: KMI could not provide specific data on natural gas transported for AM Gas, and we use AM Gas' estimated 20 percent datum. We did confirm that KMI data includes AM Gas.

Cell: D19
Comment: Rick Heede:
CMS reviewed the SourceGas worksheet but found no Bcf to billion Btu conversion, nor an allocation of residential and commercial. Hammer does specify percentage allocations. Check all this work carefully.

johnei:
see worksheet 2007 Natural Gas Volume Totals for Aspen.xls for formula. Pretty sure I didn't do it right.

Cell: B27
Comment: Rick Heede:
AM Gas supplies natural gas transmitted through KinderMorgan pipelines to several large commercial customers in Aspen. According to AM president Bart Levine, AM delivers ~20 percent of the natural gas consumed in Aspen.

1Oct05: CMS confirmed that Kinder Morgan gas data includes gas transmitted for AM Gas; KMI did not respond to request for specific transported gas quantities or fractional data.

Cell: D29
Comment: johnei:
See comment in box D17

Cell: D43
Comment: Rick Heede (Jan09, updated from 2005):
We estimate the upstream fugitive emissions of methane from the natural gas system from production through delivery. In 2007, U.S. methane emissions from natural gas systems totaled 7.063 million (metric) tonnes; in the same year, natural gas consumption was 23.055 trillion cubic feet (Tcf; US dry gas production totaled 19.278 Tcf), which equals 0.6754 lb of methane per thousand cubic feet (Mcf) of gas consumed. Thus, (0.6754 lb CH4/Mcf) / 42.37 lb/Mcf (standard conversion factor, revised by EIA in 2008) = 15.94 cf of methane lost per Mcf of delivered natural gas = 1.594 percent fugitive emission rate; that is, a system loss rate relative to delivered natural gas. This is prior to accounting for the GWP value of methane, done below and in Table 2. *

We are NOT attributing this additional emissions source to SourceGas or AM Gas. We are, however, allocating such additional systemic emissions to consumers for whom the production occurs.

The result is that an amount equivalent to 14.27 percent of the CO2 emitted by burning natural gas is emitted as fugitive methane by the natural gas industry. That is, a 0.571 percent fugitive methane rate times methane as 25xCO2 = 14.27 percent as CO2e.

* Production (2.03 million tonnes CH4), Gas Processing (0.66 million tonnes), Transmission and Storage (2.41 million tonnes), Distribution (1.97 million tonnes CH4), Total (7.06 million tonnes CH4). We are not including the small quantities of methane released from end-use equipment in the residential and commercial sectors (0.01 million tonnes CH4). EIA 2008.

Sources: Energy Information Administration (2008) Annual Energy Review 2007; Energy Information Administration (2008) Emissions of Greenhouse Gases in the United States 2007. Note: EIA has adopted the IPCC FAR GWP value of methane = 25xCO2, EIA 2008, page 12: "Methane. In its Fourth Assessment Report, the IPCC developed revised global warming potential factors (GWPs) for selected gases. The GWP for methane was revised from the previously published value of 23 in the IPCC's Third Assessment Report to 25 in the Fourth Assessment Report. The revised GWP for methane is used in this report. In addition, this report incorporates an increase in the density of methane from 42.28 to

42.37 pounds per thousand cubic feet, in order to provide consistent temperature and pressure values for methane in all EIA data."

See also Kirchgessner, David A., Robert A. Lott, R. Michael Cowgill, Matthew R. Harrison, & Theresa M. Shires (~2000) Estimate Of Methane Emissions From The U.S. Natural Gas Industry, US EPA: AP 42, Fifth Edition, vol. 1 chapter 14, www.epa.gov/ttn/chief/ap42/index.h

Cell: G43
Comment: Rick Heede:
These factors are for easy visibility and are derived from the factors calculated in the main worksheet.
The main factors are 19.7 percent lower than at sea level, eg, 96.22 lb CO2/Mcf vs 120.593 lb CO2/Mcf at sea level.

Cell: I44
Comment: Rick Heede:
lb CO2 per million Btu should be the same in Aspen as at sea level at STP. The minor difference derives from the factors supplied by SourceGas. This factor is from the DOE.

Cell: E45
Comment: Rick Heede:
Energy Information Administration (2008) Annual Energy Review 2007; Energy Information Administration (2008) Emissions of Greenhouse Gases in the United States 2007. Note: EIA has adopted the IPCC FAR GWP value of methane = 25xCO2, EIA 2008, page 12: "Methane. In its Fourth Assessment Report, the IPCC developed revised global warming potential factors (GWPs) for selected gases. The GWP for methane was revised from the previously published value of 23 in the IPCC's Third Assessment Report to 25 in the Fourth Assessment Report. The revised GWP for methane is used in this report. In addition, this report incorporates an increase in the density of methane from 42.28 to 42.37 pounds per thousand cubic feet, in order to provide consistent temperature and pressure values for methane in all EIA data."

Aspen Emissions Inventory for 2007: Propane

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started 7 August 2008
Last Modified: 2 February 2009

Future inventorists must request updated propane sales figures from AmeriGas, Ferrellgas, Cross Propane, and Propane Services (and any new propane vendors serving Aspen).

Data supplied by:	Data supplied by:	Data supplied by:	Data supplied by:	Data not supplied by:
Cross Propane & Supply	Propane Services	Tad Peed, Mngr.	Brian Mater	Ferrellgas, Inc.
Tom McBrayer	Basalt, 970-927-4757	AmeriGas	Corp Comm, HQ, Kansas	970-945-8611
GWS, 970-384-2222		970-963-3113	913-661-1873	970-243-2720
tmcbrayer@crosspropane.com		peedt@amerigas.com	brianmater@ferrellgas.com	

2007	Propane Sales	Approximate consumption	Carbon Factor	Carbon Dioxide	Methane	Total Emissions	Total Emissions
	gallons	Million Btu	lb CO2/gallon	tons CO2	tons CO2e	tons CO2e	tonnes C-e
Propane vendor			12.669		tons CO2e/ton CO2		
					0.0544		
AmeriGas	220,000	20,093		1,394	76	1,469	364
Ferrellgas	36,233	3,309		230	12	242	60
Cross Propane & Supply (residential sales)	51,226	4,679		324	18	342	85
Cross Propane & Supply (commercial sales)	17,732	1,620		112	6	118	29
Propane Services, Basalt	50,000	4,567		317	17	334	83
Total propane sold in the Aspen area	375,191	34,267		2,377	129	2,506	620

Methane, tons, @25xCO2	5.17	tons CH4
Methane, percent of total	5.16%	

AmeriGas estimate	Gallons Sold	Percent	Percent Aspen & TOSV
Aspen Area	220,000	64.7%	78.0%
Woody Creek Area	58,000	17.1%	
Snowmass Village Area	62,000	18.2%	22.0%
Total	340,000	100.0%	

Conversions		
1 gallon propane	91,333	Btu
1 bbl of propane	3.84	million Btu
1 million Btu	10.95	gallons
1 million Btu	138.71	lb CO2
1 million Btu	146.25	lb CO2e
1 gallon propane	12.669	lb CO2
1 gallon propane	0.028	lb CH4
1 gallon propane	13.358	lb CO2e

Cell: E17
Comment: Marta Darby:
2007 factor from CCX - 0.006 metric tons CO2/gallon (conversion to lbs. : 1 metric ton = 2204.6 pounds). CMS corrected this calculation (12Dec08) -- converting from 0.006 tonnes CO2 to lb per gallon is far too inaccurate. CMS uses standard EF of 12.669 lb CO2 per gallon from DOE, EPA, etc.

Rick Heede:
Carbon factor from Environmental Protection Agency (2005) Inventory of U.S. Emissions and Sinks: 1990-2001 Annex B: Methodology for Estimating the Carbon Content of Fossil Fuels, http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2003.html

Cell: F17
Comment: Rick Heede:
Propane sales times carbon factor of 12.669 lb CO2 per gallon at full combustion / 2000 lb per ton.

Cell: G17
Comment: Rick Heede:
A fugitive methane rate is applied to the propane production and processing infrastructure. See "methane" comments on the "Natural Gas" worksheet, in which production through delivery methane emissions are allocated to Aspen's consumption of natural gas. In the case of propane, we allocate the US national fugitive emissions rate for natural gas (from which most propane is processed) in the production and gas processing stages: 2.03 million tonnes CH4 plus 0.66 million tonnes CH4 of total natural gas system methane emissions of 7.06 million tonnes CH4, or 2.69 of 7.06 million tonnes CH4 = 38.102 percent of the natural gas rate -- which is 0.14274 tons CO2e per ton CO2 (see Natural Gas worksheet, table 2) -- from the propane's combustion. * Hence, the propane fugitive methane rate is 0.14274 x 0.38102 = 0.05439 tons CO2e per ton of propane delivered to and combusted by Aspen customers.

* Production (2.03 million tonnes CH4), Gas Processing (0.66 million tonnes), Transmission and Storage (2.41 million tonnes), Distribution (1.97 million tonnes CH4), Total (7.06 million tonnes CH4). We are not including the small quantities of methane released from end-use equipment in the residential and commercial sectors (0.01 million tonnes CH4). EIA 2008.

Sources: Energy Information Administration (2008) Annual Energy Review 2007; Energy Information Administration (2008) Emissions of Greenhouse Gases in the United States 2007.

Cell: B22
Comment: Rick Heede (Nov08):
Peed provided revised data (220,000 gallons in Aspen in 2007); see AmeriGas table below.

Marta Darby:
AmeriGas provides 500k to 625k gallons to Aspen, Woody Creek and Snowmass area.
-- Tadd Peed was unable to provide a more precise value. (per email 9/29/08)

Rick Heede:
2004 propane sales data for the Aspen area (by Township) from Tadd Peed, Manager (Carbondale office), 970-963-3113, peedt@amerigas.com; personal communication, 7Sep05.

Cell: B24
Comment: Rick Heede
9Oct08, Rick contacted Scott Brockelmeyer at Ferrellgas HQ in Kansas (scottbrockelmeyer@ferrellgas.com, 913-661-1830) for assistance in acquiring propane sales data for Aspen, by zip code. 17Nov08 update: Ferrellgas' Brian Mater will get 2007 propane sales for zipcodes 81611 and 81612. Data received 25Nov08, sorted by delivery zip codes 81611 and 81612 or calendar year 2007. Largest delivery totaled 3,960 gallons, smallest 156 gallons, 33 of 67 customers took delivery in 2007, average delivery for all 67 customers was 541 gallons (1,097 gallons for 33 deliveries in 2007).

Marta
8/19/08: FerrellGas declined to provide data. {Spoke with Karen Kraft on the phone who said her boss told her to not work with us on this.}

Rick Heede:
Several requests for data have yielded unmet promises to provide Aspen area propane sales for 2004 (most easily by sorting for zip code).

Contact Karen Kraft, 970-945-8611, karenkraft@ferrellgas.com.

Cell: B26
Comment: Rick Heede:
Tom McBrayer, mngr., provided estimates of total propane sales to Aspen-area residential customers based on delivery zip code 81611 and 81612. While this is not an exact match to the Aspen inventory physical boundary, the modified UGB, since it might include some customers up Independence Pass and Castle Creek Road, it is very close and probably exceeds the accuracy of SourceGas estimates for natural gas delivery to Aspen.

Cell: B28
Comment: Rick Heede:

Tom McBrayer, mngr., provided estimates of total propane sales to Aspen-area commercial customers based on delivery zip code 81611 and 81612. The deliveries are chiefly of construction cylinders to job sites, including the Aspen recreation Center, the Aspen Skiing Company, ACES, and private builders.

Cell: B30
Comment: Rick Heede (Oct08):
Bob, owner, estimated a small portion of his RFV sales of 600,000 gallons per year is delivered to Aspen and UGB, and most of this as “construction cylinders” to heat homes during construction. Total estimated Aspen-area sales in 2007 of ~50,000 gallons.

Cell: B39
Comment: Rick Heede:
Tadd Peed provided a revised estimate for Aspen, Snowmass, and Woody Creek regions, 24Nov08. Total of 340,000 gallons (of which 220,000 gallons to Aspen) is significantly lower than the 562,500 gallons estimated in Oct08.

Marta Darby:
Rough estimate:
30% Aspen
50% Snowmass
20% Woody Creek
email from T. Peed 9/30/08

Rick Heede:
2004 propane sales data for the Aspen area (by Township) from Tadd Peed, Manager (Carbondale office), 970-963-3113, peedt@amerigas.com; personal communication, 7Sep05.

Cell: H39
Comment: Rick Heede:
Basic data from EIA Emission Coefficients (1605b Program), e.g., 532.085 lb CO2 per bbl, 139.178 lb CO2 per million Btu, and 3.836 million Btu per bbl (AER 1995).

Aspen Emissions Inventory for 2007: Commuting, Driving Around Town, and Tourist Driving

The principal variables that need to be updated in future fuel and emissions inventories are: (a) traffic count at Castle Creek Bridge, (b) update future VMT within Aspen, and © fuel consumption for each vehicle type (if needed).

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started 11 August 2005
Last Modified: 19 November 2008

Data from:
John Krueger, Dir.
Aspen Transportation Dept.
970-920-5042
johnk@ci.aspen.co.us

Table 1

Commuting and Hwy 82, 2007	Vehicle by type	Average daily traffic, 2007	Annual traffic, 2007	Miles per trip	Miles driven (VMT)	Fuel economy	Fuel consumed	Carbon factor	Carbon dioxide	Carbon
	28-Aug-08	(both directions)	(both directions)		miles	mpg	gallons/yr	CO2/gallon	tons CO2/yr	tonnes carbon
	7 am - 1 pm									
Valley traffic across Castle Creek Bridge	**6,793**	**22,320**	**8,146,800**	(22,180 and 8.096 million vehicles in Krueger's DailyCount.xls)						
Passenger cars (sedans, cabriolets, etc)	**27.1%**	6,059	2,211,660	25	55,291,495	22.1	2,501,878	19.59	**24,511**	**6,068**
Small SUVs and small pick-up trucks	**26.8%**	5,980	2,182,875	25	54,571,866	20.2	2,701,578	19.59	**26,467**	**6,553**
Medium/Large SUVs and large "light" trucks	**39.6%**	8,843	3,227,536	25	80,688,402	17.0	4,746,377	19.59	**46,500**	**11,513**
2-axle medium-duty trucks, RVs	**2.6%**	578	211,091	25	5,277,279	10.4	507,431	19.59	**4,971**	**1,231**
3-axle trucks, dump trucks, etc	**2.5%**	552	201,496	25	5,037,403	7.4	680,730	22.38	**7,619**	**1,886**
Semis, combination trucks	**0.7%**	164	59,969	60	3,598,145	5.6	642,526	22.38	**7,191**	**1,780**
Motorcycles	**0.6%**	143	52,173	7.5	391,298	50.0	7,826	19.59	**77**	**19**
Total	**100%**	**22,320**	**8,146,800**	**na**	**204,855,889**	**17.4**	**11,788,344**	**19.91**	**117,336**	**29,051**

Table 2

Tourist travel to & from Aspen	Vehicle by type	Average daily visitor traffic	Aveage annual visitor traffic	Miles per visitor trip	Miles driven (VMT)	Fuel economy	Fuel consumed	Carbon factor	Carbon dioxide	Carbon
		arrivals	arrivals	round trip	miles	mpg	gallons/yr	CO2/gallon	tons CO2/yr	tonnes carbon
Visitor vehicle arrivals and departures	composite	350	127,750	600	76,650,000	19.15	4,002,349	19.59	39,211	9,708
Total	**composite**	**350**	**127,750**	**600**	**76,650,000**	**19.2**	**4,002,349**	**19.59**	**39,211**	**9,708**

Composite fuel economy of passenger cars, small, medium, and large SUVs and pick-ups: 19.151

Table 3

Driving around town, 2007	Vehicle by type	In-town driving VMT	Arterial roads VMT	Local roads VMT	Total Aspen VMT	Fuel economy	Fuel consumed	Carbon factor	Carbon dioxide	Carbon
	percent	miles	miles	miles	miles	mpg	gallons/yr	CO2/gallon	tons CO2/yr	tonnes carbon
Daily VMT in 1997, Aspen Area, by road type		117,706	23,157	14,617	155,480					
Estimated compound growth rate per year		2.57%	2.57%	2.57%						
2004 daily VMT, estimated		140,586	27,658	17,458	185,702					
2004 Annual Aspen VMT, estimated		**51,313,774**	**10,095,263**	**6,372,262**	**67,781,299**					
Passenger cars (sedans, cabriolets, etc)	**27.1%**	13,930,453	2,740,621	1,729,915	18,400,989	22.1	832,624	19.59	**8,157**	**2,020**
Small SUVs and light trucks	**26.8%**	13,749,145	2,704,951	1,707,400	18,161,496	20.2	899,084	19.59	**8,808**	**2,181**
Large SUVs and "light" trucks	**39.6%**	20,329,093	3,999,463	2,524,513	26,853,069	17.0	1,579,592	19.59	**15,475**	**3,831**
2-axle medium-duty trucks, RVs	**2.6%**	1,329,588	261,578	165,111	1,756,277	10.4	168,873	19.59	**1,654**	**410**
3-axle trucks, dump trucks, etc	**2.5%**	1,269,152	249,688	157,606	1,676,446	7.4	226,547	22.38	**2,536**	**628**
Semis, combination trucks	**0.7%**	377,724	74,312	46,907	498,942	5.6	89,097	22.38	**997**	**247**
Motorcycles	**0.6%**	328,620	64,651	40,809	434,080	50.0	8,682	19.59	**85**	**21**
Total	**100%**	**51,313,774**	**10,095,263**	**6,372,262**	**67,781,299**	**17.8**	**3,804,498**	**19.83**	**37,713**	**9,337**

Table 4

All commuting, tourist travel, & driving	Total Aspen VMT	Fuel economy	Fuel consumed	Carbon factor	Carbon dioxide	Carbon
	miles	mpg	gallons/yr	CO2/gallon	short tons CO2/yr	tonnes carbon
Total of Commuting on Hwy 82, Tourist Travel, & Driving Around Town	**349,287,187**	**17.8**	**19,595,191**	**19.83**	**194,260**	**48,096**

Cell: B11
Comment: Rick Heede(Mar09):
CMS updated the calculation chiefly through a revised vehicle type survey done by City staff in Aug08 that re-distrubuted the proportion of vehicles entering town at the Entrance to Aspen. The largest shift was in lowering the percentage of "Medium and Large SUVs and light trucks" from 53.8 percent in 2004 to 39.6 percent in 2007 -- and a comcomitant increase in

Cell: C11
Comment: Rick Heede:
Kim Petersen and Marta Darba and John Eisler of the City of Aspen Canary Initiative plus several staffers of the Env Health Dept and John Krueger of the City Transportation Dept surveyed vehicle types on 28 August 2008 from 7 am to 1 pm. Vehicle numbers for the two locations -- at Truscott Place and Hwy 82, inbound lane, and Cemetery Lane and Powerplant Road -- were totaled and averaged for this commuting fuel and emissions computation for2007.

