Town of Frisco

Summary

Community Greenhouse Gas Emissions Inventory, 2006

Last Modified: 7 April 2008

Rick Heede Climate Mitigation Services, 970-927-9511

	Physical Units		Energy Units		GHG Emissions		CO2e Equivalent		Percent of Total
Buildings: electricity									
Electricity (Xcel Energy)	46,682,216	kWh	476,159	10^6 Btu	42,396	tons CO2	42,396	tons CO2	32.9%
Electricity (fugitive methane - coal mines)	152	tons CH4	7,246	10^6 Btu	152	tons CH4	3,184	tons CO2e	2.5%
Total electricity	46,682,216	kWh	476,159	10^6 Btu	na	tons CO2e	45,580	tons CO2e	35.4%
Buildings: natural gas and propane									
Natural Gas (Xcel Energy)	3,855,012	ccf	332,329	10^6 Btu	19,423	tons CO2	19,423	tons CO2	15.1%
Natural Gas (natural gas - fugitive methane)	110	tons CH4	5,271	10^6 Btu	110	tons CH4	2,316	tons CO2e	1.8%
Propane (AmeriGas)		gallons		10^6 Btu	170	tons CO2	178	tons CO2e	0.1%
Propane (Ferrellgas)		gallons		10^6 Btu	44	tons CO2	46	tons CO2e	0.0%
Total natural gas & propane	33,864	gallons	340,693	10^6 Btu	na	tons CO2e	21,963	tons CO2e	17.1%
Buildings: other									
Refrigerant leakage from refrigerators, freezers, and AC units	7	kg HFC-134a	na	10^6 Btu	10	tons CO2e	10	tons CO2e	0.0%
Total buildings	na	gallons	816,851	10^6 Btu	na	tons CO2	67,553	tons CO2e	52.5%
Transportation: highway, around town, buses, boats									
Highway vehicles, driving Hwy 9	3,485,894	gallons	435,984	10^6 Btu	34,866	tons CO2	35,672	tons CO2e	27.7%
Highway vehicles, around town	1,451,245	gallons	181,509	10^6 Btu	14,384	tons CO2	14,734	tons CO2e	11.4%
Tourist road travel to & from Frisco	794,029	gallons	99,310	10^6 Btu	7,779	tons CO2	7,985	tons CO2e	6.2%
Transit Buses (Summit Stage)	97,982	gallons	13,590	10^6 Btu	1,017	tons CO2	1,017	tons CO2	0.8%
School Buses (Summit School District)	16,358	gallons	2,269	10^6 Btu	183	tons CO2	185	tons CO2e	0.1%
Other School District vehicles	3,850	gallons	482	10^6 Btu	38	tons CO2	39	tons CO2e	0.0%
Out-of-school-district fuel (ExEd trips, away games)	1,540	gallons	193	10^6 Btu	16	tons CO2	17	tons CO2e	0.0%
Summit County Public Works heavy vehicles (diesel)	15,799	gallons	2,191	10^6 Btu	164	tons CO2	166	tons CO2e	0.1%
Summit County Public Works - sheriff etc. (gasoline)	16,102	gallons	2,014	10^6 Btu	158	tons CO2	163	tons CO2e	0.1%
Town of Frisco equipment (diesel fuel)	11,598	gallons	1,451	10^6 Btu	130	tons CO2	131	tons CO2e	0.1%
Town of Frisco vehicles (gasoline)	19,402	gallons	2,427	10^6 Btu	190	tons CO2	197	tons CO2e	0.2%
Off-road (construction equip., snowmobiles, gas widgets)	49,820	gallons	6,231	10^6 Btu	488	tons CO2	488	tons CO2	0.4%
Total highway vehicles, around town, buses, & misc	5,963,621	gallons	864,862	10^6 Btu	59,414	tons CO2	60,793	tons CO2e	47.2%
Transportation: boating									
Boat fuel sold at Frisco Marina	9,760	gallons	1,318	10^6 Btu	96	tons CO2	96	tons CO2	0.1%
Transportation: other									
Refrigerant leakage from vehicle air conditioners	57	kg HFC-134a	na	10^6 Btu	82	tons CO2e	82	tons CO2e	0.1%
Total transportation	5,973,381	gallons	866,180	10^6 Btu	59,591	tons CO2e	60,970	tons CO2e	47.4%
Landfill (Frisco's share of Summit County Solid Waste)									
Landfill & Materials Recovery: electricity	48,800	kWh	498	10^6 Btu	48	tons CO2	48	tons CO2	0.0%
Landfill & Materials Recovery: diesel fuel	10,349	gallons	1,435	10^6 Btu	116	tons CO2	116	tons CO2	0.1%
Landfill & Materials Recovery: gasoline & propane	173	gallons	22	10^6 Btu	1	tons CO2	1	tons CO2	0.0%
Landfill: fugitive methane	na	tons CH4		10^6 Btu	na	tons CH4		tons CO2e	0.0%
Total landfill	various		1,955	10^6 Btu		na	165	tons CO2e	0.1%
Nitrous Oxide sources									
Frisco parks & ballfields	544	kg N	na		17	kg N2O	6	tons CO2e	0.0%
Summit schools (no data)		kg N	na			kg N2O		tons CO2e	0.0%
Private greenspace within town limits	481	kg N	na		15	kg N2O	5	tons CO2e	0.0%
Total nitrous oxide sources	1,025	kg N	na		32	kg N2O	10	tons CO2e	0.0%
Total	various	units	1,684,986	10^6 Btu	various	units	128,698	tons CO2e	100.0%
Credit for windpower (Town and individual customers)	1,921,000	kWh	19,594	10^6 Btu	1,876	tons CO2e	1,876	tons CO2e	
Total net emissions after renewable energy credits	various	units	1,665,392	10^6 Btu	various	units	126,823	tons CO2e	
Methane and nitrous oxide of total emissions					262	tons CH4	6,991	tons CO2e	5.4%
Carbon dioxide of total emissions							121,707	tons CO2	94.6%

1 ton CH4 = 47.792 million Btu (EPA "Natural Gas Methane Units Converter")

Cell: L2
Comment: Rick Heede:
This worksheet summarizes all sources of greenhouse gas emissions attributable to the community of Frisc, Colorado, in 2006. See the boundary definition in the Summary Report and the set of worksheets for details. All relevant sums -- physical units, energy units, GHG emissions, and CO2e equivalent -- are linked to their respective worksheets and thus automatically updated whenever any changes are made.

Cell: F5
Comment: Rick Heede:
EPA (undated) “Natural Gas Methane Units Converter,” 2 pp., www.epa.gov/gasstar; PDF in Climate / Emissions / Emissions Factors. 1 ton CH4 = 47.792 million Btu

Cell: B16
Comment: Rick Heede:
AmeriGas and Ferrellgas quantities sold were reported but are whited out in this summary sheet, per vendor request, Sep07. Both gallons sold and million Btu consumed are included in gas and propane totals.

Town of Frisco

Community Greenhouse Gas Emissions Inventory, 2006

Last Modified: 7 April 2008

Summary

Rick Heede Climate Mitigation Services, 970-927-9511

	Physical Units		Energy Units		GHG Emissions		CO_2e Equivalent		Percent of Total
Buildings: electricity									
Electricity (Xcel Energy)	46,682,216	kWh	476,159	10^6 Btu	42,396	tons CO2	42,396	tons CO2	32.94%
Electricity (fugitive methane - coal mines)	152	tons CH4	7,246	10^6 Btu	152	tons CH4	3,184	tons CO2e	2.47%
Total electricity	46,682,216	kWh	476,159	10^6 Btu	na	tons CO2e	45,580	tons CO2e	35.42%
Buildings: natural gas and propane									
Natural Gas (Xcel Energy)	3,855,012	ccf	332,329	10^6 Btu	19,423	tons CO2	19,423	tons CO2	15.09%
Natural Gas (natural gas - fugitive methane)	110	tons CH4	5,271	10^6 Btu	110	tons CH4	2,316	tons CO2e	1.80%
Propane (AmeriGas)		gallons		10^6 Btu	170	tons CO2	178	tons CO2e	0.14%
Propane (Ferrellgas)		gallons		10^6 Btu	44	tons CO2	46	tons CO2e	0.04%
Total natural gas & propane	33,864	gallons	340,693	10^6 Btu	na	tons CO2e	21,963	tons CO2e	17.07%
Buildings: other									
Refrigerant leakage from refrigerators, freezers, and AC units	7	kg HFC-134a	na	10^6 Btu	10	tons CO2e	10	tons CO2e	0.008%
Total buildings	na	gallons	816,851	10^6 Btu	na	tons CO2	67,553	tons CO2e	52.49%
Transportation: highway, around town, buses, boats									
Highway vehicles, driving Hwy 9	3,485,894	gallons	435,984	10^6 Btu	34,866	tons CO2	35,672	tons CO2e	27.72%
Highway vehicles, around town	1,451,245	gallons	181,509	10^6 Btu	14,384	tons CO2	14,734	tons CO2e	11.45%
Tourist road travel to & from Frisco	794,029	gallons	99,310	10^6 Btu	7,779	tons CO2	7,985	tons CO2e	6.20%
Transit Buses (Summit Stage)	97,982	gallons	13,590	10^6 Btu	1,017	tons CO2	1,017	tons CO2	0.79%
School Buses (Summit School District)	16,358	gallons	2,269	10^6 Btu	183	tons CO2	185	tons CO2e	0.14%
Other School District vehicles	3,850	gallons	482	10^6 Btu	38	tons CO2	39	tons CO2e	0.03%
Out-of-school-district fuel (ExEd trips, away games)	1,540	gallons	193	10^6 Btu	16	tons CO2	17	tons CO2e	0.01%
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Off-road (construction equip., snowmobiles, gas widgets)	49,820	gallons	6,231	10^6 Btu	488	tons CO2	488	tons CO2	0.38%
Total highway vehicles, around town, buses, & misc	5,963,621	gallons	864,862	10^6 Btu	59,414	tons CO2	60,793	tons CO2e	47.24%
Transportation: boating									
Boat fuel sold at Frisco Marina	9,760	gallons	1,318	10^6 Btu	96	tons CO2	96	tons CO2	0.07%
Transportation: other									
Refrigerant leakage from vehicle air conditioners	57	kg HFC-134a	na	10^6 Btu	82	tons CO2e	82	tons CO2e	0.06%
Total transportation	5,973,381	gallons	866,180	10^6 Btu	59,591	tons CO2e	60,970	tons CO2e	47.37%
Landfill (Frisco's share of Summit County Solid Waste)									
Landfill & Materials Recovery: electricity	48,800	kWh	498	10^6 Btu	48	tons CO2	48	tons CO2	0.04%
Landfill & Materials Recovery: diesel fuel	10,349	gallons	1,435	10^6 Btu	116	tons CO2	116	tons CO2	0.09%
Landfill & Materials Recovery: gasoline & propane	173	gallons	22	10^6 Btu	1	tons CO2	1	tons CO2	0.00%
Landfill: fugitive methane	na	tons CH4		10^6 Btu	na	tons CH4		tons CO2e	0.00%
Total landfill	various		1,955	10^6 Btu		na	165	tons CO2e	0.13%
Nitrous Oxide sources									
Frisco parks & ballfields	544	kg N	na		17	kg N2O	6	tons CO2e	0.004%
Summit schools (no data)		kg N	na			kg N2O		tons CO2e	0.00%
Private greenspace within town limits	481	kg N	na		15	kg N2O	5	tons CO2e	0.00%
Total nitrous oxide sources	1,025	kg N	na		32	kg N2O	10	tons CO2e	0.01%
Total	various	units	1,684,986	10^6 Btu	various	units	128,698	tons CO2e	100%
Credit for windpower (Town and individual customers)	1,921,000	kWh	19,594	10^6 Btu	1,876	tons CO2e	1,876	tons CO2e	
Total net emissions after renewable energy credits	various	units	1,665,392	10^6 Btu	various	units	126,823	tons CO2e	

Methane and nitrous oxide of total emissions	262	tons CH4	6,991	tons CO2e	5.43%
Carbon dioxide of total emissions			121,707	tons CO2	94.57%

1 ton CH4 = 47.792 million Btu (EPA "Natural Gas Methane Units Converter")

Cell: L2
Comment: Rick Heede:
This worksheet summarizes all sources of greenhouse gas emissions attributable to the community of Frisc, Colorado, in 2006. See the boundary definition in the Summary Report and the set of worksheets for details. All relevant sums -- physical units, energy units, GHG emissions, and CO2e equivalent -- are linked to their respective worksheets and thus automatically updated whenever any changes are made.