The survey counted 6,793 vehicles, for which the distribution by type is shown below. (We exclude 88 RFTA and school buses from this survey, since fuel consumption by RFTA and school buses is estimated elsewhere.) Finally, CMS annualized the motorcycle percentage by halving the number of motorcycles since bike riding drops to near zero during the winter.

Cell: D11
Comment: Rick Heede:
Final AADT data from Krueger shows 22,320 vehicles per day, Mar09.

Krueger, John D. (2008) Traffic Counts on SH 82 at the Castle Creek Bridge (memo to Mayor and City Council), dated 20 March 2008, 8 pages.

Rick called Krueger to confirm that AADT for 2007 remains 23,013 vehicles per day (JK: yes). Also asked Krueger to reconcile his other data from TrafficDailyCounts2007.xls, which shows AADT of 22,180 vehicles per day (and 8,095,716 vehicles crossing Castle Creek Bridge) in 2007. Kruger will review and respond.

Update 19Nov08: "Rick, It looks like 22,302 is the number. I have not been able to totally reconcile everything but, I am very close. John D. Krueger Director of Transportation." CMS updated AADT from 23,013 vehicles per day to JK's 22,302 vehicles per day. This change reduced fial commuting emissions from 120,979 tons CO2 to 117,242 tons CO2, or by 3,737 tons CO2. The 2004 emissions estimate was 125,714 tons CO2.

Cell: E11
Comment: Rick Heede:
"Average Daily Traffic" times 365 days/yr.

Cell: F11
Comment: Rick Heede:
The typical commute to work is assumed to be 25 miles each direction.# We assume that 2-axle trucks (such as FedEx, UPS,* and other working vehicles) travel 20 miles per trip. Heavier 3-axle trucks are also assumed to travel 25 miles per trip (e.g., an average of originating in El Jebel, Carbondale, or on waste-collection trips between the City and the County Landfill).

Nov08 update: CMS considered reducing the average typical commuting distance from 25 to 20 miles (to better agree with the average RFTA passenger trip length of 16 miles (Dan Blankenship)), but rejected the change in order to preserve comparability between 2004 and subsequent years.

Cell: H11
Comment: Rick Heede:
New vehicle fuel economy data are used in combination with average fleet fuel economy data. This leads to two conservatisms: 1. older vehicles may get poorer fuel economy, and 2. actual driving experience suggests that fuel economy is ~10 percent worse than EPA's fuel economy tests. Furthermore, snowy roads increase fuel consumption. Data from ORNL and Federal Highway Administration (see below).

Passenger cars in use average 22.1 mpg. TEDB Table 4.1 (average fuel economy of passenger automobiles in use, 2002 datum from US DOT/Federal Highway Administation (2002) Highway Statistics 2002, Table VM-1; www.fhwa.dot.gov). New passenger cars average 28.7 mpg (TEDB, Table 4.7).

New small SUVs (25.4 mpg) and small pick up trucks (21.7 mpg) averaged to 23.55 mpg. (Table 4.8); in order to reflect actual vehicle stock mpg and the average in-use fuel economy, the new vehicle average of 23.55 is factored by the average new truck mpg of 20.5 (table 4.8) divided by average in-use truck of 17.6 mpg: 17.6/20.5 = 0.8585. Thus the Aspen vehicle population of small SUVs/light trucks is 23.55 mpg times 0.8585 = 20.22.

New large and medium SUVs (17.6 mpg and 21.3) and new large pick up trucks (18.3 mpg) and new small and large vans (23.5 and 18.3 mmpg) are averaged to 19.8 mpg. As above, this new SUV/truck fuel economy is adjusted to reflect the lower mpg of the average vehicle population in use: 19.8 mpg * 0.8585 = 17.0 mpg. Note: propably conservative, considering the weight driven around by the typical SUV and pick-up truck and work van in Aspen. This category also contains Hummers (10-13 mpg, practical experience is closer to 8 mpg), Suburbans, Ford 350s, and similar brontomobiles.

2-axle medium-duty trucks (10-14,000 lb) average 10.4 mpg (Table 5.4).

3-axle trucks single-unit trucks (dump trucks, garbage trucks, etc) average 7.4 mpg (TEDB Table 5.1).

Semis or combination trucks (33,000 lb +) average 6.1 mpg (Table 5.4), 5.2 mpg in Table 5.2, and 5.5 mpg (Table 5.5); we use 5.6 mpg as the average.

Davis & Diegel (2004) Transportation Energy Data Book 2004, Tables 4.1, 4.8, and 5.4, Oak Ridge National Laboratory, USDOE.

Motorcycles: EIA uses 50 mpg (Energy Information Administration/2001 National Household Travel Survey, p. K-37).

Cell: I11
Comment: Rick Heede:
Miles driven / fuel economy. Conservative estimates.

Cell: B14
Comment: Rick Heede:
CMS uses vehicle counts from this site since it counts nearly all traffic entering Aspen from downvalley, Highlands, and Cemetery Lane. Some traffic circumvents the congested Hwy 82 entrance to Aspen by taking McLain Flats Road/Cemetery Lane and Powerplant Road under Castle Creek Bridge. There is no traffic counter on this access road, which fairly heavily used during congested times on Hwy 82, and CMS is thus underestimating total average traffic flow in and out of Aspen by an unknown quantity (but probably less than 10 percent?).

Cell: H23
Comment: Rick Heede:
Average of all vehicle types: VMT / estimated fuel consumption.

Cell: D27
Comment: Rick Heede:
Visitors arriving in private vehicles varies greatly by season. Of Aspen's 7,000 tourist "pillows," average occupancy in the summer is ~70 percent, or 4,900 visitors per night. Average occupancy per room is ~2.0 (to account for visitors who arrived in the same vehicle), and average length of stay varies (in summer) from 1.9 in May to 2.7 nights in July. Assuming 2.3 nights per visit and 2 persons per room and 4,900 occupied pillows and 67 percent arrivals by car means, on average, that 710 tourist vehicles arrive per summer day. (Of course, visitors may do a lot of driving whilst here; we are merely estimating new arrivals per day. Their daily driving is reflected in "Hwy 82" and/or "Driving around town".)

Off-season and winter season arrivals by car are lower than in summer: approximately 2/3 of summer visitors vs 20 percent of winter visitors arrive in personal vehicles. Winter visitors also stay longer: on average about 4.4 days (ranging from 3.2 in Nov to 4.9 in Dec). While occupancy is somewhat higher in winter, the stays are longer and the driving population is smaller. Finally, the 20 percent of winter arrivals by car are typically from the front range or elsewhere in Colorado, thus tending to reduce the average distance driven.

All in all, this estimate assumes that 350 personal vehicles arrive in Aspen every day, on average, throughout the year.

Most of this data was kindly provided by Bill Tomcich of Stay Aspen Snowmass, 920-7120. The derived fuel consumption estimates are the author's.

Note: there is little hard data on which to base a more accurate estimate. The ACRA summer visitor study does not elucidate mode of travel by visitors (nor does it mention any international visitorship). An accurate estimate would estimate visitors by month and with a better sense of the home state or country of visitors who arrive by personal vehicle. Note also that we have not included visitors who drive to Aspen as part of their camping trips to the area, nor drivers who are visiting friends and relatives, nor second home owners who drive here.

Cell: F27
Comment: Rick Heede:
32 percent of Aspen summer visitors are from Colorado -- chiefly the Front range, which is 400 miles round-trip. Californians comprise 8 percent, Texans 6 percent, Floridians (5 percent, Illini 4 percent, and New Yorkers 3 percent. THE ACRA data does not, unfortunately, give the number of summer visitors (percentages are shown instead). However, ACRA data show "four in ten lodging visitors indicate that they flew to get to Aspen."

ACRA (2004) Summer Survey: Understanding the Aspen Summer Visitor, slide #8.

It is probably conservative to use an average distance driven of 600 miles (round-trip) considering the longer distances driven by the substantial number of out-of-state visitors.

Note: we have not diluted the distances driven by tourists arriving in Aspen by allocating a portion of their driving emissions to other destinations also visited en route. Whether Aspen is or is not the principal reason for the visitors' itineraries, it is our purpose to estimate fuel consumption and emissions for visitors arriving in Aspen, regardless of where else they may have visited on their way here.

Cell: H27
Comment: Rick Heede:
We use the composite fuel economy developed for personal vehicle types driven around Aspen. See below (cell K35) for details.

Cell: K32
Comment: Rick Heede:

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

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

Cell: C35
Comment: Rick Heede:
The traffic counters do register vehicle classes at both the Castle Creek and Mill & Main Streets:
Class 1: Less than 18 feet,
Class 2: 18-25 feet in length,
Class 3: greater than 25 feet.

However, these sizes are not detailed enough for our fuel consumption purposes. We engaged Lee Cassin and the Env Health Dept staff, plus John Krueger of the City Transportation Dept, to survey vehicle types during several mornings during mid-August 2005. The main data set we use was taken on 25Aug05, from 7 am to 1 pm. (Thanks, everybody.) The survey counted 8,003 vehicles, for which the distribution by type is shown below. (We exclude 104 RFTA buses and 20 school buses from this survey; fuel consumption by RFTA and school buses is estimated elsewhere.)

Note: A high fraction of the semis serving Aspen's markets, hardware stores, lumber yards, etc arrive at night and depart before dawn. Our survey may, therefore, have underestimated the number of semis, since the principal vehicle type survey was done from 7am to 1 pm.

Cell: H35
Comment: Rick Heede:
See cell note in Table 1 above.

Cell: B38
Comment: Rick Heede:
VMT estimates for 1997 from Colorado Department of Public Health (2000) Technical Support Document for the PM10 Redesignation Request and Maintenance Plan for the Aspen Area, Air Pollution Control Division, Denver, p. 6.

Cell: B39
Comment: Rick Heede:
Estimated annual compound VMT growth rate from Technical Support Document (cited above, p. 2). Original source: CDOT Entrance to Aspen Environmental Impact Statement. The factor was used to estimate Aspen-area PM10 emissions in 2015; we apply the same growth rate to estimate VMT in 2004.

Cell: B41
Comment: Rick Heede:
Daily VMT times 365.

Cell: H50
Comment: Rick Heede:
Average of all vehicle types: VMT / estimated fuel consumption.

Cell: H54
Comment: Rick Heede:
See cell note in Table 1 above.

Cell: H57
Comment: Rick Heede:
Average of all vehicle types: VMT / estimated fuel consumption.

Aspen emissions inventory for 2007: Roaring Fork Transit Authority (RFTA)

Future inventories must update: (a) fuel consumption by RFTA route served (or total RFTA fuel consumption), (b) check future Aspen ridership as a percentage of total "on/offs", (c) update biodiesel percentage (13.4 percent in 2007), and update average fuel economy by route served.

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started 5 August 2008
Last Modified: 6 December 2008

Data provided by:	Data provided by:
Kenny Osier	Dan Blankenship, CEO
RFTA Dir Maintenance	dblankenship@rfta.com
kosier@rfta.com	970-945-7380
970-384-4959	

RFTA fuel consumption and emissions, 2007

Table 1	Allocated to Aspen inventory	Vehicle miles per route, 2007	Fuel economy	Fuel consumed per route	Fuel allocated to Aspen inventory	Emission factor	Carbon dioxide	Carbon
	percent		mpg	gallons	gallons	CO2/gallon	tons CO2/yr	tonnes carbon
	22.384 lb CO2/gallon * (1.0 - (0.134 * 0.7845)) = 22.384 * 0.8949 = 20.031 lb CO2/gallon					22.384 lb CO2/gal 1-(0.134*0.7845) biodiesel credit		
Roaring Fork Transit Agency (excluding I-70 corridor, Woody Creek)								
City shuttles	100.0%	360,815	5.17	69,790	69,790	20.031	699	173
Galena Street shuttle	100.0%	29,659	6.40	4,634	4,634	19.594	45	11
Crosstown shuttle	100.0%	28,499	7.20	3,958	3,958	19.594	39	10
Burlingame ABC	100.0%	19,640	5.10	3,851	3,851	20.031	39	10
Valley routes	71.6%	2,223,772	5.25	423,576	303,280	20.031	3,037	752
Burlingame	100.0%	13,018	5.10	2,553	2,553	20.031	26	6
Maroon Bells	50.0%	34,989	5.07	6,901	3,451	20.031	35	9
Aspen Skiing Company contract	66.7%	271,678	5.18	52,447	34,967	20.031	350	87
Music Festival contract	100.0%	21,192	5.10	4,155	4,155	20.031	42	10
Maroon Creek Road	100.0%	38,783	5.20	7,458	7,458	20.031	75	18
Senior Van	50.0%	15,080	8.00	1,885	943	19.594	9	2
Total	**na**	**3,057,125**	**5.26**	**581,209**	**439,040**	**20.021**	**4,395**	**1,088**

1 metric tonne = 1.1023 short ton; CO2/C = 3.664

2004 (revised)	417,212	5.2%	4,486	(90) tons CO2e
				-2.0%

RFTA: Saved Fuel and Emissions

Table 2	Allocated to Aspen inventory	Total Ridership	Avoided trips allocated to RFTA	Miles per avoided trip	Passenger-miles saved by RFTA	Vehicle-miles saved by RFTA	Fuel saved	Carbon dioxide	Carbon
	percent	riders	riders	miles	miles	miles	gallons	sh tons CO2/yr	tonnes carbon
						occupancy of: 1.63 persons/vehicle			
Roaring Fork Transit Agency (excl. I-70, Woody Creek, GWS, TOSV)									
City shuttles									
Cemetery Lane	100%	102,096	102,096	2	204,192	125,271	6,541	64	16
Hunter Creek	100%	277,752	277,752	1	277,752	170,400	8,898	87	22
Castle/Maroon	100%	478,275	478,275	2	956,550	586,840	30,642	300	74
Burlingame ABC	100%	11,767	11,767	3	35,301	21,657	1,131	11	3
East End Dial-A-Ride	100%	48,537	48,537	2	97,074	59,555	3,110	30	8
Seasonal shuttles									
Galena Street shuttle	100%	53,718	53,718	1	53,718	32,956	1,721	17	4
Crosstown shuttle	100%	34,393	34,393	1	34,393	21,100	1,102	11	3
Maroon Creek Road	100%	77,268	77,268	2	154,536	94,807	4,950	48	12
Valley routes	71.6%	1,629,234	1,166,532	20	23,330,631	14,313,270	747,380	7,322	1,813
Burlingame	100%	49,998	49,998	5	249,990	153,368	8,008	78	19
Maroon Bells	50%	67,950	33,975	10	339,750	208,436	10,884	107	26
Aspen Skiing Company contract	66.7%	553,571	369,066	10	3,690,658	2,264,207	118,228	1,158	287
MAA campus	100%	55,759	55,759	5	278,795	171,040	8,931	87	22
RFTA charters	50%	58,506	29,253	10	292,530	179,466	9,371	92	23
Senior Van	50%	3,647	1,824	4	7,294	4,475	234	2	1
Total	**na**	**3,502,471**	**2,790,212**	**11**	**30,003,164**	**18,406,849**	**961,130**	**9,416**	**2,331**

Average passengers per vehicle-mile in 2007 (D53/D27): 1.15 (average of all routes)

		Percent change	2004 gallons	2004 tons CO2
2,565,462	ridership 2004	8.8%	924,660	9,045

Composite fuel economy of passenger cars, small, medium, and large SUVs and pick-ups: 19.15

Cell: H11
Comment: Rick Heede:
In this worksheet we estimate those of RFTA's emissions attributable to Aspen's emissions boundary: i.e., RFTA riders in town routes, riders originating or arriving in Aspen (Ruby Park to Airport/AABC/North Forty or stops between) on the Valley Routes, and special service routes (Aspen Skiing Company, Music Festival, etc).

Energy and emissions from electricity and natural gas consumption used at RFTA's main bus barn across from the Airport is not specifically estimated here, but is included in the Electricity and Natural Gas worksheets. Energy used in downvalley facilities is not included.

Cell: C12
Comment: Rick Heede:
Update Sep08: Asked Kenny and Dan for update to the Boarding and Alighting Survey, and whether 35.8 percent is reasonable.

Rick Heede:
Most of these routes are fully allocated to the City of Aspen emissions boundary. We ascribe one-half of the fuel consumed on the Maroon Bells and the senior van routes to Aspen. Two-thirds of the ASC fuel consumption is allocated to Aspen (since these routes service Buttermilk, Highlands, and Snowmass Ski Areas, and only Snowmass is outside the boundary.

The 2003 Boarding and Alighting Survey asked 45 thousand RFTA riders where they got on and got off. 35.81 percent (8,062 of 22,511) indicated Aspen.

Note: "Aspen", in RFTA's survey, includes Ruby Park terminal to the Truscott bus stop. The fuel and emissions inventory boundary includes riders to Country Inn, AABC, and the Airport. We thus add one-half of the riders from Aspen who alight from Country Inn through Brush Creek (that is, half of 1,502 surveyed riders, or an additional 751). Thus, 8,062 plus 751 = 8,813 of 22,511 equals 39.15 percent of all RFTA's riders are attributable to Aspen and its immediate community.

Even though every RFTA bus serving the Hwy 82 corridor drive into or out of Aspen, we allocate 39.15 percent of the fuel used by RFTA on Valley routes to serving Aspen. Estimated "on/offs" for RFTA's Valley routes in 2003 total 3,109,148, of which 1,217,222 represents Aspen's share.

Cell: D12
Comment: Rick Heede:
Vehicle miles data updated to 2007 by Kenny Osier, RFTA Director of Maintenance, 9Sep08.

Cell: E12
Comment: Rick Heede:
Revised from data supplied by Kenny Osier, RFTA Director of Maintenance, personal communication, Sep08.

Cell: F12
Comment: Rick Heede:
Fuel consumption per route is computed from vehicle miles per route divided by each route's average fuel economy (both updated by Kenny Osier, Sep08).

Cell: G12
Comment: Rick Heede:
Fuel consumed per RFTA route multiplied by the percent allocated to Aspen and its emissions boundary.

Cell: H12
Comment: Rick Heede:
Updated by Osier Sep08 to B20 fuel during most of the year. Averaged over the year, the biodiesel factor is 13.4 percent of total diesel fuel. Heede updated the calculations in the "Emission Factor" column.

Rick Heede:
Carbon emissions per gallon of diesel and gasoline from EIA data. Diesel emissions are reduced by the fuel's biodiesel component. In RFTA's case (2004), B5 is used, which is 5 percent biodiesel mixed with conventional diesel.

While life-cycle net carbon savings estimates vary widely (see below), we use a net savings of 78.45 percent based on the NREL report cited below. The emissions benefit of using B5 fuel is thus petroleum diesel times 0.95 plus an adjustment for the net carbon savings of biodiesel fuel: the carbon coefficient is 22.384 lb CO2 per gallon * (1.0 - (0.05 * 0.7845)) = 22.384 * 0.9608 = 21.506 lb CO2 per gallon.

The upstream carbon emissions from biodiesel production are not analyzed here. Such an analysis would include fuel inputs to growing, fertlizing, harvesting, transporting soy or other organic feedstocks, processing electricity and fuels, and storage and delivery fuel inputs. The net carbon savings from biodiesel is certainly less than the carbon absorbed from the atmosphere in the carbon fixation phase of the feedstock. Note that upstream emissions from conventional fuels are not attributed to diesel and gasoline consumption by RFTA or other consumers in Aspen. Estimates of "wells-to-tank" energy inputs range from 20 to 30+ percent above the emissions from the fuels' combustion, depending on the bondary definitions used. See Wang (2001).

Net carbon savings estimates vary widely: from zero to 80+ percent; some organizations assume 100 percent carbon neutrality. National Renewable Energy Laboratory (1998) "Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus," May1998, 314 pp., which concluded that biodiesel reduces net emissions of CO2 by 78.45% compared to petroleum diesel. Mark Delucchi of Institute for Transportation Studies University of California, Davis suggests that the use of biofuels would increase greenhouse gas emissions as land is converted from forests, wetland and conservation reserve acres to grow more corn and soybeans. European research suggests a range of 40 to 56 percent carbon savings.

13aug07 Note: US DOE (2006) Technical Guidelines: Voluntary Reporting of Greenhouse Gases (1605(b)) Program, p. 64. CMS has not reviewed DOE's net carbon calculations in detail, but DOE's calculations presumably use a lower net carbon savings factor, as illustrated by their datum of 21.04 lb CO2 per gallon of B20 vs CMS' 21.506 lb CO2 per gallon (DOE does not appear to account for carbon inputs to the biodiesel cycle, as CMS does by using NREL's estimates).

DOE's 1605 factors: B100: zero carbon, B20: 17.71 lb CO2, B10: 19.93, B5: 21.04.
E100: zero carbon, E85: 2.9 lb CO2 per gallon, E10 (Gasohol): 17.41 lb CO2.

Cell: I12
Comment: Rick Heede:
Gallons per route times CO2 per gallon / 2000 lb per ton.

Cell: B21
Comment: Rick Heede:
CMS discussed Boarding & Alighting Survey results and its interpretation for the Aspen emissions inventory. Valley Routes are now attributed 71.6 percent to Aspen (up from 36.15 percent in 2004).

Dan's approval of changing from 36 to 71.6 percent of total Valley Route miles and fuel and emissions to the Aspen emissions inventory, 8Oct08: "Rick: I think your methodology is sound. Also think that dropping the average miles per trip to 20 is a good idea. I think our calculation was something closer to 16, although it is difficult to get a precise bead on the average passenger trip length because we track boardings and alightings by jurisdictions and not by specific bus stops. Dan"

CMS, 7Oct08: "Thanks, that helps. It seems to me that I misinterpreted the data in 2004. Since we are measuring energy use and emissions for commuters and tourists on a round trip basis -- just as we do for air travel and driving -- it would behoove us to count both sides of a bus ride and the energy used in between, not simply riders crossing Castle Creek Bridge as a percentage of total boarding and alightings. This way we would be estimating emissions for RFTA's comings and goings for all bus travel that transects Aspen's emissions boundary. To be clear: I'd use 35.8 * 2 = 71.6 percent of Valley Route fuel and emissions."

Dan's explanation, 6Oct08: "I believe the reason why the Aspen percentage of boarding and alightings is only 36% whereas your estimate indicates that 72% of valley riders cross the Castle Creek Bridge is that boardings and alightings take into account where someone is getting on and off the bus, and there is one boarding and one alighting for each passenger. So, when a passenger is on a bus crossing the Castle Creek Bridge he/she may be included in the 72% of total valley passengers who are doing that on any given day. However, in terms of boardings and alightings, on the day the survey is conducted, half of that individual's boarding and alighting was ascribed to the community in which he/she boarded the bus and half was ascribed to the community in which they alighted from the bus.

Let's say 5,000 commuters crossed the Castle Creek Bridge on valley buses, either inbound or outbound on a given day, and that number represented 72% of the 6,944 total valley bus riders for that day. However, those 5,000 commuters crossing the Castle Creek Bridge translate into 10,000 boardings and alightings, out of a total of 13,888 valley bus boarding alightings, with only half of the 10,000 (or 5,000) ascribed to getting on or off in Aspen. So 5,000 divided by 13,888 = 36% of the total valley bus boardings and alightings for that day which were ascribed to Aspen and the other 36% was ascribed to the down valley communities where the passengers either got on or off a bus that had a trip beginning or ending in Aspen."

Cell: C33
Comment: Rick Heede:
Most of these routes are fully allocated to the City of Aspen emissions boundary. We attribute one-half of the fuel consumed on the Maroon Bells and the senior van routes to Aspen. Two-thirds of the ASC fuel consumption is allocated to Aspen (since these routes service Buttermilk, Highlands, and Snowmass Ski Areas, and only Snowmass is outside the boundary).

Cell: D33
Comment: Rick Heede
Ridership data updated to 2007 by Kenny Osier, Sep08.

Rick Heede:
Ridership data for 2004 from Phil Schultz, RFTA's Information Technologist and data-hound, personal communication, 29Aug05. We exclude Glenwood Springs "Ride" (151,212 riders), I-70 corridor service to Silt, New Castle, and Rifle (49,349 riders), and ADA in Aspen and GWS (294 riders). Total RFTA 2004 ridership: 3.51 million.

In-town shuttles, Burlingame, and MAA shuttles are fully allocated to within the inventory boundary. The Valley routes are allocated 39.1 percent to within the boundary, based on "on/offs" from Ruby Park to AABC (see RFTA fuel consumption comment for detail). Two-thirds of Ski Co ridership is allocated to Aspen (since Aspen Mtn, Highlands, and Buttermilk bases are both within the boundary, and the buses serving Snowmass Mountain are transporting Aspen locals and visitors to Snowmass more than the other way around).

Cell: E33
Comment: Rick Heede:
"Avoided trips" estimates the ridership carried by RFTA's transit services on a route-by-route basis. Most routes are fully allocated to Aspen, such as the City and Seasonal shuttles. The Valley routes carried 1.629 million riders, of which 39.1 percent is attributed to Aspen and its emissions boundary (out to Airport/AABC/North Forty). Note that we use a vehicle occupancy of 1.63 persons per vehicle in the fuel savings estimate in this table and do NOT assume that each rider would drive a single-occupancy vehicle.

Cell: F33
Comment: Rick Heede:
CMS changed the "miles avoided per trip" of Valley route riders from 25 miles to 20 miles, Oct08. Blankenship concurs, 8Oct08: "Rick: I think your methodology is sound. Also think that dropping the average miles per trip to 20 is a good idea. I think our calculation was something closer to 16, although it is difficult to get a precise bead on the average passenger trip length because we track boardings and alightings by jurisdictions and not by specific bus stops. Dan."

Rick Heede:
This column assumes average distance ridden per route based on interviews with RFTA staff and this report's reviewers. The Valley routes comprise the main component. Aspen to Snowmass Village is ~14 route miles, Basalt is ~20 route miles, El Jebel is 24 route miles, Carbondale is 32 route miles, and Glenwood Springs ~44 route miles, with relatively minor ridership to Aspen from the I-70 corridor. No definitive estimate can be made with respect to average distance ridden over several valley routes, and CMS assumes that 20 miles is a reasonable estimate of average distance travelled by riders to and from Aspen.

RFTA provided transportation to 3.1 million riders on the Hwy 82 corridor in 2003, based on a series of ridership surveys conducted in 2003. The same survey also estimated average miles traveled on Valley routes at 15.0 miles per passenger (15.7 miles if Snowmass Village is included, and 28.7 miles if the I-70 riders are included). These averages include the larger proportions (60.9 percent) of Valley route riders who travel between major stops outside of the Aspen emissions boundary. Thus, of the 39.1 percent of Valley passengers that boarded or alighted in Aspen (or out to the Airport), we estimate saved fuel from 25 miles of avoided driving attributable to RFTA's bus service. This savings estimate also factors in occupancy per vehicle of 1.63. See note below.

Shorter route miles and average distance ridden are estimated and checked with RFTA staff, 21Nov05.

Cell: G33
Comment: Rick Heede:
"Passenger-miles" is "avoided trips" times estimated average miles per trip/route.

Cell: H33
Comment: Rick Heede:
The fuel and emissions savings estimate factors in occupancy per vehicle of 1.63; meaning that we estimate the fuel consumed on the basis of 1.63 RFTA riders would drive one vehicle to or from Aspen in the absence of RFTA services.

Occupancy data from Mt. Sopris Project Team (1993) Origin and Destination Summer Survey, Mt. Sopris Transportation Project Final Report, p. 65. The Survey logged 15,180 person-trips in 9,303 vehicle-trips (Aspen, eastbound, workday). Recreational trips

logged a higher occupancy of 2.43 persons/vehicle, whereas work trips logged 1.22 persons/vehicle.

Cell: I33
Comment: Rick Heede:
Fuel saved is a function of vehicle-miles saved times the fuel economy of the average vehicle presumptively used to get people where they want to go in the absence of RFTA bus service. Some riders would hitchhike, or carpool, or bicycle, or move closer to work, or not go. This study assumes none of these alternatives, and estimates fuel savings as if all riders would need access to a car, or a shared car (hence the 1.63 occupancy rate). The calculation is based on the same composite fuel economy of vehicles entering Aspen in August 2004 (see worksheet on "Road Vehicles").

Cell: B38
Comment: Rick Heede:
RFTA's Year Round City Service includes (for 2004): Cemetery Lane (82,217), Hunter Creek (249,139), Castle/Maroon (427,622), and East End Dial-a-ride (50,016); total 812,994 riders.

RFTA 2004 Ridership data from Phil Schultz, RFTA Dir IT, 29Aug05.

Cell: B48
Comment: Rick Heede:
Total Valley Service (1,597,038 riders) less Woody Creek (9,184 riders) and Town of Snowmass Village (59,300 riders). Valley Service to Snowmass Village is included, since that proportion of total ridership has been accounted for in the percentage allocation to Aspen (39.1 percent of total riders).

Cell: F58
Comment: Rick Heede:
CMS reviewed the Valley Route ridership allocation with Dan Blankenship in Oct08 (see cell note in Table 1).

For the purposes of comparing ridership and avoided gasoline and emissions between 2004 and 2007, CMS enters the revised 2004 ridership allocated to Aspen here.

Cell: J60
Comment: Rick Heede:
Composite fuel economy for the vehicle types assumed to be used for commuting -- passenger cars, small SUVs/small pick-up trucks, and large SUVs/large pick-up trucks -- is derived in the "Road Vehicles" worksheet. Note that we also apply a commuter occupancy of 1.63 persons per vehicle.

Aspen Emissions Inventory, fuel use: Aspen Schools, City, County, SkiCo, & misc.

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started 14 August 2008
Last Modified: 6 February 2009

Future inventorists should update each of the fuel-consumption categories by contacting the entities listed on this worksheet and in the comments to each section. The specific data required and the methodology used to make estimates are discussed in the cell comments.

Data provided by:

Fred Brooks, ASD Bus Fleet Mngr
925-3760, x4010

Ellie Nieslanik, Valley Co-op
970-704-4210

Dylan Hoffman, County Energy Manager
920-5393

Matt Hamilton, Aspen Skiing Co
970-300-7153

Landon Dean
T-Lazy-Seven Ranch
970-925-4614

National Vehicle & Fuel Emissions Lab., EP
Craig Harvey
harvey.craig@epa.gov

	Vehicle miles traveled (VMT)	Fuel consumed	Fuel consumed	Fuel economy	Carbon factor	Attributed to Aspen	Carbon dioxide	Carbon	
	(if known)	Diesel	Gasoline	mpg	CO2/gallon	Percent	sh tons CO2/yr	tonnes carbon	
Aspen School District					diesel / gasoline				
School buses	122,457	17,500		7.0	22.38	100%	**196**	**48**	
Other School District vehicles	124,857		12,500	10.0	19.59	100%	**122**	**30**	
Out-of-district fuel (ExEd trips, away games)			5,000	-	20.99	100%	**52**	**13**	
Total School vehicles		17,500	17,500				**371**	**92**	
Pitkin County Public Works Dept.									
Trucks, plows, etc. (diesel fuel)		44,323			22.38	20%	**99**	**25**	
Sheriff and other vehicles (gasoline)			44,061		19.59	20%	**86**	**21**	
Total Pitkin County vehicles		44,323	44,061				**186**	**46**	
City of Aspen									
Trucks, plows, etc. (diesel fuel)		57,611			22.38	100%	**645**	**160**	
Sheriff and other vehicles (gasoline)			37,823		19.59	100%	**371**	**92**	
Total Pitkin County vehicles		57,611	37,823				**1,015**	**251**	
Construction and off-road equipment									
Fuel deliveries by Roaring Fork Coop	na	36,841			22.38	100%	**412**	**102**	
Snowmobiles (T-Lazy-Seven Ranch only)	na		7,355		19.59		**72**	**18**	
Misc off-road equip. (mowers, blowers, etc)	na		57,437		19.59		**563**	**139**	
Total off-road vehicles		36,841	64,792				**1,047**	**259**	
Aspen Skiing Company (Aspen, Highlands, & Buttermilk)					Biodiesel credit				
Snow groomers, other diesel vehicles (B20 biodiesel)		173,807			18.87	100%	**1,640**	**406**	Aspen, Buttermilk, and
Snowmobiles, misc vehicles (gasoline)			63,543		19.59	100%	**623**	**154**	Highlands (Snowmass excl)
Total Aspen Skiing Company fuel use		173,807	63,543				**2,263**	**560**	
Total School District, City, County, ASC, & misc.	**na**	**330,082**	**227,719**	**na**	**na**	**na**	**4,881**	**1,209**	

Cell: D13
Comment: Rick Heede:
Fuel consumption data sources are listed for each entity included.

Cell: F13
Comment: Rick Heede:
Fuel economy is derivd from VMT and fuel consumption data provided by Aspen School District fleet manager. Newer school buses use less fuel per mile.

Cell: B15
Comment: Marta:
12/4/08: Spoke with Fred Brooks re: fuel consumption
2007-08 school year (July-July): Diesel: 17,500 gallons; Unleaded: 12,500 gallons
2006-2007: Diesel: 17,600 gallons; Unleaded: 12,400 gallons
**Five of the 18 school bus routes are within the City limits. The district extends from Independence Pass to roughly 40 yards west of Watson Divide Road.
**Of the unleaded fuel usage, Fred estimated that roughly 12,000 gallons were used for "activity" and "away" trips, outside the City of Aspen. The roughly 500 gallons used within the City were primarily consumed by a maintanence truck and two snowplows.

Marta:
9/16/08: Spoke with Fred Brooks re: mileage of buses and other small vehicles. He did not have fuel consumption data. The data period runs from "July-July of 2007-2008"

School Buses:
Bus mileage: 122,457 miles
Route mileage: 74,315 miles
Activity mileage (sports games, etc., on a bus): 46,367 miles

Fleet of 20 small vehicles: 124,367 miles.

Cell: B16
Comment: Rick Heede:
The Aspen School District operated 18 buses in the 2004/2005 school year on 14 routes. The fleet drives 73,222 miles in the 176-day school year. The average bus route (though it varies greatly) is 29.7 miles and the fleet drives an average of 416 miles per school day.

Cell: B17
Comment: Rick Heede:
The District also operates 25 other vehicles -- such as Suburbans for field trips, maintenance vehicles, and snowplows that were driven 43,385 miles in 2004 and consumed 13,380 gallons of (chiefly) gasoline.

Cell: B18
Comment: Rick Heede:
The fuel consumed by "other school district vehicles" above do not include fuel purchased on the road for the two dozen long-distance Experiential Education outings (as far as South Dakota, for example, or to Moab in a fleet of Navigators and the like); nor are the several trips by the Varsity and other sports teams beyond range of the fuel in the vehicles' tanks.

In lieu of having an accounting of these fuel purchases we assume such out-of-district fuel consumption at 40 percent of the consumption by "other school district vehicles."

Note: the fuel economy is the average of diesel fuel and gasoline.

Cell: B22
Comment: Marta (data updated 14Aug08):
Rego no longer w/PitCo. Data from Dylan Hoffman, PitCo Energy Manager.

Rick Heede:
Fuel data for 2004 from Rego Omerigic, Pitkin County Public Works Fleet Manager, 8Aug05. Tel 970-920-5393; rego@co.pitkin.co.us

Cell: B28
Comment: Rick Heede:
Fuel data for 2004 from Chicago Climate Exchange "City of Aspen - CCX Preliminary Emissions Analysis," based on data supplied by Lee Cassin, City Env Health Dept.
Data for fuel purchased for City-owned vehicles in 2004. We assign 100 percent of such fuel use to the emissions inventory (unlike County fuel purchases, of which we assign twenty percent to Aspen).

Cell: D29
Comment: martad:
Updated from CCX

Cell: E30
Comment: martad:
Updated from CCX

Cell: B35
Comment: Marta:
Email from Ellie 9/17/08: I ran my reports again for 2007 and added them up and I did miss one person, but it doesn't make a huge difference so total gallons=36841 and $=110,393 and then Rafta was the same gallons=706,445 and $=1,902,696.

Then curiosity got me because there is really only one way to get this info quickly so I went back to 2004 and added that up again and I did come up with about the same figure (within 500 gallons), but I can tell you that there were about 7 regular accounts that we used to deliver to that we didn't in 2007 in Aspen due to selling, retirement, or they just don't buy from us anymore. I went next to our transport business and found the huge difference and that is that there were 2 construction companies buying diesel from us that were working, I believe on Hwy 82 project and of course they are gone now also. They were big consumers.

Also, Rafta started buying biodiesel from us in November 2004 but before that, they did buy some clear diesel from us. I cannot be specific with the date because they used to be right here behind us and so they would fill up here at our station and not purchase fuel by the tanker, and I go back to 2002 with that and it's possible to be even before that. I just don't have the time to research anymore today.

The one biggest consumer on the hwy project used alone about 90,000 gallons in 2004.

9/17/08: Spoke with Ellie at the Coop.
Within Aspen billing addresses with 81611 & 81612 ZIP codes
Total Diesel sales = 32,841 gallons
RFTA sales = 706,445 gallons (mainly biodiesel)
Total diesel sales = 738,748 gallons

In 2004, RFTA purchased 300 gallons of diesel, which Ellie believes were included in the 2004 values.