Cell: F5
Comment: Rick Heede:
EPA (undated) “Natural Gas Methane Units Converter,” 2 pp., www.epa.gov/gasstar; PDF in Climate / Emissions / Emissions Factors. 1 ton CH4 = 47.792 million Btu

Cell: B16
Comment: Rick Heede:
AmeriGas and Ferrellgas quantities sold were reported but are whited out in this summary sheet, per vendor request, Sep07. Both gallons sold and million Btu consumed are included in gas and propane totals.

Town of Frisco Emissions Inventory for 2006: Electricity

Future inventorists need to update electricity sales ("Consumption," row C) by Xcel Energy and to verify that the same geographic boundary is used by Xcel to compile the data. Also update the carbon dioxide and methane emissions factors for sources of purchased electricity (updated in Table 2 below).

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started 23 April 2007
Last Modified: 13 February 2008

Emissions of carbon dioxide from the combustion of fossil fuels at power plants supplying electricity to Xcel Energy. Zero-carbon renewable sources are accounted for (see Table 4 below). Methane emissions from coal mines supplying power plant fuel are also included.

Table 1	Electricity		Carbon	Emissions				
	Consumption	Consumption	factor	Carbon Dioxide	Methane	Methane	Total	Total
2006	kWh	MWh	carbon/kWh	tons CO2	tons CH4	tons CO2-eq	tons CO2+CH4	tonnes C-eq
			lb CO2/kWh		lb CH4/kWh	CO2 x 21	lb CO2-equiv/kWh	kg C-eq/kWh
Xcel Energy			1.816		0.006	21	1.953	0.242
			Percent of total					
Residential: Total	19,704,466	19,704	42.2%	17,895	64	1,344	19,239	4,763
Commercial: Total	26,741,986	26,742	57.3%	24,287	87	1,824	26,110	6,465
Industrial		-		-	-	-	-	-
Municipal: Total	235,764	236	0.5%	214	1	16	230	57
Other (irrigation pumps)		-		-	-	-	-	-
Total electricity and emissions	46,682,216	46,682		42,396	152	3,184	45,580	11,285

Table 2

Emissions factors (CO2-e/kWh consumed)	Xcel Energy	Diluted by Xcel coal mix
CO2 (generation)	1.692	
CO2 (T&D losses)	0.124	
Total CO2	1.816	
Methane (kg CH4/MWh) from "elec carbon factor"	4.994	2.946
Methane (lb CH4/kWh)	0.011	0.006
Methane (as CO2-e) (lb CO2-e/kWh)	0.231	0.136
Total CO2-e/kWh	2.048	1.953

Xcel Energy investment in energy efficiency and peak shaving, 2006

Table 3

US averages for 2005 by electric generation source

	Emissions	Emissions	Generation	US power sector
	million tonnes CO2	million tons CO2	Billion kWhs	Elec emissions rate
Table 12.7a All Sectors			Table 8.2a	lb CO2/kWh gen
Gas	365	402	752	1.070
Oil	113	124	122	2.036
Coal	1,953	2,152	2,014	2.137
Total fossil	2,444	2,694	2,903	1.856
Table 12.7b Utils	Utils only		Table 8.2b	
Gas	296	326	875	0.745
Oil	97	107	116	1.854
Coal	1,894	2,088	1,993	2.096
Total fossil	2,299	2,534	2,787	1.818

Table 4

Frisco credits for windpower contracts (Xcel and Renewable Energy Choice)

2006	kWh	tons CO2e	2007	kWh	tons CO2e	Total Frisco Wind kWh	Offset tons CO2e
Town Windpower	1,400,000	1,367	Xcel Windsource	521,000	509	1,921,000	1,876

Credited in the Summary worksheet

Table 5

Preliminary estimate of end-use sectors

2006	Consumption	Consumption	End-use by sector	Carbon Dioxide	Methane	Methane	Total	Total
	kWh	MWh	Percent of total	tons CO2	tons CH4	tons CO2-eq	tons CO2+CH4	tonnes C-eq
Residential	19,704,466	19,704	42.2%	17,895	64	1,344	19,239	4,763
Commercial	26,741,986	26,742	57.3%	24,287	87	1,824	26,110	6,465
Industrial	-	-	0.0%	-	-	-	-	-
Municipal (street lighting only)	235,764	236	0.5%	214	1	16	230	57
Total all sectors	46,682,216	46,682	100.0%	42,396	152	3,184	45,580	11,285

Cell: E12
Comment: Rick Heede:
The carbon factors -- the amount of carbon dioxide per average kWh delivered to customers -- varies depending on the fuel mix of the electricity provider serving Frisco. *

Xcel Energy estimated the carbon factor for its electricity generation in Colorado as 1,692 lb CO2 per MWh. 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 Xcel datum of 1.692 lb CO2/kWh x 1.0735 = 1.816 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), 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. CMS uses the factor estimated by Xcel Energy (7Dec07) as 7.35 percent to account for the relative proximity of Xcel's power plants to Frisco. Losses also occur in local grids, powerlines, and transformers, and Xcel has included a grid loss factor for local distribution, too.

Cell: G13
Comment: Rick Heede:
CMS has calculated emissions of methane from coal mines supplying Colorado power plants -- diluted by the Xcel Energy's resource mix (59 percent coal, 35 percent gas, 3 percent each hydro and wind; Xcel, 17dec07) -- in order to estimate emissions of the greenhouse gas associated with the generation of electricity in Colorado. We have used Colorado's total emissions of methane from all 13 Colorado coal mines (0.233 million tonnes CH4) (estimated by Center for Climate Strategies (2007) Draft Emissions Inventory), electricity generation (46.72 billion kWh) and coal production (34.93 million tonnes) to estimate the emissions rate of 4.994 kg CH4 per MWh and 6.68 kg CH4 per tonne coal mined.

In the case of Xcel, 59 percent of its generation is by coal, hence we multiply 4.994 kg CH4/MWh x 0.59 = 2.946 kg CH4 per MWh of total Xcel generation. This, for the time being, ignores emissions of methane from natural gas generation and ancillary emissions upstream from gas-fired powerplants.

Cell: H13
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 21xCO2 (100 hundred year horizon, mole basis), per IPCC Second Assessment Report, and while adjusted in the Fourth Assessment Report this adjusted factor has been approved by the IPCC governing bodies for use in national inventories. CMS uses the SAR convention.

Note: Some practitioners use the GWP factor in IPCC's Fourth Assessment Report: 23xCO2 (100 hundred year horizon, mole basis),

Cell: I15
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 as well as fugitive 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 and excavators, nor the diesel fuel to run the mining and transportation modes. See the Boundary definition in the final report for details.

Cell: B16
Comment: Rick Heede:
2006 summary of electricity sales by sector and rate class from Todd Anderson, 24 July 2007. Revised data supplied on 17Dec07. Completed data supplied again 8Feb08. CMS ignores Xcel Energy's calculated emissions from electricity sales. First, CMS applies a grid loss factor (from Xcel T&D data, see below). Second, CMS adds ancillary emissions from coal mining (coal is 59 percent of Xcel's gen-mix), i.e., fugitive methane emissions associated with supplying coal to Xcel's generation (this is likely conservative, in that methane from natural gas, 35 percent of Xcel gen-mix, is excluded, as is energy and CO2 emissions from gas processing and coal operations and coal-trains).

Feb08: Xcel Energy provided final data on 17Dec07 and 8Feb08 on electricity sales within Frisco Town Limits in 2006. This excludes sales to residential and commercial customers outside town limits but within the broader Frisco community for which CMS sought data. (CMS counted 383 residential lots outside town limits in contiguous Summit County; also excludes Summit County Middle School and Bus Barn and Hospital and County Commons areas.)

Cell: J31
Comment: Rick Heede:
This analysis uses US average carbon emissions per kWh generated by source. 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 Xcel procures power from utility-owned power plants, we use the utility only carbon factor for each gas and coal-fired plant, which are highlighted in red on the worksheet.

Cell: G32
Comment: Rick Heede:
Energy information Administration (2005) Annual Energy Review 2004. Tables as cited below.

Cell: C34
Comment: Rick Heede:
CMS note of 27Dec07:
Mr Anderson supplied a revised carbon factor for Xcel Energy's Colorado system: 1,692 lb CO2/MWh, or 1.692 lb CO2/kWh. Mr. Anderson also estimated Xcel's grid loss factor: transmission of 1.000, Primary of 1.0235, and Secondary of 1.050. CMS interprets this to mean a total loss of 7.35 percent between bus bar and end use customer (unless revised by Xcel). As noted below, CMS typically applies a more conservative factor of 6 percent, but we will use Xcel's 7.35 percent in Frisco.

Furthermore, Xcel has supplied data on its Colorado system resource mix: 59 percent coal, 35 percent natural gas, 3 percent hydro, and 3 percent wind generation.

CMS notes of 1Aug07:
Xcel's system-wide carbon emissions: 1,262.6 lb CO2 per MWh (Michelle Edwards, Xcel, personal communication, June 2006). However, Xcel's Triple Bottom Line report for 2006, page 71, shows an emissions rate of 1,712 lb CO2 per MWh, presumably system-wide. The previous year's report, p. 44, commits the company to "reduce CO2 intensity by 7 percent from 2003 baseline by 2012. (1646 lb per MWh to 1531 lb/MWh.) www.xcelenergy.com/docs/2006_TBL-FullReport.pdf (CMS saved in Climate/Corporations). This factor may be for Xcel Energy's overall system, not specific to Colorado.

Untill Todd Anderson has provided a better factor to use for Xcel's Colorado generation, CMS applies Ms Edward's datum.

That datum -- 1.263 lb CO2/kWh -- is adjusted upwards by 6 percent to account for transmission and distribution losses. The 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: D38
Comment: Rick Heede:
Ignores emissions of methane from natural gas production, processing, and distribution to Xcel's gas-fired powerplants (35 percent of Xcel's Colorado system generation). Dilutes coal-mining CH4 rate by Xcel's coal-fired capacity (59 percent, Todd Anderson, Xcel Energy, 17Dec07).