Rick Heede:
Fuel data of diesel fuel sales to Aspen zip codes in 2004 from Ellie Nieslanik, accounting, and Bill Bransman, fuel sales, Roaring Fork Valley Coop, personal communication, 9Aug05. Tel 970-704-4210.

While such deliveries are chiefly fuel for construction equipment, a variety of other end-users also receive diesel fuel for off-road equipment such as tractors and backhoes.

A complete assessment of such uses has not been made, however, and we use the Coop fuel deliveries as a proxy for construction and off-road equipment. It is likely a conservative estimate considering that many contractors and excavators purchase their own fuel..

Cell: B36
Comment: Heede (Feb09):
T Lazy Seven contact (Landon Dean, 925-4614) estimated total fuel consumption for snowmobile rental fleet of 7,355 gallons of unleaded gasoline in 2007.

Rick Heede (Dec08):
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.

CMS will call T-Lazy-Seven forestimated snowmachine rental hours in 2007. Preliminary assumption of 20 hrs per day * 140 days (20-week season) = 2,800 hrs; times 4.42 gallons/hr = 12,376 gallons.

Rick Heede (2005):
We have not estimated fuel purchased for snowmobiles. 2,000 gallons is probably conservative for T-Lazy-7 Ranch at Maroon Creek. Snowmobile use by the Aspen Skiing Company is not included here, but such fuel use (as well as for groomers) is estimated in SkiCo's emissions inventory.

Cell: B37
Comment: Rick Heede (Dec08:
ORNL's (2007) Transportation Energy Data Book, 26th edition, Table 2.10, shows US fuel consumption for mowing equipment (1.261 billion gallons), Soil & Turf equipment (0.799 billion gallons), Wood cutting equipment (0.270 billion gallons), Leaf blowers (0.220 billion gallons), Snowblowers (0.047 billion gallons), and Trimming equipment (0.134 billion gallons). Total equals 2.731 billion gallons, and includes both commercial and residential uses. The average annual fuel

consumption in the US is thus (mid-2006 population of 299 million) 2,731 million gallons / 299 = 9.13 gallons per capita.

CMS uses the ORNL datum of 9.13 gallons per household per year. Aspen households totaled 6,291 hh in the 2004 inventory, whcih CMS assumes has not changed significantly to 2007: 6,291 hh * 9.13 gallons/hh = 57,437 gallons of fuel for gas-powered widgets in 2007.

Rick Heede:
There is no accurate way to estimate fuel used by mowers, trimmers, blowers, snow-removal equipment and generators and fuel-burning widgets around Aspen. We assume 4 gallons per household for lawn mowers and similar noise-generators per year as a minimal estimate of widget fuel consumption. Aspen housing units is estimated at 6,439 population in 2002 / Pitkin County's persons per household of 1.325 = 4,860 housing units. 4,860 hh x 4 gallons/hh-yr = 19,440 gallons per year. The real number, if professional gardening or contract snowplowing services are included, could easily be ten times higher.

Housing data from Venturoni (2004) 2004 Pitkin County Community Survey, slide #4, NW Colorado Council of Govts.

Cell: B41
Comment: Heede, 15Nov08:
Marta sent and CMS verified original data: diesel (B20) consumption CY2007 at Highlands, Buttermilk, and Aspen Mtn: 44,499, 63,215, and 66,093 gallons, respectively.
Gasoline: 4,249, 50,396, and 8,898 gallons, respectively.
Snowmass is not included (325,007 gallons of diesel and 105,167 gallons of gasoline), nor "SMC" (Snowmass Center?): 2,699 and 21,210 gallons.

Marta:
8/14/08: Data from Matt Hamilton @ SkiCo.

Rick Heede:
Fuel data from Aspen Skiing Company, Auden Schendler, 23Nov05. Diesel and gasoline consumption is reported by ski area; we include Aspen Mtn, Highlands, and Buttermilk, and exclude Snowmass Ski Area.

Cell: G41
Comment: Rick Heede, 17Nov08:
As noted in the cell below, CMS applies the emission factor based on NREL's study, which accounts for fossil carbon inputs to biodiesel, and ignores EIA's 1605b factor.

Marta:
In 2007, "pretty much all of the diesel" was B20 [from email correspondence with Matt Hamilton on 8/14/08]. Factor from www.eia.doe.gov/oiaf/1605/excelFuel%20Emission%20Factors.xls

Auden Schendler, 14Aug08: "We're scrapping biodiesel this year b/c of new federal diesel standards that, as far as we can tell, obviate the value of the bio."

Rick Heede:
20 percent of SkiCo's diesel consumption is 100 percent biodiesel. While life-cycle net carbon savings estimates vary widely (see below), we use a net savings of 78.45 percent based on the NREL report cited below. The emissions benefit of using B5 fuel is thus petroleum diesel times 0.95 plus an adjustment for the net carbon savings of biodiesel fuel: the carbon coefficient is 22.384 lb CO2 per gallon * (1.0 - (0.20 * 0.7845)) = 22.384 * 0.8431 = 18.872 lb CO2 per gallon.

Also see the notes under RFTA's biodiesel calculation.

National Renewable Energy Laboratory (1998) "Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus," May1998, 314 pp., which concluded that biodiesel reduces net emissions of CO2 by 78.45% compared to petroleum diesel.

Cell: G42
Comment: Rick Heede, 15Nov08:
Marta ignored the net carbon calculation of B20 emission factor in the above cell note and simply used the DOE factor that does not account for carbon inputs to biodiesel production, processing, and transportation. CMS applies the corrected factor for B20 fuel cited in the cell note above based on NREL's study and that accounts for carbon inputs and other biodiesel emission sources such as fertilizer inputs.

Marta Darby, 13Nov08:
From EIA DOE spreadsheet regarding factors. Carbon factor is for B20. The spreadsheet is located in the 2007 Inventory Worksheet folder.

Aspen Emissions Inventory: Commercial Air Travel, 2007

This worksheet estimates gallons of jet fuel consumed and carbon dioxide emissions attributable to revenue-passengers flying into and out of Aspen in 2007. Future emissions inventorists need to update enplanement & deplanement data from the Aspen Pitkin Airport staff.
CMS has updated the emission factors for short haul (DEN-ASE), other domestic flights, and international flights based on 2006 or 2007 data. These factors change only slightly from year to year, and future inventorists may elect to not update these factors (see worksheet "US Coml Avg 2006").

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started: 19 November 2008
File last modified: 2 March 2009

Data from:
David Ulane
ASE Ops Mngr.
970-429-2853
davidu@co.pitkin.co.us

Other sources:
ORNL Transportation Energy Data Book
http://cta.ornl.gov/data/index.shtml
MIT Global Airline Industry Program Airline Data Project
web.mit.edu/airlinedata/www/Revenue&Related.html

red data require updating in future inventories

Fuel factor: 21.09 lb CO2e per gallon of jet fuel (Table 2c)

Table 1a Fuel and Emissions from passengers flying to and/or out of Aspen Pitkin Airport (ASE), 2007

65.5 % use ASE	Aspen enplanements	US origin	Aspen/Denver leg: Miles flown per leg	Aspen/Denver leg: Total miles	Aspen/Denver leg: Fuel	Aspen/Denver leg: Emissions	US domestic legs: Miles flown per leg	US domestic legs: Total miles	US domestic legs: Fuel	US domestic legs: Emissions	International origin	International legs: Miles flown per leg	International legs: Total miles	International legs: Fuel	International legs: Emissions
	passengers	passengers	miles	passenger-miles	gallons	tons CO2e	miles	passenger-miles	gallons	tons CO2e	passengers	miles	passenger-miles	gallons	tons CO2e
		82%	short haul fuel rate:		0.0462	gallons/pax-mile	US domestic fuel rate:		0.0242	gallons/pax-mile	18%	international fuel rate:		0.0178	gallons/pax-mile
			short haul emission factor:		0.9735	lb CO2/pax-mile	US domestic emission factor:		0.5094	lb CO2/pax-mile		international emission factor:		0.3747	lb CO2/pax-mile
Deplanements	177,630	145,657	125	18,207,075	840,532	8,863	975	142,015,185	3,430,421	**36,170**	31,973	4,875	155,870,325	2,769,320	**29,200**
Enplanements	183,632	150,578	125	18,822,280	868,933	9,162	975	146,813,784	3,546,333	**37,392**	33,054	4,875	161,137,080	2,862,893	**30,186**
Totals	**361,262**	**296,235**	**na**	**37,029,355**	**1,709,466**	**18,025**	**na**	**288,828,969**	**6,976,754**	**73,562**	**65,027**	**na**	**317,007,405**	**5,632,213**	**59,386**

Table 1b Fuel and emissions for commercial air travel via ASE: all travelers

All air travelers using the Aspen Pitkin County Airport

	Total miles passenger-miles	Fuel gallons	Emissions tons CO2e
Inbound	316,092,585	7,040,273	74,232
Outbound	326,773,144	7,278,160	76,740
Totals	**642,865,729**	**14,318,433**	**150,973**

Table 1c Fuel and emissions for coml air travel via ASE: allocated to Aspen Inventory

All air travelers using the Aspen Pitkin County Airport: allocated to Aspen inventory
70 percent of Table 1b

	Total miles passenger-miles	Fuel gallons	Emissions tons CO2e
		allocation factor	70%
Inbound	221,264,810	4,928,191	51,963
Outbound	228,741,201	5,094,712	53,718
Totals	**450,006,010**	**10,022,903**	**105,681**

Table 2a Fuel and emissions for Aspen residents & visitors using other regional airports, 2007

34.5 % use other airports	DIA , EGE, GJT	US origin	no Aspen/Denver legs				Domestic legs to Denver, Eagle, Grand Junction: Miles flown per leg	Total miles	Fuel	Emissions	International origin	International legs to Denver, Eagle, Grand Junction: Miles flown per leg	Total miles	Fuel	Emissions
	passengers	passengers					miles	passenger-miles	gallons	tons CO2e	passengers	miles	passenger-miles	gallons	tons CO2e
		95%					US domestic fuel rate:		0.0242	gallons/pax-mile	5%	international fuel rate:		0.0178	gallons/pax-mile
							US domestic emission factor:		0.5094	lb CO2/pax-mile		international emission factor:		0.3747	lb CO2/pax-mile
Deplanements	93,561	88,883					1,100	97,771,160	2,361,693	**24,902**	4,678	5,000	23,390,230	415,570	**4,382**
Enplanements	96,722	91,886					1,100	101,074,782	2,441,493	**25,743**	4,836	5,000	24,180,570	429,612	**4,530**
Totals	**190,283**	**180,769**					**na**	**198,845,942**	**4,803,186**	**50,645**	**9,514**	**na**	**47,570,800**	**845,182**	**8,912**

Table 2b Fuel and emissions for commercial air travel via regional airports: all travelers

All air travelers using the Aspen Pitkin County Airport

	Total miles passenger-miles	Fuel gallons	Emissions tons CO2e
Inbound	121,161,389	2,777,263	29,283
Outbound	125,255,352	2,871,105	30,273
Totals	**246,416,742**	**5,648,368**	**59,556**

Table 2c Fuel and emissions for coml air travel via regional airports: allocated to Aspen Inventory

All air travelers using the Aspen Pitkin County Airport: allocated to Aspen inventory
70 percent of Table 1b

	Total miles passenger-miles	Fuel gallons	Emissions tons CO2e
		allocation factor	70%
Inbound	84,812,972	1,944,084	20,498
Outbound	87,678,747	2,009,773	21,191
Totals	**172,491,719**	**3,953,858**	**41,689**

Note 1: we have not included the related global warming impacts of high-altitude aircraft operations such as vapor trail formation, NOx, particulates, etc.
www.aspenzgreen.com/offsets_calculator_air.cfm

Cell: C16
Comment: Rick Heede (2Mar09):
Ulane: website PDF data is incorrect. CMS corrects 2007 entries to: 183,632 enplanements & 177,630 deplanements.

Rick Heede (27Feb09):
Revised data from Ulane (via 11Feb09 ASE Passenger Report as PDF from website) shows increase in 2007 enplanements (192,917 pax) and deplanements (187,072, total 379,989. (Previous data totals 361,262 pax.)
FYI: 2008 enplanements (185,711 pax) and deplanements (179,315), total 365,026 pax.

Rick Heede (23Dec08):
Passengers deplaning and enplaning at Aspen are nearly identical in 2004 vs 2007 (respective totals are 362,105 vs 361,262 passengers). However, 2006 was substantially higher at 401,303 passengers, and 2008 is also ahead of 2007 at 387,799 passengers through October; if Nov08 & Dec08 equal same months in 2007, total 2008 would reach 440,252.

ASE data from www.aspenairport.com/pdf/passenger_report.pdf

Cell: D16
Comment: Rick Heede:
(2005): The 80/20 split between domestic and international originations is based on winter visitors flying into Aspen. Data from Aspen Skiing Company.

Jan09 update with ASC (Bob Bayless, 970-300-7040): international origins slightly up to estimated 82 percent domestic and 18 percent international.

Cell: E16
Comment: Rick Heede:
The direct air distance between Aspen and Denver is 125 miles (great circle distance as calculated by the Canary air travel calculator at www.aspenzgreen.com/offsets_calculator_air.cfm). In practice, the actual flight path over Red Table VOR en route to ASE is closer to 140 miles. CMS uses the direct distance.

Cell: F16
Comment: Rick Heede:
Passengers in both direction times miles flown for the Denver to Aspen leg equals total passenger-miles.

Cell: G16
Comment: Rick Heede:
Fuel rate is calculated for each type of flight. See the worksheet “US Coml Ave 2006” for details.

The calculation is total passenger-miles for enplanements and deplanements times the fuel rate for each type of flight (in gallons per passenger-mile flown) divided by 2000 lb/ton.

Cell: H16
Comment: Rick Heede:
CO2 emissions are calculated for each type of flight -- ASE-DEN, other US domestic flights, and international flights. See the worksheet “US Coml Ave 2006” for details.

The calculation is total passenger-miles for enplanements and deplanements times the emission factor for each type of flight (in lb CO2 per passenger-mile flown) divided by 2000 lb/ton.

Cell: I16
Comment: Rick Heede:
2005: The average “passenger trip” in 2002 was 850 miles. Davis, Stacy C. (2004) Transportation Energy Data Book 2004, Oak Ridge National Laboratory, Oak Ridge, TN, Table 9.2. We assume 1,100 miles per trip in lieu of the longer distance traveled by domestic visitors to Aspen.

LAX to Aspen (via DEN, 730 + 130 miles) 860 miles, LGA to ASE is 1,770 miles, MIA to ASE is 1,800 miles, Chicago ORD to ASE is 1,010 miles, Houston is 914 miles, Washington DC is 1,570 miles. Since NY/NJ/PA, Chicago, and LA are the three most important originations for winter visitors, we use 1,100 miles as a reasonable average flying distance for year-round travel distances.

Based on a conversation with Kris McKinnon, ASC Mng Dir Worldwide Marketing. Air travel distances from www.webflyer.com

Jan09 update: MIT data * shows average stage length for US domestic commercial aircraft was 1,095 miles in 2007. While this does equal average trip distance flown -- which is presumably longer than stage distance -- it does support CMS use of 1,100 miles to estimate average domestic air travel distance for Aspen in 2007.

* Massachusetts Institute of Technology, Global Airline Industry Program, Airline Data Project, web.mit.edu/airlinedata/www/Revenue&Related.html

Cell: M16

Comment: Rick Heede:
Jan09: International visitors comprise roughly 18 percent of winter visitors, according to Aspen Skiing Company data (personal communication, 2Jan09). The precise fraction is proprietary to ASC. This does NOT equal year-round aveage of visitors to Aspen or Valley resident travel, hence this percentage may be adjusted. This is a slght change from the 2004 estimated value of 20 percent international.

Cell: N16
Comment: Rick Heede:
We estimate that the average international visitor (and international travel by outbound residents) is ~5,000 miles, which is likely conservative. This is equivalent to a flight from London to Aspen (4,770 miles) or Paris (4,980 miles). Rio de Janeiro is 5,930 miles, Sydney is 8,220 miles, and Tokyo is 5,720 miles. Of course, a number of visitors fly in from Canada, Mexico, Venezuela, and other closer countries to average out the number of visitors from Australia and elsewhere in Asia.

The three most important international markets for the Aspen Skiing Company (personal communication 17Aug05) are the UK, Australia, and Brazil.

Cell: N38
Comment: Rick Heede (Jan09):
CMS analyzed the Pitkin County air travel results. First, when business owners, voters, and assessors list of homeowners were asked “What airport do you use most often to fly in and out of this area?” the respondents often selected more than one airport, and thus the sum totaled more than 100 percent. CMS harmomized the responses to 100 percent to calculate the relative values of the responses for each group as follows:

On average, Aspen Pitkin Airport was used by 56.76 percent of respondents, 28.72 percent used Denver International, and 14.51 percent used GJT or EGE or other regional airports.

CMS note, Jan09: We do not change the proportion between Aspen and other airports in the 2007 emissions inventory so as to keep the basic metrics comparable; that is, CMS uses the 2004 percentage of 65.5 percent ASE and 34.5 percent non-ASE. If future inventorists determine that a larger proportion of Aspen visitors use non-ASE airports, perhaps based on a future travel survey, this proportion should be revised.

Rick Heede:
2005: An average of 65.5 percent of visitors and residents of Aspen who do fly do so in and out of the Aspen Airport, according to the Pitkin County Survey. 31.8 percent travel to DIA for flights, although GJT, EGE, and other airports are also used.

In other words, we estimate that an additional amount of travelers and miles flown depart from other airports. The number of travellers using other airports is thus (1-0.655)/0.655 times = 0.526718 times the respective deplanements and enplanements at Aspen Pitkin Airport.

This datum averages respondents from the business surveys, voter surveys, and assessor surveys collected by Linda Venturoni (2004) 2004 Pitkin County Community Survey, Northwest Colorado Council of Governments, slide 21; www.nwc.cog.co.us

Cell: D41
Comment: Rick Heede:
CMS assumes that the proportion between US and international origins shifts for non-Aspen airports. CMS assumes that 95 percent of non-Aspen visitors originate in the U.S., and 5 percent originate internationally.

Cell: B61
Comment: Rick Heede:
Such impacts have been estimated to range between two to 3.5 times the impact of converting jet fuel to carbon dioxide in the atmosphere.

IPCC (1999) Aviation and the Global Atmosphere - Summary for Policymakers.

CMS investigated the state of the art of non-CO2 radiative forcing (RF), and concluded -- chiefly on the basis of Wuebbles (2006) and Sausen et al (2007) -- that RF contributes 1.83 times the RF of CO2 alone. Aspen’s canary Initiative air travel calculator (see www.aspenzgreen.com/offsets_calculator_air.cfm) makes RF calculations and offset costs voluntary.