Cell: B39
Comment: Rick Heede:
Calculated for Colorado methane emissions rate per ton of coal mined. Data from Center for Climate Solutions (2007) Draft Inventory, Appendices A (Electricity) and E (Energy industry). See worksheet on "Electricity carbon factor", Tables 7 and 8. The Colorado rate (4.99 kg CH4 per MWh) is ~3.5 times higher than the average US rate (1.415 kg CH4 per MWh).

Cell: C45
Comment: Rick Heede:
Xcel Energy (2007) Triple Bottom Report 2006, page 62: "In Colorado, Xcel Energy spent more than $27 million in 2006 on energy effi ciency and conservation projects for electric residential and business customers. The projects achieved a savings of nearly 30 megawatts of peak production, nearly 47 gigawatt-hours of energy."

Cell: C50
Comment: Rick Heede:
The Town of Frisco contracted for 1.4 million kWh of American Wind renewable energy credit for three years (2006-2008) from Renewable Energy Choice in Boulder, Colorado.

Cell: F50
Comment: Rick Heede:
Data from Todd Anderson, Xcel Energy Dec07 and confirmed Feb08. Of the 521,000 total WindSource kWh by Frisco customers in 2007, 498,124 kWh by residential (96%) and 22,876 kWh (4%) commercial. Most customers do not sign up for all WindSource, and those 135 residential customers used a total of 852,621 kWh of electricity, and the 2 commercial customers used a total of 41,374 kWh.

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Notes

Town of Frisco Emissions Inventory: Electricity CO2 & methane factor

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started 23 April 2007
Last Modified: 13 February 2008

Future inventorists may wish to update Colorado's coal-mining methane emission rate, but since this changes relatively slowly, this can also be ignored unless coal operators show significant progress in reducing emissions. A related item that does have to be updated is the "Diluted by Xcel coal mix" in table 2 of the "electricity" worksheet. In 2006, coal providee 59 percent of Xcel's generation, and should be revised if needed.

Table 1	US averages for 2005 by electric generation source			
2005	Emissions	Emissions	Generation	US power sector
	million tonnes CO2	million tons CO2	Billion kWhs	Elec emissions rate
Table 12.7a All Sectors			Table 8.2a	lb CO2/kWh gen
Gas	364.9	402.2	751.5	1.070
Oil	112.6	124.1	121.9	2.036
Coal	1,952.6	2,152.4	2,014.2	2.137
Total fossil	2,444.4	2,694.5	2,903.3	1.856
Table 12.7b Utils	Utils only		Table 8.2b	
Gas	**295.9**	**326.2**	**875.1**	**0.745**
Oil	**97.4**	**107.4**	**115.8**	**1.854**
Coal	**1,893.9**	**2,087.6**	**1,992.5**	**2.096**
Total fossil	2,298.5	2,533.6	2,786.8	**1.818**
Table 12.7c Coml + Indl	CHP (coml + Indl)		Table 8.2d	
Gas	69.1	76.2	88.7	1.717
Oil	15.2	16.8	6.1	5.493
Coal	58.8	64.8	21.6	6.001
Total fossil	145.9	160.8	116.5	2.761

Table 2	Calculation of US average and Colorado average methane emissions rate from coal mining (subsurface + underground) & post-mining							Colorado:
	Coal mined	Coal mined	Electricity generated	Methane released	Methane released	Methane/tonne coal mined	Methane per MWh	Ave. CH4 emissions rate
	million tons	million tonnes	Billion kWh	Million tonnes CH4	kg CH4	kg CH4/tonne	kg CH4/MWh	
US average coal-mining methane rate	1,333.30	1,209.56	2,014.20	2.85	2,850,000,000	2.356	1.415	
Colorado ave. coal-mining methane rat	38.50	34.93	47.90	0.233	233,333,333	6.681	4.871	
	Colorado electricity sales (2004):		46.72	0.233	233,333,333	6.681	**4.994**	**kg CH4/MWh**

(linked to "electricity" worksheet, cell C40)

Table 3	Colorado data (CCS Inventory, 2007)		
	tonnes CO2-e/ton mined	kg CH4/ton mined	kg CH4/tonne mined
EIA 2004 cited in CCS:	0.127	6.05	6.666
million tonnes methane (CO2e)	4.90		

Cell: I11
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: F12
Comment: Rick Heede:
Energy information Administration (2006) Annual Energy Review 2005. Tables as cited below.

Cell: F35
Comment: Rick Heede:
EIA (2006) Emissions of Greenhouse Gases in the United States 2005, Table 16.

Cell: E40
Comment: Rick Heede:
CCS (2007) Draft Colorado Inventory, p. A-11: data for 2004: 47,900 GWh generated. Other data: demand (sales plus losses) = ~51,500 GWh; total sales (Table A-5) = 46,724 GWh, of which Xcel sold 25,748 GWh.

Cell: H45
Comment: Rick Heede:
CCS (2007) Draft Colorado Inventory, Appendices A (Electricity) and E (Energy Industry, including coal mining and methane emissions).

Town of Frisco Emissions Inventory for 2006: Natural Gas

Future inventorists must update annual sales from Xcel Energy ("Consumption," in Billion Btu in column D). The Xcel data includes natural gas transported for third parties and is included under "commercial" sales. As a consequence, some gas consumed in apartment buildings and town homes may be listed in the commercial sector. The geographic boundary is Frisco Town Limits, *not* including customers in contiguous areas outside town.

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started 23 April 2007
Last Modified: 13 February 2008

Data provided by:
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Jeff Grebe, President
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Table 1	Natural Gas		Emissions	Emissions				
	Consumption	Consumption	factor	Carbon Dioxide	Methane	Methane	Total	Total
2006	Thousand cf (Mcf)	Billion Btu (10^9)	carbon per btu	short tons CO2	short tons CH4	tons CO2eq	tons CO2e	tonnes C-eq
(Altitude adjusted to 1,160 cf/million btu:)	cubic feet/million btu		tonnes C/billion Btu	tons CO2/billion Btu	tons CH4/ton CO2	tons CO2e/ton CO2	tons CO2e/billlion Btu	tonnes Ce/billlion Btu
Xcel Energy	1,160		14.47	58.44	0.00568	0.11925	65.41	16.20
Residential	201,232	**173.5**	0^9 Btu*tonsCO2/10^9 btu	10,139	57.6	1,209	11,348	2,810
Commercial	184,269	**158.9**		9,284	52.7	1,107	10,391	2,573
Municipal (included above)					-	-	-	-
Total, Xcel Energy	**385,501**	**332.3**		**19,423**	**110**	**2,316**	**21,739**	**5,382**
	52.2%							

	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 CO2e	tons CO2e	tonnes C-eq
Xcel "transport gas"	1,160	none in 2006						
Transported natural gas	-			-	-	-	-	-
Total, Xcel transport gas	**-**	**-**		**-**	**-**	**-**	**-**	**-**

	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 CO2e	tons CO2e	tonnes C-eq
Xcel Energy + Transported Gas	**385,501**	**332**		**19,423**	**110**	**2,316**	**21,739**	**5,382**

Total West Slope: 6,986 **Billion Btu** **Frisco, % of W Slope:** 4.8%

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

Methane from natural gas industry:	**6.7**	million tonnes CH4
CO2 from natural gas consumption:	**1,178**	million tonnes CO2
Methane emissions rate as CH4	**0.00568**	kg CH4/kg CO2
Methane emissions rate as CO2-e	**0.11925**	kg CO2-e/kg CO2
CO2 plus methane emissions rate (short tons)	**65.415**	tons CO2-e/billlion Btu
Carbon plus methane emissions rate (metric)	**16.196**	tonnes C-e/billlion Btu

Table 3. Carbon factors (Frisco)

10.077	lb CO2/hundred cf (ccf
11.279	lb CO2-e/ccf
0.1008	lb CO2 per cubic foot
1,160	cubic feet / million Btu
862	Btu per cubic foot
58.44	tons CO2 per billion Btu
116.89	lb CO2 per million Btu
130.83	lb CO2e per million Btu
13.08	lb CO2e per therm

Standard conversions

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

EPA Methane Converter

1 lb CH4	23.552	cf
1 cf CH4	0.0425	lb Ch4
1 lb CH4	23,896	Btu
1 ton CH4	47,792,000	Btu
1 ton CH4	47.792	million Btu

EPA AP42 App A 1985

1 cf (dry gas)	1,027	Btu
1 lb (compressed gas)	20,551	Btu
1 ton (compressed gas)	41,102,000	Btu
1 tonne (compr gas)	45,306,735	Btu

Table 4	Preliminary estimate of end-use sectors							
2006	Consumption	Consumption	End-use by sector	Carbon Dioxide	Methane	Methane	Total	Total
	Thousand cf (Mcf)	Billion Btu (10^9)	Percent of total	short tons CO2	short tons CH4	tons CO2-eq	tons CO2-e	tonnes C-eq
Residential	**201,232**	**173**	**52.2%**	**10,139**	**58**	**1,209**	**11,348**	**2,810**
Commercial	**184,269**	**159**	**47.8%**	**9,284**	**53**	**1,107**	**10,391**	**2,573**
Transport gas	**-**	**-**	**0.0%**	**-**	**-**	**-**	**-**	**-**
Preliminary total commercial	**184,269**	**159**	**47.8%**	**9,284**	**53**	**1,107**	**10,391**	**2,573**
Total all sectors	**385,501**	**332**	**100.0%**	**19,423**	**110**	**2,316**	**21,739**	**5,382**

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

Cell: E12
Comment: Rick Heede:
Xcel Energy supplied natural gas sales data in therms per year (albeit in ccf in years 1990-2002). 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 Carbon/Btu or, as it is usually reported, TgC/QBtu (teragrams of carbon perquadrillion Btu); in normal parlance this factor equals 14.47 kg of carbon per million Btu (kgC/million Btu), which, at average heating value, equals ~974 cubic feet of gas. Our calculation sidesteps the issue of how many ccf Xcel Energy sold in 2006 since the data is reported in units of million Btu (in XCel's parlance: "dekatherms"). 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 CMS 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. Xcel Energy 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 Btu/cf).

Cell: F13
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: G13
Comment: Rick Heede:
See notes in Table 2 below for methodology used to estimate fugitive methane emissions rate applied to Frisco's consumption of natural gas.

Cell: C15
Comment: Rick Heede:
Feb08: CMS has not updated this conversion factor for the Frisco inventory because Xcel supplied data in therms (100,000 Btu), not million cubic feet, and the emission calculations are based on CO2 per billion Btu. The conversion below from billion Btu to cf is thus a slight underestimate, since Frisco is at a higher elevation than Aspen (9040 ft and 7908 ft, respectively).

2005, for Aspen inventory: 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: B16
Comment: Rick Heede:
Feb08: Xcel Energy provided final data on 17Dec07 and 8Feb08 on natural gas sales within Frisco Town Limits in 2006. This excludes sales to residential and commercial customers outside town limits but within the broader Frisco community for which CMS sought data. (CMS counted 383 residential lots outside town limits in contiguous Summit County; also excludes Summit County Middle School and Bus Barn and Hospital and County Commons areas.) CMS has ignored Xcel's carbon coefficients for both electricity and natural gas in favor of our own calculations, since CMS applies a grid loss factor and methane emissions associated with coal mining and natural gas production, processing, and transportation. In any event, Xcel has also excluded emissions from gas used in its own gas pipeline compressor stations (see 8Feb08 worksheet, note 3).

Aug07: Xcel's Todd Anderson supplied data on 1Aug07 for1990-2006 (including their predecessor Public Service Company of Colorado for 1990-~2003). The data for 2003-2005 is reportedly not reliable, but, we presume, their 2006 data is complete and correct. The data coverage is for sales (in therms) within Frisco Town Limits only, not -- as we requested -- also for areas in unincorporated Summit County and contiguous to Frisco Town Limits that CMS established as the emissions boundary with Town staff in April 2007. Note to future inventories: Xcel sales data were supplied after four months of repeated requests; future inventories should take this possible time lag into account for planning purposes.

Cell: B18
Comment: Rick Heede:
Feb08: Xcel data combines commercial customers and "transport gas" to third parties. No information was provided on the end-users, types of customers (e.g., apartment building owners or commercial building owners), or the quantity transported. Hence the classification of residential and commercial is rendered too fuzzy and uncertain for the calculation of average gas and electricity consumption per household.

Cell: B24
Comment: Rick Heede:
Xcel Energy supplies natural gas transmitted through its pipelines to third party entities in Frisco and is reported by Xcel in the data provided to CMS for the Frisco emissions inventory.

Xcel Energy finally confirmed (8Feb08) that "transport gas" is included under commercial gas sales above. Xcel provided no information on its third party transport gas customers or the disposition or quantity of this gas segment, citing confidentiality issues.

Cell: C33
Comment: Rick Heede:
Xcel Energy's report to the Colorado Public Utilities Commission for 2006 was not found at the PUC website (1Aug07), Denver, 303-894-2000, www.dora.state.co.us/puc

Cell: D36
Comment: Rick Heede:
CMS estimates the upstream fugitive emissions of methane from the natural gas system from production through delivery. In 2005 (the most recent data available), U.S. methane emissions from natural gas systems totaled 6.70 million (metric) tonnes; in the same year, natural gas consumption was 21.981 trillion cubic feet (Tcf), which equals 0.0657 lb of methane per hundred cubic feet (ccf) of gas consumed. Thus, (0.067198 lb CH4/ccf) / 0.04228 lb/cf (standard conversion factor) = 1.58936 cf of methane lost per ccf of delivered natural gas = 1.589 percent fugitive emission rate; that is, a system loss rate relative to delivered natural gas. *

We are NOT attributing this additional emissions source to Xcel Energy. We are, however, allocating such additional systemic emissions to consumers in the Town of Frisco for whose benefit the production, processing, and distribution of natural gas occurs.

The result is that an amount equivalent to 11.925 percent of the CO2 emitted by burning natural gas is emitted as fugitive methane by the natural gas industry, here expressed by CMS in units of CO2-e. The 11.925 percent factor is used by CMS to estimate emissions of methane from the natural gas system as a source of emissions added to combustion of the delivered natural gas. Note: This emissions estimate does NOT include Xcel Energy system upsets or unintended pipeline breaks or other leakage events that -- on occasion -- release unreported quantiites of natural gas to teh atmosphere.

* Production (1.87 million tonnes CH4), Gas Processing (0.63 million tonnes), Transmission and Storage (2.34 million tonnes), Distribution (1.85 million tonnes CH4), Total (6.70 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). Note: Updated to 2005 data 1Aug07, CMS.

Sources:
Energy Information Administration (2006) Annual Energy Review 2005, Table 6.1 (2005p data);
Energy Information Administration (2006) Emissions of Greenhouse Gases in the United States 2005, Table 17.

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.html

Cell: F36
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, 10.077 lb CO2/ccf vs 12.0593 lb CO2/ccf at sea level.

Cell: I36
Comment: Rick Heede:
EPA (undated) “Natural Gas Methane Units Converter,” 2 pp., www.epa.gov/gasstar; PDF in Climate / Emissions / Emissions Factors.

Cell: E37
Comment: Rick Heede:
Derived from Btu content of Xcel Energy natural gas supply in 2004 with Xcel’s altitude adjustment plus carbon content per billion Btu. See comment under “Emissions Factor” for details.

Cell: E38
Comment: Rick Heede:
This factor is used to generate results for individual homes and commercial buildings. (It takes the carbon emissions factor and adds the CO2-equivalent of the fugitive methane developed in Table 1 above. As such it adds to CO2 the methane factor shown in Table 2: Methane emissions rate as CO2-e, which in 2004 = 11.925 percent of CO2.)

Cell: I43
Comment: Rick Heede:
It is unclear why the 1985 datum for 1 lb of compressed gas differs from the more recent Methane Converter sheet. The latter reports units of CH4, whereas AP42 is probably natural gas, albeit chiefly methane (CH4).

Town of Frisco Emissions Inventory for 2006: Propane

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started 23 April 2007
Last Modified: 19 September 2007

Future inventorists must request updated propane sales figures from AmeriGas and Ferrellgas (and any new propane vendors serving Frisco and surrounding neighborhoods).

Note: at the request of AmeriGas, sales data is entered but whited out

Data supplied by:
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Table 1

2006	Propane Sales	Approximate consumption	Carbon Factor	Carbon Dioxide	Methane	Total Emissions	Total Emissions
	gallons	Million Btu	lb CO2/gallon	tons CO2	tons CO2-eq	tons CO2-e	tonnes C-eq
Propane vendor			12.669		tons CO2-e/ton CO2 0.0446		
	(data whited out below)	(at company request)					
AmeriGas propane sales to Frisco zipcode 80443				170.2	7.6	177.8	44.0
Ferrellgas propane sales to Frisco				44.3	2.0	46.3	11.5
Total propane sold in the Frisco area	33,864	3,093		215	10	224.1	55

Table 2 Calculation of methane emissions rate for propane

Methane from propane (gas prod'n + processing	2.5	million tonnes CH4
CO2 from natural gas consumption:	1,178	million tonnes CO2
Methane emissions rate as CH4	0.00212	kg CH4/kg CO2
Methane emissions rate as CO2-e	0.04456	kg CO2-e/kg CO2

Note: CMS has not estimated emissions from diesel fuel consumed by LP delivery vehicles.

Cell: H9
Comment: Rick Heede:
Mr. Brockelmeyer, corporate communications at regional offices in Kansas, supplied average LP gas sales to Frisco; Ferrellgas records only indicate 25 customer accounts in Frisco. CMS was unable to probe further about sales to homes or businesses outside town limits but contiguous to Frisco and within our defined geographic boundary. CMS should check with local Frisco office for sales to gas stations and other retail outlets in Frisco.

Cell: E18
Comment: 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: F18
Comment: Rick Heede:
Propane sales times carbon factor of 12.669 lb CO2 per gallon at full combustion / 2000 lb per ton.

Cell: G18
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 methane emissions from the production through delivery of natural gas are allocated to Frisco’s consumption of natural gas. CMS applies the same ancillary emissions factor for propane -- a sub-set of the natural gas industry.

The result is that an amount equivalent to 11.925 percent of the CO2 emitted by burning natural gas is emitted as fugitive methane by the natural gas industry. CMS applies the same percentage factor to consumption of propane in Frisco.

In the case of propane, therefore, CMS allocates the US national fugitive emissions rate for natural gas (from which most propane is processed) in the production and gas processing stages: 1.87 million tonnes CH4 plus 0.63 million tonnes CH4 of total natural gas system methane emissions of 6.70 million tonnes CH4, or 2.50 of 6.70 million tonnes CH4, or 37.31 percent of the natural gas rate (0.00568 kg CH4/kg CO2 from combustion), which converts to 0.00568 * 0.3731 = 0.0021221 kg CH4 / kg CO2 from propane combustion. At methane GWP of 21xCO2: 0.0021221x21 = 0.044564 kg CO2-e per kg CO2 from propane combustion. This, in simple terms, means a methane factor of 4.4564 percent above emissions from propane combustion.

Sources used to estimate the fugitive methane emission rate for natural gas and propane: Energy Information Administration (2006) Annual Energy Review 2005; Energy Information Administration (2006) Emissions of Greenhouse Gases in the United States 2005.

Cell: C22
Comment: Rick Heede:
At the request of AmeriGas, CMS has entered propane sales data that estimates CO2 emissions but is hiding the quantity of LP sales by both Ferrellgas and AmeriGas. 19Sep07.

Cell: B23
Comment: Rick Heede:
Jean S. Konawalczyk, Counsel, AmeriGas, Valley Forge, PA, 18Sep07: AmeriGas “sold 26,864.2 gallons in the subject zip code to 17 residential customers and 7 commercial and industrial customers, including retailers, construction companies, property development and management companies and a carpenter.”

Cell: B25
Comment: Rick Heede:
Scott Brockelmeyer promptly provided estimated propane sales to Frisco; 25 accounts, verified with an account mngr that his estimate of 7,000 gallons per year is accurate (even though they may not have done a thorough inquiry of accounts and sales, and the average annual consumption per account (7,000/25) is only 280 gallons: quite low for residential consumption.

Cell: F31
Comment: Rick Heede:
Calculations are shown under “Methane,” cell note at ~G17 and is based on methane emissions from the natural gas industry (CH4 from production and processing, and thus excluding CH4 from pipelines and distribution). Emissions from the production and delivery of both natural gas and propane thus exclude emissions from energy used to transport and deliver each fuel: energy for natural gas pipeline compressor stations, for example, and, for propane, the diesel fuel consumed in transporting propane from processing plants and in trucks delivering propane to ultimate consumers.

Town of Frisco Emissions Inventory for 2006: Road Vehicles

Future inventories should consider taking a survey of vehicle types driven around Frisco and adjust the distribution shown below. Most importantly, if a reliable estimate of Vehicle Miles Traveled (VMT) is generated for Frisco (and CMS is unaware of one), the methodology used below must be revised.

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started 23 April 2007
Last Modified: 23 October 2007

The only data that need revising in future inventories are CDOT AADT traffic counts at locations cited below (marked in **red**). Unless vehicle distribution is surveyed or other methodological changes need to be made.

The principal variables that need to be updated in future fuel and emissions inventories are: (a) traffic counts at CO Highway 9 at I-70 and at Main Street and near Swan Mtn Road (see CDOT data), (b) update future VMT within Frisco, (c) vehicle fuel economy by type, and (d) carbon coefficient of transportation fuels (especially if biodiesel and ethanol fuels are sold in town).