Aspen Emissions Inventory: General Aviation, 2007

The Aspen Pitkin Airport handled 32,848 general aviation & military arrivals and departures in 2007. This worksheet develops a profile of the typical aircraft and missions flown, ie, size, performance, fuel flow, distance flown, and total carbon dioxide emissions for the flights into and out of Aspen in 2007. See comment at B4. Air line operations totalled 9,500 arrivals and departures (see Commercial Aviation worksheet for details).

See comment E4

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started 11 August 2008
Last Modified: 27 January 2009

Future emissions inventories may simply update operational data from (available from the Airport staff) and Air Ambulance operations (available from Pitkin County Emergency Services). Future inventories may also change fuel consumption rates, aircraft performance, and other factors.

Data from:
David Ulane
ASE Ops Mngr.
970-429-2853
davidu@co.pitkin.co.us

Data from:
Ellen Anderson
Pitkin County Emergency Mngt Coordinator
970-920-5234

Average 1,000 nm flight: 6.94 tons CO2e

Table 1 Jet Turbine Aicraft Operations

	Total GA Operations	Jet aircraft (percent)	Jet operations	Fuel consumption 1,000 nm trip (gal)	Total jet fuel (gallons)	Fuel emission factor lb per gallon	CO2e emissions tons CO2e	Allocated to Aspen percent	CO2e emissions tons CO2e	Carbon metric tonnes C
Total general aviation operations:	22,039	75%	16,529	658	10,875,012	21.088	114,665	70%	80,266	21,905
Total Air Taxi operations:	9,578	90%	8,620	658	5,671,448	21.088	59,799	70%	41,860	11,424
Total military operations	45	75%	34	658	22,205	21.088	234	70%	164	45
Total GA plus Air Taxi operations:	31,662	na	25,183	na	16,568,665	21.088	174,699		122,289	33,374
Total jet fuel & CO2e emissions					16,568,665	21.088	174,699		122,289	33,374

Table 2 Turbo Prop Aircraft Operations

	Total GA Operations	Turboprops (percent)	Turboprop operations	Fuel consumption 600 nm trip (gal)	Total jet fuel (gallons)	Fuel emission factor lb per gallon	CO2e emissions tons CO2e	Allocated to Aspen percent	CO2e emissions tons CO2e	Carbon metric tonnes C
Total GA operations:	22,039	15%	3,306	195	644,009	21.088	6,790	70%	4,753	1,297
Total Air Taxi ops:	9,578	10%	958	195	186,588	21.088	1,967	70%	1,377	376
Total military operations	45	25%	11	195	2,192	21.088	23	70%	16	4
Total GA plus AT ops:	31,662	na	4,275	na	832,789	21.088	8,781		6,147	1,677
Total jet fuel & CO2e emissions					832,789	21.088	8,781		6,147	1,677

Table 3 Air Ambulance Flights (helicopters & fixed-wing)

	Total Operations	Trip distance Roundtrip (hrs)	Fuel rate (gallons/hr)	Fuel consumption gallons	Fuel emission factor lb per gallon	CO2e emissions tons CO2e	Allocated to Aspen percent	CO2e emissions tons CO2e	Carbon metric tonnes C
Air ambi fixed-wing flights:	47	1.50	60	4,230	18.355	39	70%	27	7
Air ambi helicopter flights:	47	1.50	80	5,640	21.088	59	70%	42	11
Total Air Amulance operations:	94	na	140	9,870		98		69	19
Total avgas & jet fuel & emissions				9,870		98		69	19

Table 4 Civil, Local, & Itinerant Flights (piston aircraft)

	Total Operations	Trip distance (hrs)	Fuel rate (gallons/hr)	Fuel consumption gallons	Fuel emission factor lb per gallon	CO2e emissions tons CO2e	Allocated to Aspen percent	CO2e emissions tons CO2e	Carbon metric tonnes C
Gen'l Aviation - piston aircraft	2,204	3.00	20	132,234	18.355	1,214	70%	850	232
Local sightseeing, T&Gs, training	1,186	1.50	16	28,464	18.355	261	70%	183	50
Total GA piston + "Civil" ops:	3,390	na	na	160,698		1,475		1,032	282
Total AvGas & emissions				160,698		1,475		1,032	282

Table 5 Total fuel and emissions from General Aviation using Aspen Pitkin County Airport and attributed to Aspen inventory

	Fuel consumption gallons	CO2e emissions tons CO2e	Carbon metric tonnes C
Total fuel and emissions by GA aircraft using the Aspen Pitkin Airpor	12,300,415	129,537	35,352

Table 6 Allocation of total fuel and emissions to communities in the Roaring Fork Valley

Roaring Fork Valley community		Fuel consumption gallons	CO2e emissions tons CO2e	Carbon metric tonnes C
City of Aspen emission boundary (modified UGB)	70%	12,300,415	129,537	35,352
Town of Snowmass Village & Brush Creek & Wildcat	20%	3,514,404	37,011	10,101
Rest of Pitkin County	6%	1,054,321	11,103	3,030
Garfield and Eagle County	4%	702,881	7,402	2,020
Total fuel and emissions by GA aircraft using the Aspen Pitkin Airpor		17,572,022	185,053	50,503

Average private jet		
B&CA average jet:	3.40	tons CO2/hr
CMS calculation, ave je	2.98	tons CO2/hr

Cell: E4

Comment: Rick Heede (Jan09):

CMS has revised the average fuel performance by relying on the average fuel flow for all 141 production and in-service but out-of-production aircraft published in Business & Commercial Aviation's Operations Planning Guide (see cell note at G 14). The average 1,000 nm mission consumes 658 gallons of jet fuel.

Rick Heede (2005):
A survey of jet turbine aircraft parked at Aspen Base Operations and Airport ramps totaled 38 on 30Jul05 in size ranging from light Cessna Citations and LearJets to large Gulfstream and Challenger aircraft with ramp weights from 10,800 to 91,400 lb.

The preponderance of aircraft were of the heavier, longer-range, larger-capacity variety of personal or corporate jets. We averaged the fuel consumption for a basket of business jets from the Citation Bravo up to the Gulfstream 550.* The eleven jets sampled average 674 gallons (4,517 lb) of jet fuel for a 1,000 nautical mile trip, which is a standard operational and cost estimation mission in the jet fleet management business. This also equals the performance of a Bombardier Challenger 604 and 1.11 times the fuel consumption of a Raytheon Hawker 800 XP -- both typical of the variety of aircraft flying into Aspen. **

It is likely that the selected baseline trip of 1,000 nm is conservative relative to the origins and destinations of the "average" flight to Aspen. It is, however, a standard industry measure, and fuel consumption data will be published annually for a variety of production aircraft.

Another conservatism in the 2004 fuel and carbon emissions estimate is that we have used the fuel performance of mostly new production models, and the fleet average is somewhat lower fuel performance than the new aircraft. Specific fuel consumption for each type of aircraft has (and will continue to) improve.

Finally, we have not accounted for the other atmospheric impacts of burning jet fuel at high altitudes, namely vapor trail formation, particulates such as sulfur dioxide, NOx, and other impacts on the radiative balance of the atmosphere. Some researchers estimate such impacts are approximately 1.5 to 3.5 times the direct impact of the carbon emissions. See IPCC 1999.

* Citation Bravo (371 gallons) up to the Gulfstream III (1,069 gallons). Other aircraft performance in our review (all fuel consumption per 1,000 nm mission): Lear 45 (433 gallons); Lera 60 (477 gallons); Hawker 800XP (604 gallons); Citation X (576 gallons); Falcon 2000 (540 gallons); Challenger 604 (674 gallons); Gulfstream 550 (834 gallons), Gulfstream G-III (1,069 gallons); Gulfstream G-IV (972 gallons); and Gulfstream G-V (865 gallons). See Business & Commerical Aviation (2004) Operations Planning Guide, pp. 56-85. A "mission" includes fuel consumed for a typical sequence from start, taxi, clearance, take-off, climb, cruise, descent, landing, and taxi to stop.

** The Hawker 800XP specification sheet (www.raytheonaircraft.com/hawker/) lists trip fuel used for a 1,000 nm trip (with 4 passengers) as 4,069 lb. The flight time is 2 hrs 25 minutes, or 4,069 lb / 6.7 lb/gallon = 607 gallons; 607 gallons / 145 minutes = 4.19 gallons per minute. This means an average fuel rate 1.90 "miles per gallon" for the whole trip, with better cruise performance once the aircraft is at altitude. With six passengers, this equates to 1.85 lb CO2 per passenger-mile (compare to air carriers' average of 0.574 lb CO2 per passenger-mile).

A Gulfstream G-IV will use ~0.97 gallons fuel per nm, or 1.18 statute mpg, and a 1,000 nm trip would emit 10.25 tons of carbon dioxide (2.54 tonnes carbon). With eight passengers this means an emissions rate of 2.23 lb CO2 per passenger mile. This "Hummer of the Sky" is outperformed (in terms of fuel, not time efficiency) by a street Hummer H2 at ~9 mpg and four on-board: 0.54 lb CO2 per pax-mile. Or rouhly equivalent if the Hummer is transporting only the driver (2.17 lb CO2/pax-mile).

However, "the larger the aircraft the fewer the passengers" seems to hold true at Aspen's GA operations. Gulfstream aircraft -- often configured for eight or nine passengers -- typically carry one or two passengers. With two passengers, a 1,000 nm trip in a G-II would consume about 1,220 gallons of fuel and emit 12.84 tons of CO2 or 11.2 lb CO2 per passenger-mile (25,680 lb CO2 / 1,151 miles / 2 pax).

The G-IV will use an average of 7.1 gallons per minute, or 7.6 ounces per second. On take-off, however, the older G-II will consume 12,000 lb/hr at full thrust (three times cruise fuel consumption of 4,000 lb/hr). 12,000 lb/hr = 200 lb/min = 3.33 lb/sec = 0.5 gallons/sec = 10.5 lb CO2/sec = 1.3 kgC/sec.

Cell: E14

Comment: Rick Heede:

As in 2004, CMS estimates that 75 percent of GA LTO operations at Aspen are by jet aircraft. While this may be conservative (see Brad Rolf's work for the Airport inventory that suggests 65 percent are jets (if single and twin internal combustion engine [ICE} aircraft are included), and as high as 89.7 percent of jets + turboprops (11,361 jets of 12,659 jet + turbo-prop total). However, Rolf's data has not been verified (e.g., allegedly from FAA data, but only documents 17,487 LTOs in an undocumented year, and ASE logs ~34,000 LTOs in recent years. See worksheet "GA Chart 2007" for Aspen LTO data.

Cell: G14

Comment: Rick Heede:

CMS modified the fuel rate calculation as follows (fuel rate is linked to the worksheet on "GA fuel performance data" in this workbook) but uses the same average flight distance of 1,000 nautical miles for aircraft arriving and departing from Aspen in 2007 as in the 2004 inventory:

The 2004 rate (see comment Cell B4 in the 2004 worksheet) was 674 gallons for a 1,000 nm trip by the average jet operating out of Aspen based on a CSM aircraft type survey of Aspen aircraft;

The CMS worksheet (JetCalculatorAspen2008.xls) on all production and operating out-of-production jet aircraft averaged 658 gallons for a 1,000 nm mission; this is based on mission fuel consumption rates for 112 in-service private jets (thus not including performance data for 35 turbo-prop aircraft in the section below) based in turn on 2007 fuel data in the Aug07 issue of Business & Commercial Aviation magazine;

Brad Rolf's background work on the Aspen Pitkin Airport emissions inventory detailed LTOs by aircraft type (collected by the FAA Control Tower at Aspen). CMS did a weighted calculation of average fuel consumption weighted for LTO by aircraft type (by using BC&A data on fuel consumption by AC type) that estimated average fuel consumption for jets only of 0.556 gallons per statute mile, 1.797 mpg, and 640 gallons per 1,000 nm flight. However, Rolf did not respond to requests for confirmation of data source, year, FAA's alleged categorization of aircraft types (all single engine ICE ac were called Cesssna 182 or Beech Baron 58). Hence CMS does not rely on the data.

CMS applies the CMS / B&CA mission fuel consumption data for all jets for a 1,000 nm flight: 658 gallons per 1,000 nm mission. Note: "mission" includes start-up, taxi and ground operations, take-off and climb, cruise, descent, and

landing. Note: CMS has calculated fuel performance for light to extended range jet aircraft, categories 2-6 in the attached worksheet "GA fuel performance data."

Cell: I14
Comment: Rick Heede:
Jet fuel factor is typically cited (e.g., by EPA and EIA) as 21.095 lb CO2 per gallon (based on 19.33 kg carbon per million Btu). CMS -- in the attached worksheet "US Coml Ave 2006" -- accounts for 1 percent of liquid fuel not combusted to CO2 (per EPA and IPCC) and also accounts for associated methane and nitrous oxide emissions (EIA fuel factors for Jet fuel). The net result is 21.088 lb CO2e per gallon of jet fuel.

Cell: M15
Comment: Rick Heede:
We convert short tons (2000 lb) of carbon dioxide to metric tonnes of carbon at CO2/C = 3.664191. From Kevin Baumert, World Resources Institute, May05: "CO2 conversion is, precisely: C=12.0107 + O=15.9994 x 2 = 44.0095/12.0107 = 3.664191"

Cell: G25
Comment: Rick Heede (Jan09):
CMS uses the same average flight distance of 600 nm for turboprop aircraft as in the 2004 inventory.
Rick Heede (2004):
A 600 n-mile mission in a turboprop averages ~2.5 hours at a fuel burn of ~80 gallons per hour (range for production aircraft is on the order of 58 gallons per hour for a Cessna Grand caravan to Beech King Air 350 at 112 gallons per hour).

Source: Business & Commercial Aviation (2004) "2004 Operations Planning Guide," pp. 60 & 78.

Cell: I25
Comment: Rick Heede:
Turboprop aircraft use jet fuel. See note above.

Cell: E36
Comment: Rick Heede:
John Eisler: Info from Ellen Anderson, Pitkin County Emergency Management Coordinator 920-5234 on 5Aug08. Most of fixed were props.

Cell: I36
Comment: Rick Heede:
Turboprop aircraft use jet fuel. See note above.

Cell: C39
Comment: Rick Heede:
Flight for Life data from Pitkin County Emergency Services (Rich Walker, Director), 20July2005.

Total helicopter flights in 2004: 47;
Total fixed-wing flights in 2004: 55.
We assume that each flight is 120 miles each way, 240 miles roundtrip (and represent an average of a flight to Grand Junction and a flight to the Front Range; in 2004, flights to each area were roughly fifty-fifty).

We use the Eurocopter BK-117 helicopter to estimate fuel consumption rate for emergency choppers (the BK-117 is frequently used in such service). It is an 8 passenger helicopter originally designed in 1977. In the EMS configuration it is capable of carrying a pilot, patient and 5 other passengers or a pilot, two patients and three other passengers. It is powered by two 700 horsepower Lycoming LTS 101-750-B1 engines. The craft uses 80 gallons of jet fuel per hour of operation, max speed in 150 knots (173 mph). www.flightforlife.net/aircraft.htm

Thus, a typical flight from Grand Junction or the Front Range of 120 miles takes approximately 45 minutes each way and would consume an estimated 120 gallons round trip.

Cell: E46
Comment: Rick Heede:
The FAA data on Landing and TakeOffs (LTOs) lacks detail about type of aircraft using Aspen. The majority are itinerant (non-local), and CMS has allocated 10 percent of all itinerant LTOs as piston-powered single and twin aircraft using Aviation Gasoline (AvGas). Plus CMS adds all local civilian aircraft LTOs as piston-powered. In 2007, this equals 2,204 LTO plus 1,186 LTO = 3,390 LTO.

Cell: I46
Comment: Rick Heede:
Aviation gasoline (AvGas) has an emission factor of 18.355 lb CO2 per gallon; source EIA 1605 program.

Cell: C48
Comment: Rick Heede:
CMS allocates 10 percent of total GA operations in 2007 to single-engine and twin piston aircraft. Note: same fraction as in the 2004 inventory.

Cell: C49

Comment: Rick Heede:
Data for total Civil operations ("Cl") is from the FAA via David Ulane of the Aspen Pitkin Airport and tracked yearly by airport operations staff.

The FAA-designated and recorded "Civil" flights are typically locally-based aircraft and Flights for Life (EMS). The locally-based flights are air training, sightseeing, touch-and-goes (TGs), and similar flights that originate and return to Aspen.

We subtract Pitkin Emergency Services "Flight for Life" operations for 2004 (see above) and allocate the remained to such local flights, which we estimate are of 1.5 hr duration and of an aircraft mix of piston twins and singles buring 16 gallons per hour.

Cell: B66
Comment: Rick Heede:
Bus & Coml Aviation, July 2008, page 34: FSI quoted that simulators use ~0.07 metric tonnes CO2 per hour compared to the average business aircraft emits ~3.08 tCO2 per hour. Converts to 3.4 tons CO2 per hour.
Alternate CMS calculation, based on guesstimate average speed of 1,000 nm and 2h+20m equals 493 mph and 429 kn, tehn average fuel consumption is 283 gallons per hour, 5,966 lb CO2/hr, and 2.98 tons CO2/hr.

Aspen/Pitkin County Airport
Total Passenger Enplanements

From David Ulane to Heede/CMS

7-Jan-09

Last modified: 18 April 2009

Enplanement and deplanement data for Aspen Pitkin County Airport, commercial aviation, 2003 - 2009

	2003		2004		2005		2006		2007		2008		2009	
	Enplaned	Deplaned	Enplaned	Deplaned	Enplaned	Deplaned	Enplaned	Deplaned	Enplaned	Deplaned	Enplaned	Deplaned	Enplaned	Deplaned
January	28,646	25,724	25,831	23,385	26,765	24,990	29,096	26,488	26,419	24,238	29,124	26,305		
February	27,898	29,246	25,051	24,505	26,224	24,321	27,294	27,412	25,494	25,132	28,732	28,941		
March	32,940	31,333	29,728	28,332	30,030	28,751	31,657	29,637	29,106	26,509	32,801	30,188		
April*	12,011	7,521	10,574	7,959	10,908	7,020	11,122	7,976	7,372	3,966	12,346	7,847		
May*	6,190	7,165	6,695	6,472	6,540	7,456	7,370	7,678	-	-	9,343	9,605		
June*	11,702	14,101	12,227	14,348	12,590	11,874	12,075	14,071	10,722	13,791	15,772	18,298		
July	16,590	17,728	16,067	16,257	16,259	16,963	18,548	18,467	19,401	18,776	22,726	22,576		
August	17,835	16,564	18,671	14,879	17,987	16,460	20,144	18,504	19,774	18,062	24,343	22,226		
September	10,306	8,537	8,590	7,747	12,824	12,295	13,473	11,672	12,286	10,490	14,416	12,405		
October	6,727	5,424	8,430	7,112	9,377	5,911	9,279	8,006	9,239	8,032	10,456	9,349		
November	5,549	6,017	6,857	7,555	7,170	7,399	7,521	7,871	7,899	8,746	7,637	8,531		
December	18,145	12,458	14,998	20,286	17,679	22,554	15,937	20,005	15,920	19,888	16,144	21,178		
Total Passengers:	194,539	181,818	183,719	178,837	194,353	185,994	203,516	197,787	183,632	177,630	223,840	217,449		

*The Airport was closed from April 9, 2007 through June 7, 2007 for runway rehabilitation

CMS note: 2008 enplanement and deplanement data updated from a file sent by Ulane, 16Jan09.