Table 1

Commuting and commercial vehicles	Vehicle by type	Average daily traffic, 2006	Annual traffic, 2006	Miles per trip	Miles driven (VMT)	Fuel economy	Fuel consumed	Carbon factor	Carbon dioxide	CH4 (methane) emissions	N2O (nitrous oxide) emissions	Total GHG emissions
		(both directions)	(both directions)		miles	mpg	gallons/yr	CO2/gallon	tons CO2/yr	tons CO2-e	tons CO2-e	tons CO2-e
CDOT AADT traffic count at CO9 near I-70		24,300	8,869,500									
CDOT AADT traffic count at CO9 north of Swan Mtn Road		16,000	5,840,000									
One-half of the average of the two AADT counters		10,075	3,677,375									
Passenger cars	25.8%	2,598	948,407	15	14,226,106	22.9	621,227	19.59	6,086	14.82	185.67	6,287
Small SUVs and small pick-up trucks	13.3%	1,339	488,908	15	7,333,613	21.0	349,220	19.59	3,421	7.64	95.71	3,525
Medium/Large SUVs and large "light" trucks	53.8%	5,417	1,977,227	15	29,658,399	16.3	1,815,080	19.59	17,782	30.89	387.08	18,200
2-axle medium-duty trucks, RVs	2.6%	267	97,414	20	1,948,278	10.5	185,550	19.59	1,818	1.80	9.54	1,829
3-axle trucks, dump trucks, etc	3.7%	370	135,093	25	3,377,322	8.8	383,787	22.38	4,295	4.69	55.10	4,355
Semis, combination trucks	0.3%	34	12,406	60	744,389	5.8	128,343	22.38	1,436	1.03	12.14	1,450
Motorcycles	0.5%	49	17,920	7.5	134,404	50.0	2,688	19.59	26			26
Total	100%	10,075	3,677,375	na	57,422,512	16.5	3,485,894	na	34,866	61	745	35,672

Table 2

Tourist travel to & from Frisco	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	CH4 (methane) emissions	N2O (nitrous oxide) emissions	Total GHG emissions
		arrivals	arrivals	round trip	miles	mpg	gallons/yr	CO2/gallon	tons CO2/yr	tons CO2-e	tons CO2-e	tons CO2-e
Visitor vehicle arrivals and departures	composite	200	73,000	200	14,600,000	18.39	794,029	19.59	7,779	15.21	190.55	7,985
Total	composite	200	73,000	200	14,600,000	18.39	794,029	20	7,779	15	191	7,985

Composite fuel economy of passenger cars, small, medium, and large SUVs and pick-ups: 18.39

Composite emissions per mile 1.066 lb CO2/mile

Table 3

Driving around town, 2006	Vehicle by type	In-town Frisco CO 9 & I-70 VMT	Frisco Main Street & arterial roads	Frisco local roads VMT	Total Frisco area VMT	Fuel economy	Fuel consumed	Carbon factor	Carbon dioxide	CH4 (methane) emissions	N2O (nitrous oxide) emissions	Total GHG emissions
	percent	miles (VMT)	miles (VMT)	miles (VMT)	miles (VMT)	mpg	gallons/yr	CO2/gallon	tons CO2/yr	tons CO2-e	tons CO2-e	tons CO2-e
CDOT AADT traffic count at CO9 and Main Street		22,900	8,358,500									
Estimated Daily VMT in the Frisco area, by road type		34,350	20,610	13,740	68,700							
2004 Annual Frisco VMT, estimated (each trip is 3 miles)		12,537,750	7,522,650	5,015,100	25,075,500							
Passenger cars	25.8%	3,233,527	1,940,116	1,293,411	6,467,054	22.9	282,404	19.59	2,767	6.74	84.40	2,858
Small SUVs and light trucks	13.3%	1,666,896	1,000,137	666,758	3,333,791	21.0	158,752	19.59	1,555	3.47	43.51	1,602
Large SUVs and "light" trucks	53.8%	6,741,214	4,044,729	2,696,486	13,482,429	16.3	825,118	19.59	8,084	14.04	175.96	8,274
2-axle medium-duty trucks, RVs	2.6%	332,126	199,275	132,850	664,252	10.5	63,262	19.59	620	0.62	3.25	624
3-axle trucks, dump trucks, etc	3.7%	460,590	276,354	184,236	921,179	8.8	104,679	22.38	1,172	1.28	15.03	1,188
Semis, combination trucks	0.3%	42,299	25,379	16,920	84,598	5.8	14,586	22.38	163	0.12	1.38	165
Motorcycles	0.5%	61,099	36,659	24,439	122,197	50.0	2,444	19.59	24			24
Total	100%	12,537,750	7,522,650	5,015,100	25,075,500	17.3	1,451,245	na	14,384	26	324	14,734

Total VMT for personal driving only: 74,501,393 VMT miles/yr | 4,051,801 gallons/yr | Tons CO2e/yr 40,745

Table 4

Total of Commuting, Commercial Vehicles, Tourist Travel, & Around Town	97,098,012	5,731,169	57,029	102	1,259	58,391

CDOT Counts of Average Annual Daily Traffic (AADT)

Used by CMS in estimating total VMT in Frisco

Data from CDOT at www.dot.state.co.us/app_DTD_DataAccess/Traffic/index.cfm?fuseaction=TrafficMain&MenuType=Traffic

AADT 2006 (factor and actual)

For traffic counters (and "Factors) used the VMT estimation model for Frisco
Colorado State Highway 9 at Swan Mountain Road, Main Street, and I-70 approach

Traffic Information for Highway 009C

From RefPoint 90 To RefPoint 96.998

Printable Report
set to landscape

Route	Ref Point	End Ref Point	Start Point Description	Annual Average Daily Traffic	AADT Year	AADT Derivation	AADT Single Trucks	AADT Comb. Trucks	Percent Trucks	20 Year Factor	Design Hour Vol (% of AADT)	Daily Vehicle Miles Traveled
009C	90.254	92.892	ON SH 9 S/O SWAN MTN RD	18,200	2006	Factor	350	120	2.60%	1.61	12	45,500
009C	92.892	95.953	ON SH 9 N/O SWAN MTN RD	16,000	2006	Factor	350	70	2.60%	1.62	12	46,480
009C	95.953	96.021	ON SH 9 S/O MAIN ST, FRISCO	17,900	2006	Factor	380	90	2.60%	1.62	12	2,452
009C	96.021	96.995	ON SH 9 N/O MAIN ST, FRISCO, N/O WYE	22,900	2006	Factor	410	90	2.20%	1.59	12	22,511
009C	96.995	96.998	ON SH 9 S/O I-70, FRISCO	24,300	2006	Actual	290	100	1.60%	1.64	12	2,770

If you notice an error, bug or have any questions, Please E-mail us.
For comments or questions about this site, please send e-mail to: DTD

Table 6	Comparing Frisco's estimated VMT to VMT in Boulder, Denver, & US				
	VMT/d	d/y	VMT/yr	Population	VMT/cap
Frisco (low)	204,113	365	74,501,393	6,906	10,788
Frisco (high)	266,022	365	97,098,012	6,906	14,060
Boulder	2,700,000	365	985,500,000	96,700	10,191
US	8,191,260,274	365	2,989,810,000,000	296,400,000	10,087
Denver	13,698,630	365	5,000,000,000	579,744	8,624

Cell: C14
Comment: Rick Heede:
The vehicle type distribution is taken from a vehicle survey done in Aspen in August 2005 by CMS and Aspen Dept of Environmental Health staff. CMS has not repeated the survey in Frisco and we rely on the Aspen vehicle type distribution for the Frisco inventory; future updates may wish to investigate the matter.

CMS 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. The survey counted 8,003 vehicles, for which the distribution by type is shown below. (We exclude 104 RFTA transit buses and 20 school buses from this survey; fuel consumption by RFTA and school buses is estimated elsewhere.) Likewise, Summit Stage buses are accounted for elsewhere in this inventory.

Cell: D14
Comment: Rick Heede:
CDOT database of AADT counters, accessed 26Apr07. Actual data with traffic counter (in 2006) at milemarker 96.995 on Colorado State Highway 9 at I-70. CDOT does not keep traffic counters at other Frisco locations, but does estimate traffic with a model used to generate AADT counts at Main Street and CO 9 as well as "Daily Vehicle Miles Traveled." *

CDOT estimates of daily VMT at CO9 and Main Street shows 22,511 VMT per day. CMS uses these data to estimate Frisco's overall daily and annual VMT, and thus to estimate fuel consumption and GHG emissions.

CMS uses the average of the AADT at CO9 at I-70 (24,300 vehicles per day) and the AADT on the north side of Co9 and Swan Mtn Road (16,000 vehicles per day); average 20,150 AADT.

CMS uses these AADT data in order to estimate VMT for commuting and commercial vehicles into and out of Frisco, and we have used traffic counts at two pertinent points along Highway 9 (at I-70 and at Swan Mtn Road). CMS compared total VMT generated with this model to VMT averages in Boulder, Denver, and in the US so as to ensure the model did not overestimate total VMT for this fuel and emissions inventory. This comparison is shown in Table 6 on the following page and shows reasonable congruence with average VMT data.

www.dot.state.co.us/app_DTD_DataAccess/Traffic/index.cfm?fuseaction=TrafficMain&MenuType=Traffic

* Note: CDOT's VMT estimates are not for Frisco overall, but rather VMT between traffic counters or factor sites.

Cell: E14
Comment: Rick Heede:
"Average Daily Traffic" times 365 days/yr.

Cell: F14
Comment: Rick Heede:
The typical commute to work is assumed to be 15 miles each direction, based on US Census data for 2004, which shows average commuting time to work of 15.7 minutes;s since this commute estimate includes 18.5 percent of commuting trips by walking, bicycling, and telecommuting (ie, worked at home), CMS increases the typical driven commute by ~20 percent to 19 minutes. Deducting for slower traffic in town, 15 minutes of driving on I-70 or CO9 at 60 miles per hour gives a travel distance of ~15+ miles. Of commuters driving to work, 82.9 percent drive alone, and 17.1 percent carpool.

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 Breckenridge, Dillon, Silverthorne, Copper, or on waste-collection trips between Frisco and the County Landfill).

Semis travel an average of 240 miles per day (ORNL 2005, TEDB, Table 5.4); we allocate half to other communities served by each semi entering town, thus 60 miles per trip into plus out of town.

CMS assumes half a year of motorcycle driving, reducing the per trip miles from 15 to 7.5 miles per trip-day.

* UPS trucks originate in Silverthorne and drive approximately 140 miles per day (of course, route-miles vary). Interviews with several UPS drivers, Aug05. UPS trucks average 12-14 mpg.

Cell: H14
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 22.9 mpg. TEDB Table 4.1 (average fuel economy of passenger automobiles in use, 2005 datum from US DOT/Federal Highway Administation (2002) Highway Statistics 2005, Table VM-1; www.fhwa.dot.gov). New passenger cars average 28.8 mpg (TEDB, Table 4.7).

New small SUVs (23.1 mpg) and small pick up trucks (26.3 mpg) averaged to 24.7 mpg. (Table 4.8), which CMS reduces by 15 percent to account for likely lower actual performance as well as the lower fuel economy of older small SUVs and light trucks, thus 24.7 mpg * 0.85 = 21.0 mpg.

New large and medium SUVs (20.0 mpg and 23.2) and new large pick up trucks (19.5 mpg) and new large vans (19.0 mpg). These vehicle classes average 20.43 mpg, but, as noted above, actual performance for all "light trucks, vans, and SUVs" averages 16.2 mpg, in spite of EPA ratings being consistently above 18 mpg (and mostly above 20 mpg) since 1990 except for the largest vehicle classes. CMS thus accounts for lower actual performance by reducing average new large and medium trucks and SUVs from the new vehicle average of 20.43 mpg by20 percent, or 20.43 * 0.8 = 16.34 mpg.

Note: even this reduced performance is propably conservative, considering the weight driven around by the typical SUV and pick-up truck and work van in Frisco. This category also contains Hummers (10-13 mpg, practical experience is closer to 8 mpg), Suburbans, Ford 350s, and similar brontomobiles rated at 16 mpg or less.

2-axle medium-duty trucks (10-14,000 lb) average 10.5 mpg (Table 5.4).

3-axle trucks single-unit trucks (dump trucks, garbage trucks, etc) average 8.8 mpg in 2005 (TEDB Table 5.1; vs 7.4 mpg in 2002).

Semis or combination trucks (33,000 lb +) average 5.8 mpg (Table 5.4), 5.9 mpg in Table 5.2, and 5.7 mpg (Table 5.5); CMS uses 5.8 mpg as the average.

Davis & Diegel (2007) Transportation Energy Data Book, 26th Edition, 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: I14
Comment: Rick Heede:
Miles driven / fuel economy. Conservative estimates.

Cell: L14
Comment: Rick Heede:
Emissions of methane associated with fuel use and combustion in mobile sources. Factors from California Climate Action Registry (2007) General Reporting Protocol, Table C-4. CCAR estimates CH4 emissions rate, average of light duty diesel trucks (0.01 grams CH4/mile) and heavy duty diesel trucks (0.06 grams CH4/mile). CMS applies these factors to each vehicle class.

For the community emissions estimate of commuting and driving around town, assume gasoline vehicles's average of 1994-1999 emissions rate (0.05 grams CH4/mile) and 2000-present rate (0.04 grams CH4/mile); CMS applies the average of 0.045 grams CH4/mile for the vehicle population in Frisco.

CMS has used IPCC's GWP factor for methane of 21xCO2.

Formula: (G21*0.045*1.1023/1000000)*21

Cell: M14
Comment: Rick Heede:
Emissions of nitrous exides associated with fuel use and combustion in mobile sources. Factors from California Climate Action Registry (2007) General Reporting Protocol, Table C-4. CCAR estimates N2O emissions rate, average of light duty diesel trucks (0.03 grams N2O /mile) and heavy duty diesel trucks (0.05 grams N2O /mile); average equals 0.045 grams N2O /mile. CMS has accounted for the allocation to Frisco of the School Districts bus system (33 percent of total). CMS has used IPCC's GWP factor for nitrous oxide of 296xCO2.

For the community emissions estimate of commuting and driving around town, use gasoline vehicles's emissions rate of 0.04 grams N2O /mile (same 1990s and 2000-present).

Formula: (G21*0.04*1.1023/1000000)*296

Cell: B17
Comment: Rick Heede:
Data from CDOT at www.dot.state.co.us/app_DTD_DataAccess/Traffic/index.cfm?fuseaction=TrafficMain&MenuType=Traffic

Cell: B19
Comment: Rick Heede:
The two AADT data sets are averaged and reduced by half in order to generate VMT data for Frisco that are in line with VMT averages seen in other cities. Table 6 shows a comparison with VMT data estimates in Boulder, Denver, and US.

Cell: H28
Comment: Rick Heede:
Average of all vehicle types: VMT / estimated fuel consumption.

Cell: D32
Comment: Rick Heede:
CMS contacted the Frisco Chamber of Commerce for Frisco tourism and visitor information for 2006. This section will be revised with receipt of Frisco data: ..... Meanwhile, CMS has guesstimated average daily visitor traffic as 200 per day.

CMS to delete or replace:
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: F32
Comment: Rick Heede:
CMS contacted the Frisco Chamber of Commerce for Frisco tourism and visitor information for 2006. This section will be revised with receipt of Frisco data: ..... Meanwhile, CMS has guesstimated average trip length (roundtrip) as 200 miles (2x Denver to Frisco @75mi plus 50 miles).

Note: CMS has not diluted the distances driven by tourists arriving in Frisco by allocating a portion of their driving emissions to other destinations also visited en route. Whether Frisco 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 Frisco, regardless of where else they may have visited on their way to town.

Cell: H32
Comment: Rick Heede:
We use the composite fuel economy developed for personal vehicle types driven around Aspen. See below (cell K37) for details. Until Frisco or CDOT or other agency surveys vehicle usage by type, miles driven per trip, and origin and destination, CMS employs the vehicle distribution surveyed in Aspen, Colorado in 2005.

Cell: L32
Comment: Rick Heede:
See CH4 (methane) emissions discussion above, ~cell L14.

Cell: M32
Comment: Rick Heede:
See N2O (nitrous oxide) emissions discussion above, ~cell M14.

Cell: K38
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.

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.

Formula: =(G21+G22+G23)/(I21+I22+I23)

Cell: C42
Comment: Rick Heede:
See note under "Vehicle by type' above in cell C13.

Note: A high fraction of the semis serving Frisco's markets, hardware stores, lumber yards, etc arrive at night and depart before dawn. Our survey may, therefore, have underestimated the number of semis.

Cell: H42
Comment: Rick Heede:
See notes under "Fuel economy" above.

Cell: L42
Comment: Rick Heede:
See CH4 (methane) emissions discussion above, ~cell L14.

Cell: M42
Comment: Rick Heede:
See N2O (nitrous oxide) emissions discussion above, ~cell M14.

Cell: B45
Comment: Rick Heede:
Data from CDOT at www.dot.state.co.us/app_DTD_DataAccess/Traffic/index.cfm?fuseaction=TrafficMain&MenuType=Traffic

Cell: B47
Comment: Rick Heede:
VMT estimates for Frisco is based on assumed average distances driven per vehicle tracked by CDOT's traffic AADT estimate ("factor") for traffic count on Colorado Hwy 9just north of the intersection with Main Street. Since CMS is not aware of a VMT study on Frisco (and we inquired with CDOT on the matter), CMS must use reasonable values that result comparable to other resort "driving around town" patterns. CMS assumes that 50 percent of the AADT count is attributable to traffic using Colorado Route 9 and Main Street as well as an indicator of traffic loads on local roads and back streets, and thus 30 percent of the AADT count is attributable to traffic using arterial roads, and 20 percent is attributable to traffic using local roads. Each trip is assumed to be 3 miles. Note: CMS could have simply estimated total VMT rather than detail the road allocation, but we retained this structure to aid future use of CDOT or other source official VMT estimation for Frisco.

Cell: B48
Comment: Rick Heede:
Daily VMT times 365 days per year.

The result -- 33.4 million vehicle miles traveled is half the value estimated for Aspen, Colorado,based on a 1997 CDOT VMT estimate. Since Aspen is roughly twice as large as Frisco, CMS concludes that the current Frisco estimate is reasonable.

Cell: T52
Comment: Rick Heede:
Chiefly commuting and driving around town, although commercial vehicles such as pick-up trucks and vans and SUVs are also included. Excludes 3-axle trucks, semis, and tourist driving.

Cell: T53
Comment: Rick Heede:
Personal, business, and commercial vehicles, including an unknown proportion of vehicles counted at I-70 that fuel and dine near the interstate before cruising back up the highway. This VMT total also includes estimated VMT from tourists and second home owners driving to Frisco.

Cell: T54
Comment: Rick Heede:
Boulder Inventory (unpublished background rpt on transportation by Econergy).

Cell: T55
Comment: Rick Heede:
US data from TEBD, 26th edition, Table 8.1. Data appears to cover driving in personal vehicles only.

Cell: T56
Comment: Rick Heede:
Denver GHG Emissions Inventory, page 18 (VMT) and page 10 (population).

Town of Frisco 2006 Emissions Inventory: Summit Stage

Future inventories must update: (a) fuel consumption by Summit Stage route serving Frisco (or total Stage fuel consumption), (b) check future Frisco ridership as a percentage of total "on/offs", (c) update biodiesel percentage (9.3 percent in 2006), and update average fuel economy by route served.

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started 23 April 2007
Last Modified: 26 October 2007

Data provided by:
John Jones
Summit Stage Director
johnj@co.summit.co.us
970-668-4161

Table 1 — **Summit Stage ridership, allocation to Frisco, and emissions**

	Percent allocated to Frisco	Ridership	Ridership allocated to Frisco	Ridership allocated to Frisco	Fuel allocated to Frisco	Carbon factor	Carbon dioxide	Carbon	1 metric tonne = 1.1023 short ton; CO2/C = 3.664
	percent	riders	riders	percent	gallons	lb CO2/gallon	tons CO2/yr	tonnes carbon	
						20.77			
Summit Stage - Main Routes				**Total Fuel, 2006**	**290,632**				
Town to Town									
Frisco - Breckenridge	50%	401,806	200,903	10%	29,280	20.77	**304**	**75**	
Silverthorne	0%	161,327	-	0%	-	20.77	-	-	
Frisco - Silverthorne	50%	347,317	173,659	8.7%	25,309	20.77	**263**	**65**	
Town to Resort			-	0%	-	20.77	-	-	
A-Basin	10%	14,094	1,409	0%	205	20.77	**2**	**1**	
Swan Mountain Flyer	10%	5,281	528	0%	77	20.77	**1**	**0**	
Copper Express	90%	43,642	39,278	2.0%	5,724	20.77	**59**	**15**	
Frisco - Copper Mountain	90%	222,330	200,097	10.0%	29,163	20.77	**303**	**75**	
Silverthorne - Keystone	10%	549,252	54,925	3%	8,005	20.77	**83**	**21**	
Residential			-	0%	-	20.77	-		
Boreas Pass	0%	83,743	-	0%	-	20.77	-		
Breckenridge North	0%	34,395	-	0%	-	20.77	-		
Summit Cove - Dillon Ridge	0%	13,721	-	0%	-	20.77	-		
Wildernest	0%	109,744	-	0%	-	20.77	-		
Paratransit	20%	7,500	1,500	0.1%	219	20.77	**2**		
Total	33.7%	**1,994,152**	**672,299**	33.7%	**97,982**	**na**	**1,017**	**251**	

Table 2 — **Fuel and emissions from would-be-driving (assuming no Summit Stage)**

	Riders allocated to Frisco		Cars per day	VMT	Fuel consumed	Emissions	
	riders per year	riders per day	occupancy/veh	trip length (miles)	composite mpg	composite emissions	
	672,299	1,842	1.63	10	18.39	1.065630842	
					gallons	tons CO2-e	
Would-be drivers, per year	672,299		412,453	4,124,534	224,315	2,198	tons CO2-e per year
Would-be-drivers, per day		1,842	1,130	11,300	615	6.0	tons CO2-e per day

Table 3 — **Net Summit Stage savings**

	Fuel consumed	Emissions
	gallons/yr	tons CO2-e/yr
Would-be drivers	224,315	2,198
Summit Stage	97,982	1,017
Net savings	**126,333**	**1,180**

Table 4 — **Summit Stage fuel consumption**

	2006	Emission Coefficient	Total emissions pounds	Total emissions tons	
	gallons	lb CO2/gallon			
Gasoline	26,167	19.564	511,925	256	
Diesel	241,914	22.384	5,415,003	2,708	
Biodiesel	22,551	4.824	108,780	54	
Total Fuel	290,632		6,035,709	3,018	
					Percent biodiesel
Average emission coefficient, 2006			**20.7676**	**lb CO2/gallon**	8.53%

Cell: H12
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: C13
Comment: Rick Heede:
Summit Stage serves regions in the upper Summit County area (chiefly Silverthorne and Dillon and other towns and ski resorts upstream from Lake Dillon). CMS has allocated half of "Town to Town" routes that serve Frisco, as well as 90 percent of the bus routes serving Copper Mountain and Frisco, plus one-fifth of the "Paratransit" routes. Ten percent of the Silverthorne to Keystone plus 10 percent of the Arapahoe Basin routes are also attributed to Frisco.
Note: An Origin and Destination study has not been conducted. If such a study is done in the future, CMS's allocation percentages may have to be updated to reflect better data.