Historic Revenue Passenger Enplanements & Deplanements, 1998 - 2012

Year	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Enplanement	248,510	213,903	214,816	187,622	183,704	194,539	183,719	194,353	203,516	183,632	223,840				
Deplanement	na	na	na	na	na	181,818	178,837	185,994	197,787	177,630	217,449				
Total Enp + Depl						376,357	362,556	380,347	401,303	361,262	441,289	-	-	-	-

Analysis of "missing" PAX and "additional" emissions due to runway closure

18-Apr-09

	Apr-Jun06	Apr-Jun07	Apr-Jun08	Ave 06 & 08
Pax Apr-Jun	60,292	35,851	73,211	66,752
Percent of annual total	15.02%	9.92%	16.59%	15.81%
Total annual Pax	401,303	361,262	441,289	421,296
Additional PAX if ASE not closed Apr-Jun07:		30,901		
Total Apr-Jun07		66,752		
Percent adder to 2007 total PAX:		8.55%		
Total 2007 ASE air travel:	105,750	tons CO2e		
"Additional" emissions:	9,045	tons CO2e		

Cell: F11
Comment: Rick Heede:
Data from Ulane, 15Aug05 Aspen Passenger report for 2003 & 2004. This data was used in the CMS inventory for Aspen, year 2004.

Cell: N11
Comment: Rick Heede:
Airport passenger data from Ulane's "AirportPassengerRpt2008" for 2006 to 2008, received 16Jan09.

Cell: H38
Comment: Rick Heede:
Airport Total, 2005 deplanements, Ulane Aug2005. His datum for enplanements differs slightly: 194,539 pax.

Aspen Inventory 2007: US commercial fleet average emission factor

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started: 22 December 2008
File last modified: 2 January 2009

IPCC Global Warming Potential (GWP), FAR 2007		
GWP factor methane, FAR:	25	x CO2
IPCC FAR: Physical Science Basis, Table 2-14.		
GWP factor nitrous, FAR:	298	x CO2

Table 1a — Data on fuel, energy, and CO2 emissions for U.S. domestic service, 2006

TEBD 27th edition, data for 2006

Domestic air carriers	1,834	trillion Btu, 2006, Domestic air carriers, TEBD Table 2.5
International air carriers	406	trillion btu, international air carriers, 2006
General aviation	221	trillion btu, general aviation, 2006 (jet fuel only)

TEBD 27, 2008, Table 2-12: certificated route	
6,003	vehicle miles (millions)
577,620	passenger-miles (millions)
96.22	load factor (persons/veh)
313,776	Btu per vehicle-mile
3,261	Btu per passenger-mile
1,884	Total energy use (trillion Btu)
135,000	heat content (Btu per gallon)

ORNL Transportation Energy Data Book
http://cta.ornl.gov/data/index.shtml

Table 1b

	0.0242	gallons per pax-mile, 2006
	21.09	lb CO2e per gallon of jet fuel (Table 2c)
CMS, U.S. domestic service, 2006	0.5094	US average lb CO2e/passenger-mile, 2006
DEFRA, "long-haul" service, 2007	0.3747	lb CO2/passenger-mile (international)
CMS, ASE-DEN short haul service	0.9735	lb CO2/passenger-mile (DEN-ASE)

Table 2a — Calculation of emission coefficients for Jet Fuel

19.33	kgC/million Btu (EPA 2008: Annex 2: Methodology, Table A-30)
70.83	kg CO2/million Btu (CMS result above)
42.61	lb C/million Btu
3.66	CO2/C
156.15	lb CO2 "content"/million Btu
135,000	heat content of Jet Fuel (Btu per gallon)
7.41	gallons per million Btu
21.08	lb CO2 "content"/gallon
0.99	oxydation factor (per IPCC 1997; EPA Annex 2: Methodology)
20.87	lb CO2 emission factor per gallon of Jet Fuel, 2006

Table 2b — Methane & nitous oxide emission coefficients (Jet Fuel, per EIA 1605)

70.88	kg CO2/million Btu (EIA 2008 Form 1605 Instructions, App'x H: Fuel Emission Factors)
0.27	g CH4/gallon Jet Fuel
0.01	kg CO2e of methane emissions per gallon Jet
0.31	g N2O /gallon Jet Fuel
0.09	kg CO2e of nitrous emissions per gallon Jet
0.10	kg CO2e (methane + nitrous) per gallon Jet Fuel
70.98	Final total EIA: kg CO2e per gallon

Table 2c — Final CMS-calculated jet fuel coefficient w methane & nitrous & oxidation factor

70.93	CMS: kg CO2e per gallon (no methane & nitrous, before oxidation factor)
21.080	lb CO2 "content" per gallon (before oxidation factor)
20.869	lb CO2 emission factor per gallon (with oxidation factor applied)
0.219	lb CO2e (methane + nitrous) per gallon Jet Fuel
21.299	CMS: lb CO2e per gallon before oxidation factor
21.088	**Final total CMS: lb CO2e per gallon Jet Fuel with oxidation factor**
	CMS uses this factor in Aspen GHG aviation emissions, 2006, and includes methane and nitrous oxide emissions & oxidation factor (99 percent)
156.21	lb CO2e per million Btu

Table 3 — Airline Fuel Cost and Consumption (All carriers - Scheduled)

	Domestic			International			Total		
	Consumption (million gallons)	Cost (million dollars)	Cost per Gallon (dollars)	Consumption (million gallons)	Cost (million dollars)	Cost per Gallon (dollars)	Consumption (million gallons)	Cost (million dollars)	Cost per Gallon (dollars)
2000	13,904	$ 10,811	$ 0.78	5,123	$ 4,388	$ 0.86	19,026	$ 15,198	$ 0.80
2001	13,112	$ 10,025	$ 0.76	4,956	$ 3,990	$ 0.81	18,068	$ 14,014	$ 0.78
2002	12,287	$ 8,603	$ 0.70	4,572	$ 3,335	$ 0.73	16,859	$ 11,938	$ 0.71
2003	12,417	$ 10,315	$ 0.83	4,451	$ 3,838	$ 0.86	16,868	$ 14,154	$ 0.84
2004	13,380	$ 15,141	$ 1.13	4,765	$ 5,691	$ 1.19	18,145	$ 20,832	$ 1.15
2005	13,271	$ 21,658	$ 1.63	5,040	$ 8,601	$ 1.71	18,311	$ 30,258	$ 1.65
2006	12,907	$ 24,881	$ 1.93	5,221	$ 10,536	$ 2.02	18,128	$ 35,417	$ 1.95
2007	12,877	$ 26,628	$ 2.07	5,428	$ 11,684	$ 2.15	18,304	$ 38,312	$ 2.09
2008 (Jan-Oct)	10,468	$ 32,611	$ 3.12	4,671	$ 15,759	$ 3.37	15,138	$ 48,369	$ 3.20

Table 2d — Average per passenger-mile emission factors, various sources & years

year	lb CO2/pax-mile	notes
Sep06-Dec08	0.5452	CMS field research: 37 US flights average
Sep06-Dec08	0.4279	37 flights: total CO2 / (total miles * ave pax load)
2004 (TEBD)	0.5740	CMS: US domestic average (TEBD-25)
2005 (TEBD)	0.5048	CMS: US domestic average (TEBD-26)
2006 (TEBD)	0.5094	CO2e; CMS: US domestic average (TEBD-27)

Table 4 — FAA / Bureau of Transportation Statistics

	Scheduled Service						All Services		
	Revenue Pax Enplanements (millions)	Revenue Pax ton-miles (millions)	Rev. Freight ton-miles (millions)	Over-all avail ton-miles (millions)	Over-all rev. load factor (percent)	Aircraft Rev. Departures (millions)	Revenue Pax ton-miles (millions)	Rev. Freight ton-miles (millions)	Over-all avail ton-miles (millions)
2000	666	69,250	21,143	158,878	58.4%	9.0	70,800	30,221	172,574
2004	703	73,368	26,682	171,650	59.0%	11.4	75,207	37,958	171,650
2005	739	77,901	26,841	178,969	59.2%	11.6	79,512	39,292	200,282
2006	744	79,680	28,233	179,454	60.8%	11.3	80,946	39,754	198,937
2007	769	82,849	28,585	184,759	60.8%	11.4	84,098	39,842	204,328

Airline Activity, Oct06-Sep07, National Summary, U.S. Flights): 676 million passengers www.transtats.bts.gov/

Table 2e — TEBD 27, 2008, Table 9-2: U.S. domestic & international certificated route

8,220	vehicle miles (millions)
810,098	passenger-miles (millions)
3,266	Btu per passenger-mile
2,646	Total energy use (trillion Btu)
135,000	heat content (Btu per gallon)
0.0242	gallons per pax-mile, 2006
21.09	lb CO2e per gallon of jet fuel (Table 2c)
0.5102	US average lb CO2e/passenger-mile, 2006

ORNL Transportation Energy Data Book
http://cta.ornl.gov/data/index.shtml

CMS note: very slight difference btw Table 1 (domestic) and Table 2e (dom & int).

Cell: M12
Comment: Rick Heede:
Jet fuel varies slightly in quality from year to year (19.40 kgC in 1990, but at 19.33 kgC since 1996; EPA (2008) Inventory of US GHG 1990-2006, Annex 2: Methodology, Table A-30)

Cell: D13
Comment: Rick Heede:
Domestic air carriers' domestic consumption only; see below for international air carriers and general aviation.

Cell: D14
Comment: Rick Heede:
"One half of fuel used by domestic carriers in international operation." Fn C.

Cell: E27
Comment: Rick Heede (Jan09):
CMS re-calculated the emission coefficient for jet fuel in Tables 2a, 2b, and 2c, which is based on EIA and EPA factor of 19.33 kg carbon per million Btu and accounts for both associated methane and nitrous oxide emissions (EIA fuel factors) and the fuel oxidation factor (99 percent oxidation to CO2). The result is 21.088 lb CO2e per gallon of jet fuel.

The conventional EIA factor is slightly higher, at 21.095 lb CO2 per gallon, since the methane and nitrous adjustment compensates for EIA's non-consideration of the oxidation factor (although the EPA and IPCC list the oxidation factor as 99 percent, as used here).

Cell: E30
Comment: Rick Heede:
CMS adopts DEFRA emission factor for "long haul" (>6,482 km or 4,028 miles), revised in 2007 to 0.1056 kg CO2 per passenger km, which converts to 0.3747 lb CO2 per passenger-mile. CMS uses this factor for international flights in the Aspen GHG inventory for 2007.

CMS note: while DEFRA is the oft-cited source (e.g, basis for WRI's air travel factors), CMS considers this factor on the high side for long haul flights. The reason is personal experience and actual fuel consumption data for longer domestic flights taken from Sep06-Dec08 with higher load factors and that trended toward ~0.3 lb CO2/pax-mile. Some flights with high load factor were lower (e..g, 0.22 lb CO2/pax-mile). CMS has not taken an international flight in recent years. CMS applies the DEFRA factor but anticipates further research by DEFRA and other institutions will result in lowered emission factors for long haul flights in the near future. Shorter flights, however, are likely to increase toward 1.0 lb CO2/pax-mile -- up from the current DEFRA datum of 0.561 lb CO2/pax-mile.

UK DEFRA (2007) Passenger transport emissions factors: Methodology paper, London, 17 pp

Cell: E32
Comment: Rick Heede (Jan09):
CMS has calculated the fuel consumption and emission factor based on CMS acquisition of fuel data and passenger loading for 13 specific flights between Aspen and Denver (ASE & DEN) taken by CMS principal Rick Heede from Sep06 to Dec08.

Emission factors ranged from low of 0.603 lb CO2 per passenger-mile (DASH-8, 750 lb fuel, 32 of 37 pax, Sep08) to a high of of 3.82 lb CO2 per passenger-mile (CRJ700, 2,452 lb fuel, 16 of 66 pax, Dec08). A simple average of all 13 flights is 1.174 lb CO2/pax-mile.

A more reasonable calculation is to divide total emissions for all flights (68,412 lb CO2) by the product of total miles flown (1,704 miles) and average load (41.2 passengers) for an average emission factor of 0.9737 lb CO2/pax-mile. CMS applies this factor to the Denver to Aspen (and return) portion of each deplaning passenger arriving in Aspen (177,630 pax) or departing Aspen (183,632 pax) in 2007.

Note: CMS will attempt to disaggregate total passenger enplanements heading to Denver vs enplaning on flights with other destinations (e.g., SLC, LAX, CHI, etc).

Cell: N45
Comment: Rick Heede (Jan09):
CMS requested specific fuel consumption data "gate to gate" from the pilot after each of 37 flights taken from Sep06 through Dec08, but excluding 13 legs from Aspen to Denver or vice versa. These flights were chiefly on United Airlines (also Delta and Continental) in Airbus 320s, Boeing 737 and 777 and 767 and 757, Embraer, and CRJ200 and 700 aircraft on distances ranging from 40 to 2900 nmiles and load factors averaging 88.9 percent. Fuel consumption on all 37 flights totaled 430,700 lb, total distance flown was 28,772 miles (24,997 nm), and emissions of 1.34 million lb CO2. Emissions averaged 0.5452 lb CO2 per passenger mile for this set of flights. Average load factor of 88.9 percent.

See note below for alternate calculation. CMS field research is presented for comparison purposes only, and are not used to calculate emissions for the Aspen inventory -- except for the short haul between Aspen and Denver for which national or official data is unavailable.

Cell: N46
Comment: Rick Heede:
Instead of averaging the lb CO2/pax-mile for the 37 flights (as done above), this measure calculates the average differently: total emissions for all flights based on fuel data divided by (total miles flown times average passengers onboard). Which, for the 37 flights Sep-6-Dec08, is 1.34 million lb CO2 / (28,772 miles times 109 pax) = 0.4279 lb CO2/pax-mile. This calculation is a reasonable metric, but is made here for comparison purposes only.

Cell: N47

Comment: Rick Heede:
CMS calculated average per passenger mile emissions of 0.5740 lb CO2/pax-mile in 2004 using the same source as the above calculation for 2006: ORNL's TEBD, various tables.

Cell: N48
Comment: Rick Heede:
CMS calculated average per passenger mile emissions of 0.5048 lb CO2/pax-mile in 2005 using the same source as the above calculation for 2006: ORNL's TEBD, various tables.

Cell: N49
Comment: Rick Heede:
CMS calculation of ORNL TEBD data for year 2006. Methodology has been revised and improved to account for oxidation factor of 99 percent (ie., non-combustion of 1 percent of the carbon in the fuel) as well as inclusion of methane and nitrous oxide emissions (data from EIA 1605 emission factors). This revision changes the emission factor from 21.095 lb CO2/pax-mile in 2004 to 21.088 lb CO2e/pax-mile in 2006.

Performance calculations of private & business aircraft

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started 11 August 2008
Last Modified: 19 January 2009

The tables below summarize CMS research on aircraft performance of 147 makes and models of private and business jets and turboprops. Not all makes and models use the Aspen Pitkin County Airport (and some large aircraft are too wide and/or cannot safely take off from our high-altitude airport).
Data from *Business & Commercial Aviation* (2007) "2007 Operations Planning Guide," Aug07.

1 nm =	1.150779 statute mile
1 sm =	0.868976 nautical mile

Summary & Averages of Production Aircraft

			Fuel Expense: $ per trip					Fuel burn: Gallons per trip					Fuel burn: Gallons per *statute* mile				
Category	Make	Model	300 nm	600 nm	1000 nm	3000 nm	6000 nm	300 nm	600 nm	1000 nm	3000 nm	6000 nm	300 nm	600 nm	1000 nm	3000 nm	6000 nm
						equivalent statute miles:		345	690	1,151	3,452	6,905					
Production AC	Average of Category 1 (7 ac)		$ 463	$ 844	$ 1,210			99	180	258			0.286	0.261	0.224		
Out of prod'n	Average of Category 1 (28 ac)		$ 503	$ 938	$ 1,566			107	200	334			0.310	0.290	0.290		
Category average	Average of Category 1 (35 ac)		$ 493	$ 914	$ 1,495			105	195	319			0.304	0.282	0.277		
Production AC	Average of Category 2 (11 ac)		$ 607	$ 976	$ 1,468			129	208	313			0.375	0.301	0.272		
Out of prod'n	Average of Category 2 (22 ac)		$ 780	$ 1,324	$ 2,142			166	282	457			0.481	0.409	0.397		
Category average	Average of Category 2 (33 ac)		$ 722	$ 1,208	$ 1,918			154	258	409			0.446	0.373	0.355		
Production AC	Average of Category 3 (9 ac)		$ 924	$ 1,574	$ 2,507			197	336	535			0.571	0.486	0.465		
Out of prod'n	Average of Category 3 (20 ac)		$ 939	$ 1,583	$ 2,542			200	338	542			0.580	0.489	0.471		
Category average	Average of Category 3 (29 ac)		$ 934	$ 1,580	$ 2,531			199	337	540			0.577	0.488	0.469		
Production AC	Average of Category 4 (4 ac)		$ 1,136	$ 1,845	$ 2,855			242	393	609			0.702	0.570	0.529		
Out of prod'n	Average of Category 4 (5 ac)		$ 1,183	$ 2,082	$ 3,342			252	444	713			0.730	0.643	0.619		
Category average	Average of Category 4 (9 ac)		$ 1,162	$ 1,977	$ 3,126			248	421	666			0.718	0.610	0.579		
Production AC	Average of Category 5 (17 ac)		$ 1,652	$ 2,796	$ 4,332			352	596	924			1.020	0.864	0.803		
Out of prod'n	Average of Category 5 (12 ac)		$ 1,680	$ 2,841	$ 4,510			358	606	962			1.037	0.877	0.836		
Category average	Average of Category 5 (29 ac)		$ 1,664	$ 2,815	$ 4,406			355	600	939			1.027	0.869	0.816		
Production AC	Average of Category 6 (4 ac)				$ 5,820	$16,589	$35,961			1,241	3,537	7,668			1.078	1.025	1.110
Out of prod'n	Average of Category 6 (2 ac)				$ 5,616	$16,152	$32,090			1,197	3,444	6,842			1.041	0.998	0.991
Category average	Average of Category 6 (6 ac)				$ 5,752					1,226					1.066	1.016	1.071
Production AC	Average of Category 1-6 (52 ac)		$ 1,025	$ 1,731	$ 2,991	$16,589	$35,961	218	369	638	3,537	7,668	0.633	0.534	0.510	1.025	1.110
Out of prod'n	Average of Category 1-6 (89 ac)		$ 870	$ 1,506	$ 2,515	$16,152	$32,090	186	321	536	3,444	6,842	0.537	0.465	0.453	0.998	0.991
Category average	Average of Category 1-6 (141 ac)		$ 927	$ 1,588	$ 2,691			198	339	574			0.572	0.490	0.473	1.016	1.071
Category average	Average of Category 2-6 (106 ac)		$ 1,096	$ 1,851	$ 3,086			234	395	658			0.677	0.572	0.572	1.016	1.071

Bus & Coml Aviation, July 2008, page 34: FSI quoted that simulators use ~0.07 metric tonnes CO2 per hour compared to the average business aircraft emits ~3.08 tCO2 per hour.