Cell: D13
Comment: Rick Heede:
Ridership data for 2006 from John Jones, May07.

Cell: E13
Comment: Rick Heede:
Ridership allocated to Frisco is based on CMS allocation percentages of each route times ridership per route (Summit Stage data).

Cell: G13
Comment: Rick Heede:
Fuel consumption data by route for 2006 from John Jones, May07.

Cell: H13
Comment: Rick Heede:
Carbon emissions per gallon of diesel and gasoline from EIA data. Diesel emissions are reduced by the fuel's biodiesel component. In Summit Stage's case (2006), B10 and B20 is used from April through October; biodiesel averaged 9.32 percent in 2006 (excluding gasoline in some vehicles).

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 coefficient for biodiesel is thus 4.824 lb CO2 per gallon (22.384 lb CO2 per gallon for petrodiesel * (1-0.7845)).

CMS estimates average fuel emissions coefficient of 20.768 lb CO2 per gallon. Note: this is estimate is specific to 2006, since it is based on consumption of fuel by type. See Table 2 for details.

The upstream carbon emissions from biodiesel production are not analyzed here but are well-documented in the NREL study. 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 vehicle owners in Frisco. 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, shows diesel fuel #2 as 21.15 lb CO2 per gallon. This factor is not corrected in the 2004 inventory, but should be corrected in the 2006 emissions inventory. 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: I13
Comment: Rick Heede:
Gallons per route times CO2 per gallon / 2000 lb per ton.

Cell: G16
Comment: Rick Heede:
Notes from John Jones regarding 2006 fuel consumption by Summit Stage bus fleet and other vehicles:
1. Due to technical issues with the Petro Vend system October and November were reported and billed as one month.
2. Of this total, 3255 gallons were fossil purchased at local stations. Our GM engines cannot use biodiesel in any percentage.
3. After some hard lessons, we returned the fleet to all fossil diesel in January 2007. We will only operate on biodiesel from April through October from here forward until an acceptable blend for colder weather becomes available.

Cell: H40
Comment: Rick Heede:
CMS uas used an avreage trip length of 10 miles per substituted driving for Stage riding, thus shorter than the average commute which CMS has assumed is 15 miles per trip). Some routes are clearly shorter, such as in-town rides or Frisco to Breckenridge, but some are longer, such as Frisco to Copper.

Cell: D53
Comment: Rick Heede:
Distillate fuel (petroleum diesel) less carbon savings of biodiesel, based on NREL estimate of life-cycle carbon savings: 78.45 percent.

Cell: G55
Comment: Rick Heede:
Average biodiesel of total diesel over the whole year (~8.5 percent).

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Notes

Town of Frisco Emissions Inventory: Frisco Schools, City, & misc. fuel use

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 makes estimates are discussed in comments.

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started 23 April 2007
Last Modified: 8 August 2007

grams CH4	tonnes CH4	tons CH4	tons CO2-e
4,212	0.004	0.005	0.09749

Data sources:

Deb Estreich	Tim Mack	Steve Stephens
Summit School District	Frisco Public Works	Summit County Fleets
970-668-3015	970-668-0836, x1318	970-668-4228
destreich@summit.k12.co.us	timm@townoffrisco.com	steves@co.summit.co.us

	Vehicle miles traveled (VMT)	Fuel consumed	Fuel consumed	Fuel economy	Carbon factor	Attributed to Frisco	Carbon dioxide	CH4 (methane) emissions	N2O (nitrous oxide) emissions	Total GHG emissions
	(if known)	Diesel	Gasoline	mpg	CO2/gallon	Percent	sh tons CO2/yr	tons CO2e	tons CO2e	tons CO2e
Summit School District					diesel / gasoline					
School buses	361,352	49,123		7.4	22.384	33%	183	0.10	1.77	185
Other School District vehicles	215,400		11,562	18.6	19.594	33%	38	0.06	1.05	39
Out-of-district fuel (ExEd trips, away games)	86,160		4,625		20.989	33%	16	0.02	0.42	17
Total School vehicles	662,912	49,123	16,187				237	0	3	240
Summit County Public Works Dept.										
Trucks, plows, etc. (diesel fuel)	396,685	79,337		5	22.38	18%	161	0.06	1.06	162
Trucks, plows, etc. (biodiesel)	39,145	7,829		5	4.82	18%	3	0.01	0.10	4
Sheriff and other vehicles (gasoline)	1,954,465		88,839	22	19.59	18%	158	0.29	5.20	163
Total Summit County vehicles	2,390,295	87,166	88,839				322	0	6	329
Town of Frisco										
Trucks, graders, backhoes, plows, etc. (diesel fuel)	57,990	11,598		5	22.38	100%	130	0.05	0.85	131
Sheriff and other vehicles (gasoline)	426,844		19,402	22	19.59	100%	190	0.35	6.27	197
Total Town of Frisco vehicles	484,834	11,598	19,402				320	0	7	327
School buses, County vehicles, and Town vehicle subtotal							879	1	17	897
Construction and off-road equipment										
Construction equipment	na			5	22.38	100%	-			
Misc off-road equip. (mowers, blowers, saws, etc)	9.13	gallons/capita/yr	49,820	na	19.59	100%	488			
Total off-road vehicles		-	49,820				488		-	488
										Biodiesel credit
Town of Frisco Marina										
Fuel sold at fuel dock, 2006			9,760	na	19.594	100%	96			
Total Frisco boat fuel & emissions		-	9,760				96			96
Total Frisco Govt, School District, Marina etc	3,538,041	147,887	174,290	na	na	na	1,463	1	17	1,480

Cell: D16
Comment: Rick Heede:
Fuel consumption data sources are listed for each entity included.

Cell: F16
Comment: Rick Heede:
Fuel economy is derivd from VMT and fuel consumption data provided by Summit County School District fleet manager.

Cell: J16
Comment: Rick Heede:
Emissions of methane associated with fuel use and combustion in mobile sources. Factors from California Climate Action Registry (2007) General Reporting Protocol, Table C-4. CCAR estimates CH4 emissions rate, average of light duty diesel trucks (0.01 grams CH4/mile) and heavy duty diesel trucks (0.06 grams CH4/mile); average equals 0.035 grams CH4/mile. CMS has accounted for the allocation to Frisco of the School Districts bus system (33 percent of total).

CMS has used IPCC's GWP factor for methane of 21xCO2.

Formula: (C19*0.035*1.1023/1000000)*21*H19

For the community emissions estimate of commuting and driving around town, assume gasoline vehicles's average of 1994-1999 emissions rate (0.05 grams CH4/mile) and 2000-present rate (0.04 grams CH4/mile); average equals 0.045 grams CH4/mile.

Cell: K16
Comment: Rick Heede:
Emissions of nitrous exides associated with fuel use and combustion in mobile sources. Factors from California Climate Action Registry (2007) General Reporting Protocol, Table C-4. CCAR estimates N2O emissions rate, average of light duty diesel trucks (0.03 grams N2O /mile) and heavy duty diesel trucks (0.05 grams N2O /mile); average equals 0.045 grams N2O /mile. CMS has accounted for the allocation to Frisco of the School Districts bus system (33 percent of total). CMS has used IPCC's GWP factor for nitrous oxide of 296xCO2.

Formula: (C19*0.045*1.1023/1000000)*296*H19

For the community emissions estimate of commuting and driving around town, use gasoline vehicles's emissions rate of 0.04 grams N2O /mile (same 1990s and 2000-present).

Cell: B18
Comment: Rick Heede:
Fuel consumption and route miles in 2006, Deb Estreich Bus Fleet Mngr, destreich@summit.k12.co.us 970-668-3015

Cell: B19
Comment: Rick Heede:
The Summit School District operated 18 buses (CK) in the 2005/2006 school year. No data on average bus route distance per day.

Cell: B20
Comment: Rick Heede:
Fuel consumption from Deb Eistrich; no info on number and type of "white vehicles," or miles driven. CMS estimates miles by dividing fuel consumption by assumed average fuel economy of 18.63 mpg.

Cell: B21
Comment: Rick Heede:
The fuel consumed by "other school district vehicles" above do not include fuel purchased on the road for numerous school, sports, and academic trips by students, staff, coaches, and teams for away games, business trips, etc when purchasing fuel at gas stations or for rented vehicles.

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: B26
Comment: Rick Heede:
Fuel data for Summit County fuel (gasoline, diesel, and biodiesel) purchases in 2006 from Steve Stephens, Fleet Mngr, 970-668-4228, steves@co.summit.co.us. CMS has deducted fuel for the Summit Stage and the Summit County Solid Waste Facility accounted for elsewhere, with the fuel for other County operations (road maintenance, snowplowing, sheriff's vehicles, etc) totaling 176,005 gallons in 2006. Details in "SummitCountyFuelOct07.xls" Furthermore, CMS allocates County fuel purchases on the basis of Frisco's proportion of Summit County population (11.1 percent), as detailed elsewhere.

Cell: B27
Comment: Rick Heede:
CMS has not inventoried the trucks and graders and backhoes and similar vehicles in Summit County's diesel-burning fleet. CMS assumes average fuel economy of 5 mpg for this fleet.

Cell: B29
Comment: Rick Heede:
Fuel purchases from Summit County Fleet Dept. CMS assumes that gasoline is chiefly used in County Sheriff cruisers and similar passenger cars with average fuel economy of 22 mpg in order to estimate vehicle miles traveled (VMT).

Source data:
2003 Chrysler Intrepid Police Cruiser Road Test • Fuel Economy (city/hwy): 18 / 26 mpg. www.carpages.ca/gøroadtest/2003_chrysler_intrepid_police_cruiser_road_test.aspx

US DOE (2007) Fuel Economy Guide, Model year 2007, www.fueleconomy.gov
Ford Crown Victoria 4.6 liter/8 cylinder, mpg: 17/25
Ford Impala: 3.5 liter/6 cylinder, mpg: 21/31

Cell: B34
Comment: Rick Heede:
Tim Mack, Public Works Director, by email, 7May07: "Unleaded gasoline consumption for 2006 = 19,402 gallons; Diesel consumption in 2006 = 11,598 gallons (these amounts are for all Town owned vehicles/equipment)."

CMS has assumed (as we did for Summit County Public Works Dept vehicles) average fuel economy of 22 mpg for gasoline vehicles (town vehicles, police cruisers, etc) and 5 mpg for diesel vehicles and equipment.

Cell: B43
Comment: Rick Heede:
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 divides Frisco's total population in order to estimate Frisco's share of non-transportation fuel usage; CMS uses the adjusted Frisco population detailed in "FriscoSum.xls" worksheet on Population and Households.

The formula is: =(2731/299)*'[FriscoSum.xls]Population & HH'!E29 or spelled out: 9.13 gallons per capita per year * Frisco adjusted population of 5,455 people.

Cell: D43
Comment: Rick Heede:
Preliminary: based on Frisco Website (history section): "a current population just under 2,800 full-time residents." This does not include second home population that requires a large percentage of the fuel consumed for off-road equipment purposes. Since 63 percent of Frisco's homes are second-homes, CMS doubles the population to 5,600 souls for this calculation, since second homes as well as local residents use lawncare, chainsaws, and other residential equipment.