Cell: U14

Comment: Rick Heede:

CMS bases its calculations on fuel flow per mission length segments published in B&CA Operations Plannning Guide. These mission distances are expressed in categories such as 300, 600, 1,000 NAUTICAL miles (nm). Thus, in calculating fuel combustion per statute mile for the Canary/Colorado Governor's Energy Office -- which will use a distance calculator that gives flying distances in statute miles, CMS converts all fuel burn estimates for all makes and models, as well as category averages, into fuel burn per mile. This is accomplished by dividing fuel burn per trip (columns L through P) by, for example, 300 nm * 1.1508 m/nm = 345.2 mile; ditto for 600 nm, and so forth.

General Aviation, Aspen Pitkin Airport (Sardy Field), 2007

John Eisler
Aspen Canary Initiative
16-Sep-08

Adjustments by Rick Heede
Climate Mitigation Services
20-Jan-09

original FAA data	Jan	Feb	March	April	May	June	July	August	Sept	Nov	Oct	Dec	2007
Air Taxi	1,124	984	1,355	285	-	1,096	2,063	1,874	1,397	791	725	1,006	12,700
General Aviation	2,336	2,054	2,634	620	-	2,070	3,151	3,145	2,080	1,321	1,243	1,385	22,039
												Total	34,739

Air Carrier				adjustment for Dash-8 flights classified by FAA Aspen CT as Air Taxi ops										
Air carrier	910	884	1,026	296	-	517	680	666	246	223	221	709	6,378	FAA air carrier data
Dash-8 adjustment	200	188	248	66	-	306	424	412	460	328	290	200	3,122	2xload factor DASH-8
Total Air Carrier Ops	**1,110**	**1,072**	**1,274**	**362**	**-**	**823**	**1,104**	**1,078**	**706**	**551**	**511**	**909**	**9,500**	

Itinerant (non-Carrier)	Jan	Feb	March	adjusted Air Taxi plus General Aviation results April	May	June	July	August	Sept	Nov	Oct	Dec	2007	
Air Taxi (adjusted)	924	796	1,107	219	-	790	1,639	1,462	937	463	435	806	9,578	linked to Table 1 & 2
General Aviation	2,336	2,054	2,634	620	-	2,070	3,151	3,145	2,080	1,321	1,243	1,385	22,039	linked to Table 1 & 2
Military	15	3	-	-	-	10	-	4	7	2	-	4	45	linked to Table 1 & 2
Total itinerant	**3,275**	**2,853**	**3,741**	**839**	**-**	**2,870**	**4,790**	**4,611**	**3,024**	**1,786**	**1,678**	**2,195**	**31,662**	
Local														
Civilian	52	70	165	42	-	84	114	104	248	84	154	40	1,157	
Military	8	2	-	-	-	2	1	10	4	1	1	-	29	
Total local	**60**	**72**	**165**	**42**	**-**	**86**	**115**	**114**	**252**	**85**	**155**	**40**	**1,186**	linked to Table 4
Total air taxi, GA, & local	**3,335**	**2,925**	**3,906**	**881**	**-**	**2,956**	**4,905**	**4,725**	**3,276**	**1,871**	**1,833**	**2,235**	**32,848**	

Total, all airport operations 2007 **42,348**

2007 — FAA data on "Operations" (landing or takeoff) at Aspen Pitkin Airport

	Itinerant								Local				Totals	
Month	Air Carrier	Air Taxi	Air Carrier + Air Taxi	General Aviation	GA Vs. 2006	Military	Total Itinerant	Vs. 2006	Civilian	Military	Total Local	Vs. 2006	2007	Vs. 2006
January	910	1,124	2,034	2,336	15.1%	15	4,385	16.7%	52	8	60	25.0%	**4,445**	16.8%
February	884	984	1,868	2,054	-6.8%	3	3,925	-3.2%	70	2	72	-10.0%	**3,997**	-3.3%
March	1,026	1,355	2,381	2,634	8.4%	-	5,015	8.8%	165	-	165	166.1%	**5,180**	10.9%
April*	296	285	581	620	-58.7%	-	1,201	-52.8%	42	-	42	-19.2%	**1,243**	-52.1%
May*	-	-	-	-	-100.0%	-	-	-100.0%	-	-	-	-100.0%	**-**	-100.0%
June*	517	1,096	1,613	2,070	-6.6%	10	3,693	-3.5%	84	2	86	-20.4%	**3,779**	-4.0%
July	680	2,063	2,743	3,151	4.3%	-	5,894	7.0%	114	1	115	130.0%	**6,009**	8.1%
August	666	1,874	2,540	3,145	2.4%	4	5,689	2.1%	104	10	114	442.9%	**5,803**	3.8%
September	246	1,397	1,643	2,080	-7.5%	7	3,730	-2.0%	248	4	252	769.0%	**3,982**	3.8%
October	223	791	1,014	1,321	9.4%	2	2,337	9.9%	84	1	85	193.1%	**2,422**	12.3%
November	221	725	946	1,243	-10.8%	-	2,189	-0.5%	154	1	155	496.2%	**2,344**	5.3%
December	709	1,006	1,715	1,385	-36.8%	4	3,104	-22.9%	40	-	40	90.5%	**3,144**	-22.3%
Totals	**6,378**	**12,700**	**19,078**	**22,039**	**#DIV/0!**	**45**	**41,162**	**-6.5%**	**1,157**	**29**	**1,186**	**79.7%**	**42,348**	**-5.2%**

Historical Aspen Airport operations data from FAA via David Ulane, Jan09

2008 (Jan-Nov)	7,067	12,141	19,208	18,673	74	37,882	3,512	33	3,540	**41,422**
2007	6,378	12,700	19,078	22,039	45	41,162	1,157	29	1,186	**42,348**
2006	5,411	13,847	19,258	24,693	68	44,019	609	51	660	**44,679**
2005	5,130	12,538	17,668	25,159	65	42,892	1,305	28	1,333	**44,225**
2004	5,233	12,468	17,701	25,020	72	42,793	1,207	22	1,229	**44,022**
2003	6,580	10,034	16,614	24,504	116	41,234	1,737	8	1,745	**42,979**
2002	6,902	10,034	16,936	27,335	92	44,363	2,042	36	2,078	**46,441**
2001	6,988	9,008	15,996	27,978	75	44,049	1,952	46	1,998	**46,047**
2000	7,632	7,199	14,831	30,016	167	45,014	3,570	72	3,642	**48,656**
1999	7,363	3,864	11,227	31,724	217	43,168	3,024	50	3,074	**46,242**
1998	11,475	4,233	15,708	27,546	66	43,320	2,429	42	2,633	**45,953**

Cell: K17

Comment: Rick Heede:

David Ulane pointed out that the FAA classifies some air carrier flights as “Air Taxi” (those aircraft carrying fewer than 60 passengers), and that to get an accurate estimate of air taxi operations in 2007 we need to deduct the total number of airline flights that arrive with, in our case, DASH-8 aircraft. This is done using airline load factor data provided by David Ulane for 2007, in which 1,561 DASH-8 landed at ASE. Since the FAA control tower counts both arrivals and landings, we need to count each DASH-8’s departure and deduct the sum from FAA data on Air taxi. Thus, in 2007, commercial “air carrier” aircraft total 6,378 plus 3,122 DASH-8s from air taxi equals 9,500 total arriving and departing commercial flights.

Note: commercial air travel fuel and emissions are calculated in the “Commercial Aviation 2007” worksheet and are based on total arriving and departing passengers. This is necessitated by the fact that airlines do not share total fuel consumption for their fleet serving Aspen.

General Aviation & Air Carrier & Air Taxi Operations, Aspen Pitkin Airport, 2004

Richard Heede
Climate Mitigation Services
12-Feb-09

Table 1

Air Carrier operations arriving and departing Aspen, 2004

2004	Origin & Destination	Aircraft	Passengers	Seats	Arrivals & departures	Load factor
Mesa Airlines	ASE to DEN	Dash-8: 37 seats	25,208	38,443	1,039	65.6%
	ASE to PHX	Dash-8	5,323	9,768	264	54.5%
	DEN to ASE	Dash-8	26,560	38,591	1,043	68.8%
	PHX to ASE	Dash-8	6,105	11,063	299	55.2%
Total Mesa			63,196	97,865	2,645	64.6%
Air Wisconsin		BAE 146: 89 seats	265,829	391,868	4,400	67.8%
Mesaba Airlines		RJ 85: 69 seats	34,204	49,059	711	69.7%
Total Air Carrier Arr & Dep ASE			363,229	538,792	7,756	67.4%

Source: Ulane, from Airports: USA Data Miner

CMS note: why the mismatch between ASE to PHX and PHX to ASE?

Table 2

Total ASE Operations

Air Carrier		Operations
Air carrier		5,233
Dash-8 adjustment		2,645
Total Air Carrier Ops		7,878
Itinerant (non-Carrier)		2004
Air Taxi (adjusted)		9,823
General Aviation		25,020
Military		72
Total itinerant		34,915
Local		
Civilian		1,207
Military		22
Total local		1,229
Total air taxi, GA, & local		36,144
Total, airport operations 2004		44,022

Table 3 **Original and revised Air Taxi operations, ASE 2004**

	Original Air Taxi Ops	Revised Air Taxi Ops
Air Taxi	12,468	9,823

RJ 85

Dash-8

BAE 146

Aircraft Operations Report

Aspen/Pitkin County Airport
From David Ulane to Heede, CMS
17-Jan-09

Table 4

2004

	Itinerant						Local			Totals
Month	Air Carrier	Air Taxi	Air Carrier+ Air Taxi	General Aviation	Military	Total Itinerant	Civilian	Military	Total Local	2004
January	783	912	1,695	1,960	2	3,657	56	-	56	3,713
February	773	1,089	1,862	2,031	6	3,899	18	4	22	3,921
March	916	1,297	2,213	2,833	9	5,055	87	16	103	5,158
April	277	557	834	985	2	1,821	72	-	72	1,893
May	208	587	795	1,144	4	1,943	24	2	26	1,969
June	349	1,080	1,429	2,216	7	3,652	28	-	28	3,680
July	363	1,763	2,126	3,182	21	5,329	87	-	87	5,416
August	364	1,725	2,089	3,412	7	5,508	132	-	132	5,640
September	263	1,032	1,295	2,399	6	3,700	238	-	238	3,938
October	178	616	794	1,297	-	2,091	162	-	162	2,253
November	188	596	784	1,252	6	2,042	236	-	236	2,278
December	571	1,214	1,785	2,309	2	4,096	67	-	67	4,163
Totals	**5,233**	**12,468**	**17,701**	**25,020**	**72**	**42,793**	**1,207**	**22**	**1,229**	**44,022**

Source: *Federal Aviation Administration Air Traffic Control Tower/ASE*

Cell: G25
Comment: Rick Heede:
Wikipedia:
Avro RJX series The RJX-70, RJX-85 and RJX-100 aircraft represented advanced variants of the Avro RJ Series. The RJX used Honeywell AS977 turbofans for greater efficiency (15% less fuel-burn, 17% increased range), quieter performance and 20% less maintenance costs.

Cell: H25
Comment: Rick Heede:
Wikipedia:
The Bombardier Dash 8 (formerly the de Havilland Canada Dash 8, sometimes abbreviated as DHC-8) is a series of twin-engined, medium range, turboprop airliners. Introduced by de Havilland Canada (DHC) in 1984, they are now produced by Bombardier Aerospace. Since 1996, the aircraft have been known as the Q Series, for “quiet”. Over 900 Dash 8s of all models have been built. Bombardier forecasts a total production run of 1,192 units of all Dash8/QSeries variants through the year 2016.

Engines: 2 PW120A/PW121 (Series 100) or 2 PW123C/D (Series 200), Typical Passenger Seating: 37 (Single Class), Maximum fuel capacity: 3,160 liters, Maximum takeoff weight: 36,300 lb (16,470 kg).

Cell: K31
Comment: Rick Heede:
Wikipedia:
The BAe 146 is a medium-sized commercial aircraft which was manufactured in the United Kingdom by British Aerospace (which later became part of BAE Systems). Production ran from 1983 until 2002. Manufacture of the improved version known as the Avro RJ began in 1992. A further-improved version, the Avro RJX – with new engines – was announced in 1997, but only two prototypes and one production aircraft were built before production ceased in late 2001. With 387 aircraft produced, the Avro RJ/BAe 146 program is the second most successful British civil jet to date. The BAe 146/Avro RJ is a high-wing cantilever monoplane with a T-tail, it has four turbofan jet engines engines pylon mounted underneath the wings. It has a retractable tricycle landing gear. The aircraft has STOL capabilities and very quiet operation; it has been marketed under the name Whisperjet.

Specifications (BAe 146-200) General characteristics Crew: 4 with 2 flight attendants Capacity: 85-100 passengers Length: 93 ft 8 in (28.55 m) Wingspan: 86 ft 5 in (26.34 m) Height: 28 ft 3 in (8.61 m) Wing area: 832 ft? (77.30 m?) Empty weight: 73,415 lb (33,300 kg) Max takeoff weight: 93,035 lb (42,200 kg) Powerplant: 4? Honeywell ALF 502R-5 turbofans, 6,970 lbf (31 kN) each Performance Maximum speed: 555 mph (482 knots, 893 km/h) Cruise speed: 465 mph (404 knots, 750 km/h) Range: 1,290 mi (2,075 km) with 25,000 lb (11,000 kg) of payload Service ceiling 31,200 ft (9,500 m)

Aspen Emissions Inventory: Pitkin County Landfill: Emissions and Savings

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started 7 August 2008
Last Modified: 13 April 2009

Future inventorists must update electricity and diesel fuel purchased by the Pitkin County Landfill, update recovered materials flows, and check commingled materials by weight. The estimate of methane generation and/or our estimated fraction emitted to the atmosphere must also be checked.

Data provided by:
Chris Hoofnagle
Solid Waste Manager
Pitkin County Landfill
923-3487
chrisho@co.pitkin.co.us

Dr. Jean Bogner
Landfills +, Inc.
630-665-0872

Table 1: Emissions	Electricity	Fuel consumed	Carbon factor	Methane emissions	Methane factor	Attributed to Aspen	Carbon dioxide (Aspen's share)	Carbon (Aspen's share)
	kWh	gallons	lb CO2/kWh & /gallon	tons CH4	tons CO2e	Percent	tons CO2e	tonnes carbon (C-eq)
Pitkin County Landfill					Methane GWP: 25xCO2			
Electricity	153,511		1.707			50%	**66**	**16**
Fuel consumption (diesel)		5,953	22.38			50%	**33**	**8**
Fuel consumption (gasoline)		873	19.59			50%	**4**	**1**
Fugitive methane (from Table 2)				1,357	33,937	50%	**16,969**	**4,201**
Total Pitkin County Landfill							**17,072**	**4,227**
		Aspen's share of methane emissions		678.7	tons CH4			
Biosolids, tons, 2007:	**1,650**	**0.02**	**2% tons as methane**	**33.00**	**825**	**100%**	**825**	**204**
				Total Landfill if biosolids methane is included:			**17,897**	

Table 2	Estimated methane generation and emissions, 2007	
Methane generated (low: 295 cfm)	3,285	tons CH4
Methane generated (high: 483 cfm)	5,378	tons CH4
Methane emitted (low: 1,023 tonnes)	1,128	tons CH4
Methane emitted (high: 1,440 tonnes)	1,587	tons CH4
Methane emitted (average of high and low)	1,357	**tons CH4**

Golder Associates (2007) *Landfill Gas Evaluation of the Pitkin County Solid Waste Center*, Lakewood CO, 41 p., www.golder.com

1,000 cf methane =	42.37	lb

tonne = 1,000 kg
ton = 2000 lb
1 tonne = 1.1023 ton
1 kg = 2.2046 lb

Table 3: Saved emissions (recycling)	Quantities Recycled and Sold	CO2e savings per tonne recycled	Total Pitkin County CO2e savings	Attributed to Aspen	Aspen's share, CO2e	Aspen's share, Ce
	tonnes	tonnes CO2-eq/tonne	tons CO2e	Percent	tons CO2e/yr	tonnes carbon (C-eq)
Pitkin County Landfill: Savings from Recycling						
Office paper	236	5.4	1,404	60%	**842**	209
Newsprint	1,816	2.5	5,005	60%	**3,003**	743
Cardboard	1,338	3.0	4,425	60%	**2,655**	657
Commingled materials	2,112	na	na	60%	**na**	na
Plastics (10.5 percent of commingled)	222	2.0	489	60%	**293**	73
Aluminum (6.5 percent of commingled)	137	15.7	2,376	60%	**1,425**	353
Glass (65 percent of commingled)	1,373	0.4	605	60%	**363**	90
Steel (18 percent of commingled)	380	2.3	964	60%	**578**	143
Total Landfill recycling savings	5,502	na	15,268	60%	**9,161**	2,268

Note: This savings estimate is generic and does not necessarily reflect local collection or disposal energy expenditures vs savings.
Note: Emissions from diesel fuel used by waste and recycled materials haulers are included in the transportation worksheets as a percentage of "3-axle trucks".

Cell: F13
Comment: Rick Heede (2005):
See note under Fugitive methane, in which we allocate a fraction of estimated methane generation as emissions through the landfill's topsoil as fugitive methane emitted to the atmosphere.

Jan09 update: CMS adopts the IPCC Fourth Assessment Report's revised GWP factor for methane, up from 23xCO2 to 25xCO2 (one hundred year time horizon).

Cell: G13
Comment: Heede (Feb09):
Energy Information Administration (2008) Emissions of Greenhouse Gases in the United States 2007. GWP, methodolgoy, p 12: Methane. In its Fourth Assessment Report, the IPCC developed revised global warming potential factors (GWPs) for selected gases. The GWP for methane was revised from the previous value of 23 in the IPCC's Third Assessment Report to 25 in the Fourth Assessment Report. The revised GWP for methane is used in this report. In addition, this report incorporates an increase in the density of methane from 42.28 to 42.37 pounds per thousand cubic feet, in order to provide consistent temperature and pressure values for methane in all EIA data.

Cell: H13
Comment: Rick Heede:
Approximately 50 percent of the Landfill waste is generated in Aspen. The other 50 percent is from Basalt and upstream from Basalt in Ptikin County. Estimate from Hoofnagle, personal communication, 19Jul05.

Cell: B15
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: B16
Comment: Heede (Sep08):
Marta Darby updated to 2007 electricity consumption. CMS updated to 2007 electricity carbon factor.

Rick Heede (2005):
Hoofnagle: 110,476 kWh in 2004; 50,700 kWh of which is used in recycling operations (balers, crushers, lighting, etc).

Cell: B17
Comment: Marta Darby (Sep08):
Data from Chris Hoofnagle:
5953 gallons of diesel
873 gallons of unleaded

Chris Hoofnagle refered me to James Gilliam with the county Fleet Department [429-5765].

Rick Heede:
4,849 gallons of diesel fuel consumed in 2004 by the Landfill's compliment of ~dozen loaders, dozers, trucks, graders, and excavators.

Cell: B18
Comment: Marta Darby:
Data from Chris Hoofnagle:
5953 gallons of diesel
873 gallons of unleaded

Chris Hoofnagle refered me to James Gilliam with the county Fleet Department [429-5765].

Rick Heede:
4,849 gallons of diesel fuel consumed in 2004 by the Landfill's compliment of ~dozen loaders, dozers, trucks, graders, and excavators.

Cell: B19
Comment: Heede (Feb09):
CMS adopts the findings of the Golder Associates report (2007), averaging the high and low estimates of total methane emitted (1,023 to 1,440 tonnes CH4 in 2007), or average of 1,357 (short) tons CH4. CMS also adopts the IPCC FAR GWP value of methane at 25xCO2. See cell notes to Tables 1 and 2.

Marta Darby:
Hoofnagle (9/3/08): Methane rate likely has not change appreciably in the three years since the estimate.

Rick Heede:
Methane generation is roughly 150 cubic feet per minute. Hoofnagle, personal communication, 17Aug05: "An estimate of current methane generation rate would be on the order of 150 cubic feet per minute (cfm) for the Pitkin County Landfill. This estimate is based on design capacity of 2.24 million megagrams, and refuse disposed from 1999 through 2002. This is a very rough estimate."

150 cfm times 60 x 24 x 365 = 78.84 million cubic feet (Mcf); 1 cf of methane equals 0.04228 lb: thus 78.84 Mcf x 0.04228 lb/cf = 1.6666776 short tons of methane. We assume that 60 percent (1,000 short tons) of this amount of generated methane is released to the atmosphere annually.

Note: This estimate may be too high for a small landfill in a dry/high altitude climate. Verify with Hoofnagle and other sources.

Methane conversion (lb/cf): U.S. Dept of Energy (2005) Voluntary Reporting of Greenhouse Gases (1605b) Program: Draft Technical Guidelines, DOE Office of Policy and International Affairs, p. 105. (Note: this conversion factor was off by a factor of 10 too high (said 0.418 lb/cf instead of 0.04228 lb/cf); called VRGG technical staff at 800-803-5182 to correct their draft guidelines.

Note 2: We have not estimated fugitive methane from the Landfill's receipt of about 10 yards (one truck load) of biosolids from the Aspen Wastewater Treatment Plant every ~3 days. Hoofnagle data: 3.9 million lb of biosolids from the WTF in 2004. This equals 1,771 metric tonnes. If two percent of this mass is converted to methane = 35.42 tonnes of CH4, times 23 x CO2 = 814.7 tonnes CO2-equivalent.

Note 3: Dr Jean Bogner, Landfill +, Inc (Wheaton, IL) points out that the Pitkin methane generation estimate is probably derived with the EPA LandGEM model and estimation software. As such, it probably over-estimates generation rates (does not account for chemical interactions, soil oxidation rates, microbial processes). She cannot refine the Pitkin Landfill estimate without carefully evaluating local conditions, landfill content, additions over several years, decomposition rates, etc. As a precautionary adjustment, CMS reduces the Pitkin estimate by fifty percent (of that allocated to the CIty of Aspen).

Cell: B24
Comment: Marta Darby (Sep08):
The landfill received a total of 2200 tons of biosolids in 2007. "Aspen Consolidated Sanitation District provides the lions share, although we also receive from Basalt and Mid-Vally Metro. I'd put ACSD at 75% of the total 2200 tons, or 1650" -- Email from Chris Hoofnagle [Aug. 28, 2008]

Rick Heede (2005):
The landfill received a total of 1,953 tons of biosolids from the Aspen Sanitation Wastewater Treatment plant (about 3-4 truck loads per week). We assume in this preliminary estimate that 2 percent is released as methane gas during its storage and curing period prior to being mixed in with composted wastes, chipped wood fiber, and other soils and sold as various grades of topsoil and compost.

Biosolids delivery data from Chirs Hoofnagle, Solid Waste Manager, Aug05.

This calculation does not estimate the methane emissions that would result from anaerobic digestion of the biosolids in the landfill, that is, if buried.

Cell: F29
Comment: Rick Heede:
Golder Associates (2007) Landfill Gas Evaluation of the Pitkin County Solid Waste Center, Lakewood CO, 41 pp., Table 1.

Golder estimates that between 1,907 and 3,356 tonnes of methane is recoverable (2007), rising to 2,562 to 4,161 tonnes per year at peak in 2021. At $20 per tonne carbon credit, this recovery is worth $128,000 - $245,000 (2007), rising to $171,000 - $ $303,000 in 2021.

Cell: C38
Comment: Rick Heede:
Data updated to 2007 by Marta Darby.

Original data from Hoofnagle to Darby, 2Sep08:
Recycling Tons in 2007

cardboard	1,475	= 1,338 tonnes, etc
newsprint	2,002	
office pac	260	
co-mingled containers	2,328	
carpet pad	no data	
mixed paper	no data	
TOTAL	6,065	= 5,502 tonnes.

Cell: D38
Comment: Rick Heede:

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

Abstract: Waste management has at least five types of impacts on climate change, attributable to (1) landfill methane emissions, (2) reduction in industrial energy use and emissions due to recycling and waste reduction, (3) energy recovery from waste, (4) carbon sequestration in forests due to decreased demand for virgin paper, and (5) energy used in long-distance transport of waste. A recent U.S. EPA study provides estimates of overall per-ton greenhouse gas reductions due to recycling. Calculations using these estimates suggest that the U.S. could realize substantial greenhouse gas reductions through increased recycling, particularly of paper.

Cell: G38
Comment: Rick Heede:
We allocate 50 percent of the savings from recycled materials to Aspen.

Cell: B44
Comment: Heede (Nov08:
Hoofnagle, Aug08 to Darby, re: breakdown of commingled materials: "I'd say off the top of my head that half the total tonnage is glass. Of the other half, probably half of that is in the aluminum and tin cans. The truth is we don't really know that one." But seemed to agree with the 2004 materials composition in an email 3Sep08: "I think that the recycling breakdown is roughly the same as these numbers." Consequently, CMS uses the 10.5 percent for plastics. 6.5 percent aluminum, 65 percent glass, and 18 percent steel used in 2004.

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: B45
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: B46
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: B47
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.

Aspen Emissions Inventory: Nitrous Oxide Sources

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started 11 August 2005
Last Modified: 29 November 2008

Update data on fertilizer applications rates at the City and Maroon Creek Clubs, city parks, city athletic fields, and privately-owned greenspace.

Data provided by
Maroon Creek Club Superintendent
544-1666, Steve

City of Aspen Parks and Golf Depts
Steve Aiken, Aspen Golf Course, 920-5719
Brian Flynn, Aspen Parks Dept.

Table 1: Nitrous oxide emissions	Nitrogen in fertilizer applied	Direct N2O	Indirect N2O (volatilized)	Indirect N2O (run-off & leaching)	Total Nitrous Oxide	Carbon dioxide-equivalent emissions	Carbon-equivalent emissions
	kg Nitrogen/yr	kg N2O	kg N2O	kg N2O	kg N2O	sh tons CO2-eq 296 x CO2	tonnes C-eq
Maroon Creek Club (organic)	3,458	55.32	11.06	41.49	107.9	35.2	8.7
City of Aspen Golf Course	4,051	64.82	12.96	48.61	126.4	41.2	10.2
City of Aspen Parks	1,502	24.03	4.81	18.02	46.9	15.3	3.8
City of Aspen athletic fields	2,687	42.99	8.60	32.25	83.8	27.4	6.8
Private greenspace within City limits	15,078	241.25	48.25	180.94	470.4	153.5	38.0
Private greenspace within Urban Growth Boundary	6,883	110.13	22.03	82.60	214.7	70.1	17.3
Total Nitrous Oxide Emissions	**33,659**	**539**	**108**	**404**	**1,050**	**343**	**85**

Table 2: Organic fertilizer application:	kg N	variable	fixed factor	kg N2O
Direct:	1,000	0.8	0.020	16
Indirect (volat.)	1,000	0.2	0.016	3
Indirect (leach)	1,000	0.3	0.040	12
Total N2O emissions for a 1,000 kg N application (example):				**31.2**

Table 3: Synthetic fertilizer application:	kg N	variable	fixed factor	kg N2O
Direct:	1,000	0.9	0.020	18
Indirect (volat.)	1,000	0.1	0.016	2
Indirect (leach)	1,000	0.3	0.040	12
Total N2O emissions for a 1,000 kg N application (example):				**31.6**

Direct emission calculation:
Direct N2O emissions = N applied (kg N) * fractiondirect * 0.02 kg N2O /kg N
Indirect emission calculation:
Volatilization N2O = N applied (kg N) * fractionvolatilized * 0.016 kg N2O /kg N
Run-off/leaching N2O = N applied (kg N) * fractionrunoff * 0.04 kg N2O /kg N

Table 1.H.16. Fractions by nitrogen source	fraction-direct	fraction-volatilized	fraction-runoff
Synthetic commercial fertilizers	0.9	0.1	0.3
Organic commercial fertilizers and manure	0.8	0.2	0.3

Cell: D13
Comment: Rick Heede:
Direct emission calculation: Direct N2O emissions (kg N2O) = N applied (kg N) * fraction(direct) * 0.02 kg N2O /kg N

U.S. Dept of Energy (2005) Voluntary Reporting of Greenhouse Gases (1605b) Program: Draft Technical Guidelines, DOE Office of Policy and International Affairs, pp. 191-92.

Cell: E13
Comment: Rick Heede:
Indirect emission calculation: Volatilization N2O (kg N2O) = N applied (kg N) * fraction(volatilized) * 0.016 kg N2O /kg N.

U.S. Dept of Energy (2005) Voluntary Reporting of Greenhouse Gases (1605b) Program: Draft Technical Guidelines, DOE Office of Policy and International Affairs, pp. 191-92.

Cell: F13
Comment: Rick Heede:
Indirect emission calculation: Run-off/leaching N2O (kg N2O) = N applied (kg N) * fraction(runoff) * 0.04 kg N2O /kg N

U.S. Dept of Energy (2005) Voluntary Reporting of Greenhouse Gases (1605b) Program: Draft Technical Guidelines, DOE Office of Policy and International Affairs, pp. 191-92.

Cell: H13
Comment: Rick Heede:
The Global Warming Potential (GWP) of nitrous oxide is 296 times that of carbon dioxide over a 100-year time horizon. IPCC (2001) Climate Change 2001: The Scientific Basis, Table 6.7, p. 388.

Cell: B16
Comment: Rick Heede (17Nov08):
CMS uses the formula ((70*43560*2.5/1000)/2.2046) to calculate kg of nitrogen from application of 1 + 1.5 lb N per 1,000 sf per year over 70 acres. We do not have area data on greens and tees (application rate of 2 to 3 lb N per 1,000 sf). and CMS assumes the same 2.5 lb application rate on all 70 acres.

Lauren McDonell (Nov08):
Steve (Maroon Club superintendent) reported that 1.5lbs N/1,000 sq. ft. polybased fertilizer is applied to roughs & fairways in Spring, 1lb N w/ ammonium sulfate/ 1,000 sq. ft in Fall. For greens and tees, approximately 2-3 lbs N is applied annually. For both, combinations of organic and synthetics and slow and quick release fertilizers are used.
_____
Rick Heede (2005):
Maroon Creek Club uses organic fertilizer applied at a rate of 2.25 to 2.5 lb per 1,000 sq.ft. MCC has 70 acres (@43,560 sq.ft/ac), thus 6,861 to 7,623 lb Nitrogen, which converts to an average of 3,285 kg N.

Cell: B17
Comment: Rick Heede (29Nov08):
Lauren McDonell update:
Greens - 700 lbs quick release 13313 analysis fertilizer, ammonium nitrate and sulfate of potash. Two additional applications of 375 lbs of potash on greens.
Greens: 700 lbs of 13-3-13 equals 91 lbs (41.28 kg) of nitrogen
Fairways, roughs, tees - May 22, 2008 5 tons of 4200 analysis fertilizer - 1/2 urea and 1/2 IBDU (slow release). Aug. 7, 2008 9 tons of 29019 analysis fertilizer, 1/2 urea, 1/2 nitroform, sulfate of potash. Fairways roughs and tees: 10,000lbs 42-0-0 equals 4,200 lbs (1905.09 kg) nitrogen PLUS Fairways roughs and tees: 16,000lbs 29-0-19 equals 4,640 lbs(2104.67 kg) nitrogen

Total Nitrogen in kg for Aspen Golf Course = 4051.04 kg N.

Lauren McDonell (Nov08):
Data from Steve Aiken, Aspen Golf Course, Nov., 5, 2008 (extension 5719).

Greens - 700 lbs quick release 13-3-13 analysis fertilizer, ammonium nitrate and sulfate of potash. Two additional applications of 375 lbs of potash on greens.

Fairways, roughs, tees - May 22, 2008 5 tons of 42-0-0 analysis fertilizer - 1/2 urea and 1/2 IBDU (slow release). 7Aug08: 9 tons of 29-0-19 analysis fertilizer, 1/2 urea, 1/2 nitroform, sulfate of potash.
_____
Rick Heede (2005):
Data from Aspen Parks and Golf Depts via Lee Cassin, 4Oct05. Original data for golf course: 359 lb on tees, 9,980 lb on fairways + roughs + clubhouse grounds, and 437 lb on greens = 10,776 lb of nitrogen applied = 4,888 kg N.

Cell: B18
Comment: Rick Heede (29Nov08):
Lauren got acreage: 38 acres of City parks, plus 34 acres of sports fields. Verify that parks get 2 lb Nitrogen per 1,000 sf (rather than per acre [very low]) and playing fields get 4 lb N per 1,000 sf. This calculation for Aspen parks

is: 38 acres * 43,560 sf/ac * 2 lb N/1,000 sf = 3,311 lb N, divided by 2.2046 lb/kg = 1,502 kg N.

Lauren McDonell (Nov08):
I checked with Brian Flynn and fertlizer data for City of Aspen parks is:

For Aspen Parks: coated, time-release organic fertilizer: 2 lbs N, 0.5 lbs P, 1.25 lbs K, and inert material this year.

For Aspen playing sports fields: time release, organic fertilizer, 4 lbs N, 1 lb P, 3.5 lbs K, and inert material this year.
_____
Rick Heede (2005):
Data from Aspen Parks and Golf Depts via Lee Cassin, 4Oct05. Original data varies by year, but in 2004 1,081lb in neighborhood parks, 2,700 lb on athletic fields, and 200 lb for landscaping and trees = total of 3,981 lb = 1,806 kg N.

City application in 1998 = 2,762 lb, 2000 = 2,962 lb, 2002 = 3,281 lb N.

Note: these estimates are not measured application but recommended application rate by type of area times area.

Cell: B19
Comment: Rick Heede (29Nov08):
See cell note above: 34 acres of sports & playing fields get 4 lb N per 1,000 sf. This calculation for Aspen playing fields is: 34 acres * 43,560 sf/ac * 4 lb N/1,000 sf = 5,924 lb N, divided by 2.2046 lb/kg = 2,687 kg N.

Cell: B20
Comment: Lauren McDonell (Nov08):
I checked with Bridget Kelly and land areas changed slightly in 2007. Greenspace within City of Aspen is now 2,545 acres.

If all else stays the same, the new calclulation should be: 2,545 times 0.75 times 0.33 = 630acres (@43,560 sq. ft.) = 27.4 million sq.ft. with 1.2 lb N per 1,000 sq. ft. = 32,925 lb N = 14,935 kg N.
_____
Rick Heede:
We do not have purchase or application date for private yards and commercial properties by owners or contractors, and we (conservatively) assume the following:

That the City of Aspen's 2,544 acres is 75 percent privately-owned with one-half the application rate of city parks and fields (1.2 rather than ~2.4 lb per 1,000 sq.ft.) on the one-third of privately-owned land that we assume is fertilized greenspace: 2,544 acres times 0.75 times 0.33 = 636 acres (@43,560 sq.ft.) = 27.7 million sq.ft. with 1.2 lb N per 1,000 sq.ft. = 33,242 lb N = 15,078 kg N.

Cell: B21
Comment: Lauren McDonell:
I checked with Bridget Kelly and land areas have changed slightly for 2007. Land within city limits (2,545) minus land within UGB (4,867) equals 2,322.

If all else stays the same, the new calculations: 2,322 acres times 0.75 times 0.1667 = 290.3 acres (@43,560 sq.ft.) = 12.65 million sq.ft with 1.2 lb N per 1,000 sq.ft = 15,174 lb N = 6,883 kg N
_____
Rick Heede:
Land within city limits totals 2,544 acres and land within the Urban Growth Boundary totals 4,868 acres. We apply half the application rate of the low rate used within city limits to the additional UGB acreage of 2,324 acres:

That the UGB area outside city limits of 2,324 acres is 75 percent privately-owned with one-half the application rate of city parks and fields (1.2 rather than ~2.4 lb per 1,000 sq.ft.) on the one-sixth of privately-owned land that we assume is fertilized greenspace: 2,324 acres times 0.75 times 0.1667 = 290.5 acres (@43,560 sq.ft.) = 12.65 million sq.ft. with 1.2 lb N per 1,000 sq.ft. = 15,185 lb N = 6,888 kg N.

UGB area data from Bridgette Kelly, City of Aspen Pitkin County GIS and Mapping Dept., personal communication, 4Oct05.

Cell: E26
Comment: Rick Heede:
These tables are taken from U.S. Dept of Energy (2005) Voluntary Reporting of Greenhouse Gases (1605b) Program: Draft Technical Guidelines, DOE Office of Policy and International Affairs, pp. 191-92.

The DOE/EIA methodology is generally consistent with the IPCC Guidelines and the US EPA's Annex 3: Methdological Descriptions for Additional Source or Sink Categories (Annex 3 to EPA's (2005) Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2003), yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2005.html