Cell: L47
Comment: 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: B48
Comment: Rick Heede:
Fuel data estimate from Phil Hofer, Marina Mngr, 2May07. Sales in dollars divided by average price of $3.99 per gallon (Hofer's estimate); $39,064 / $3.99 = 9,760 gallons. Does not included the Marina's own fuel consumption; request for data mid-May.

CMS thus ignores emissions from gasoline brought in by boat owners.

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Notes

Frisco Emissions Inventory: Fertilizers

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started 23 April 2007
Last Modified: 10 October 2007

Update data on fertilizer applications rates at Town of Frisco's parks, green spaces, and athletic fields, and privately-owned greenspace.

Data provided by:
Tim Mack
Public Works Director
timm@townoffrisco.com
668-0836, x1318

Table 1: Nitrous oxide emissions from fertilizers	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 CO2e 296 x CO2	tonnes C-eq
Golf courses in Frisco: none	-	0.00	0.00	0.00	-	-	-
School District ball fields, etc.	-	0.00	0.00	0.00	-	-	-
Town of Frisco Parks	544	8.71	1.74	6.53	17.0	5.5	1.4
Private greenspace within Town Limits: na	481	7.69	1.54	5.77	15.0	4.9	1.2
Total nitrous oxide from fertilizers	**1,025**	**16**	**3**	**12**	**32**	**10.4**	**3**

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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) * fraction volatilized * 0.016 kg N2O /kg N
Run-off/leaching N2O = N applied (kg N) * fraction runoff * 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: D12
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: E12
Comment: Rick Heede:
Indirect emission calculation:
Volatilization N2O (kg N2O) = N applied (kg N) * fraction(volatilized) * 0.016 kg N2Økg 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: F12
Comment: Rick Heede:
Indirect emission calculation:
Run-off/leaching N2O (kg N2O) = N applied (kg N) * fraction(runoff) * 0.04 kg N2Økg 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: H12
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: B15
Comment: Rick Heede:
Frisco does not host any golf courses. For future information and comparison: Aspen's 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: B16
Comment: Rick Heede:
Called (ref from Deb Eistrich, 6Aug07) re: fertilizer application,. Facilites Dept: Hunter Amsbaugh, groundskeeper, Dave Meyers, Facililites Mngr, 668-0631.

CMS has not received an estimate of fertilizer application to the Summit County Middle School located in Frisco. CMS thus ignores this emissions source as non-material.

Cell: B17
Comment: Rick Heede:
Tim Mack, 16May07: "Buildings/Grounds Department applied 1200 lbs. of granular Nitrogen to 8 acres of turf area in 2006."
CMS calculates that this converts to an application rate of 3.44 lb N per 1,000 sf.

Cell: B18
Comment: Rick Heede:
Town of Frisco: www.townoffrisco.com/visitors/frisco-fast-facts.html. Population: 2,697 year round; 4,209 second homeowners; Combined approx. 6,906 people. Elevation: 9,100 feet above sea level. Size: 3 square miles (= 1,920 acres = 83,635,200 sf).

CMS estimates emissions from use of fertilizers on private property in Frisco as follows:

Assume that the average planted or turfed area per household that is fertilized annually equals 200 sf (probably conservative), thus Frisco's 3,080 households (2,697 HHs in town plus 383 HHs outside town limits) gives 616,000 sf of fertilized area. If we assume an application rate of one-half the application rate on Frisco parks and turf areas (Tim Mack, 16May07: "Buildings/Grounds Department applied 1200 lbs. of granular Nitrogen to 8 acres of turf area in 2006." CMS calculates that this converts to an application rate of 3.44 lb N per 1,000 sf.) Thus 0.5 * 3.44 lb/1,000 sf = 1.72 lb N per 1,000 sf.

Thus, 1.72 lb N per 1,000 sf * 616,000 sf = 1,060 lb N, which equals 480.6 kg N.

Cell: E23
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

Town of Frisco Emissions Inventory: Summit County Solid Waste Facility

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started 23 April 2007
Last Modified: 12 Oct 07

Future inventorists must update electricity and diesel fuel purchased by the Summit County Landfill, update recovered materials flows, and check commingled materials by weight. Also verify that methane emissions are at or near zero (2006 inventory: zero emissions per Aaron Byrne)

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

Data provided by: Aaron Byrne
Operations Manager, Summit County Landfill
970-468-9263x12
aaronb@co.summit.co.us
Bonita P
BonitaP@co.summit.co.us

Table 1: Emissions	Electricity	Fuel consumed	Carbon factor	Total Emissions	Methane factor	Attributed to Frisco	Carbon dioxide (Frisco's share)	Carbon (Frisco's share)
	kWh	gallons	lb CO2/kWh & /gallon	short tons CO2	short tons CO2-eq	Percent	sh tons CO2-eq/yr	tonnes carbon (C-eq)
Summit County Landfill					CO2 x 21	Pop: Town Limits only		
Electricity	269,242		1.953	262.88		18.1%	**48**	**12**
Fuel consumption (diesel)		57,098	22.38	639.04		18.1%	**116**	**29**
Fuel consumption (gasoline)	190		19.56	1.86		18.1%	**0**	**0**
Propane	766		12.67	4.85		18.1%	**1**	**0**
Fugitive methane (60 percent of 150 cfm generated)				0.00	-	18.1%	**-**	**-**
Total Summit County Landfill							**164.7**	**41**

Table 2: Saved emissions	Quantities Recycled and Sold	GHG savings per tonne recycled	Total Summit County GHG savings	Attributed to Frisco	GHG Savings (Frisco's share)	Carbon (Frisco's share)		Summit County Recycling Rate per capita
Summit County Landfill: Savings from Recycling	tons	tons CO2-eq/ton	tons CO2-eq	Percent	sh tons CO2-eq/yr	tonnes carbon (C-eq)	Summit population 04	lb per capita
Office paper		5.4	-	18.1%	**-**	-	30,094	
Newsprint & office paper (combined data)	794	2.5	1,985	18.1%	**360**	89		52.77
Cardboard	920	3.0	2,760	18.1%	**500**	124	Frisco adjusted pop'n	61.14
Plastics	76	2.0	152	18.1%	**28**	7	5,455	5.05
Aluminum	17	15.7	267	18.1%	**48**	12		1.13
Glass	585	0.4	234	18.1%	**42**	11	Frisco's adjusted %	38.88
Steel	392	2.3	902	18.1%	**163**	40	18.1%	26.05
Tin	25	na	na	18.1%	na	na		1.66
Total Landfill recycling savings	2,809	na	6,300	18.1%	**1,142**	283		186.68

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

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".
Note: While materials recycling typically saves energy and emissions, it must be made clear that the high emissions "savings" ignore substantial emissions from pick-up, hauling, trucking to recycling centers far from Summit County, and subsequent processing.
Note: From and energy and emissions perspective, recycling aluminum has by far the highest GHG savings per ton.

Cell: F13
Comment: Rick Heede:
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.

Cell: H13
Comment: Rick Heede:
No data exists on the source and origin of wastes received at the Summit Solid Waste Facility. CMS attributes 18.1 percent of the energy and emissions from the facility to the Town of Frisco based on 2004 US Census data (see worksheet on population in FriscoSum.xls) and adjusted to account for Frisco's high proportion of second homeowners and visitors.

Cell: B15
Comment: Rick Heede:
Fuel and electricity consumption in 2006 from Bonita P (per Aaron Byrne, Operations Manager, personal communication, 26Sep07: "2006: Diesel Fuel Delivered to Landfill - 57,098 gallons, Gasoline - 190 gallons, Electricity all of 2006 includes all buildings 269,242 kWh, Gallons of propane 766 gallons."

Cell: B16
Comment: Rick Heede:
Bonita, Administrative Asst for Summit Solid Waste Facility, sent electricity consumption data for the gate house (including the scales and the offices,32,350 kWh in 2006), the old shop (soon to be decommissioned, 25,852 kWh in 2006), the new shop (72,880 kWh in 2006), and the Materials Recycling Facility (MRF, on-line in late Aug06, 138,160 kWh in 2006; average ~40,000 kWh per operational month); total 269,242 kWh for the year.

Cell: B17
Comment: Rick Heede:
Data from Bonita, 25Sep07: 57,098 gallons of diesel fuel consumed in 2006 by the Facility's compliment of loaders, dozers, trucks, track hoes, graders, excavators, wood chipper,and 2 compactors. The compactor operates nearly constantly during work hours. The wood chipper, a

Cell: B20
Comment: Rick Heede:
Methane generation at the Summit County Solid Waste Facility is zero according to Aaron Byrne, Operations Manager, personal communication 26Sep07. The State of Colorado requires annual monitoring and lab testing, and only one of the samples in the last two years tested for minor quantities of methane. CMS thus accepts this finding and estimates methane emissions from the landfill is zero to negligible. This finding is consistent with the notion that methane generation in high-altitude landfills in dry climates is minor.

Even so, and for comparison purposes, the landfill in Aspen showed emissions of approximately 150 cubic feet of methane per minute. Note: 150 cfm times 60 x 24 x 365 = 78.84 million cubic feet of methane per year; 1 cf of methane equals 0.04228 lb: thus 78.84 Mcf x 0.04228 lb/cf = 1.6666776 short tons of methane. CMS assumed in the Aspen Emissions Inventory that 60 percent (1,000 short tons) of this amount of generated methane is released to the atmosphere annually.

Note 2: We have not estimated fugitive methane from the Landfill's receipt of biosolids from the Summit County's (including the Frisco) Wastewater Treatment Plant. In the Aspen inventory, teh landfill received one truck load (~10 tons) every three days. This totals ~1,771 metric tonnes. If two percent of this mass is converted to methane = 35.42 tonnes of CH4, times 21 x CO2 = 743.8 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 reduced the Pitkin estimate by fifty percent (of that allocated to the CIty of Aspen).

Cell: D27
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: F27
Comment: Rick Heede:
See the note under "Frisco adjusted population," cell I31 below.

Cell: G27
Comment: Rick Heede:
CMS allocates emissions savings from recycled materials on the basis of Frisco's population share of Summit County

Cell: B28
Comment: Rick Heede:
Recycling data from Bonita, Summit County Solid Waste Facility, 3Oct07.

Cell: I31
Comment: Rick Heede:
CMS calculates that Frisco's 2004 population (US Census Bureau) of 3,350 is 11.1 percent of the Summit County total (30,094 souls). Since this does not account for Frisco's high percentage of second homeowners, visitors, and tourists, CMS adds 50 percent of the second homeowners to the official Frisco population estimate as detailed below.

Frisco data (viewed Oct07): www.townoffrisco.com/visitors/frisco-fast-facts.html. Population: 2,697 year round; 4,209 second homeowners; Combined approx. 6,906 people.

However, for many calculations derived from population data -- such as recycling activity and driving and lawncare and snowplowing -- occupancy as well as tourism and second homeowners must be accounted for. Even though it is not possible to estimate "average occupancy" in town over the year, CMS adds one-half of the second homeowners as a population proxy for such calculations. This number does not account for residents in the wider community of Frisco (those ~383 properties in unincorporated Summit County near and/or contiguous to Frisco's town limits). CMS does use the US Census Bureau population estimates for Frisco -- 3,350 souls -- for 2006 Frisco resident population, plus 0.5 of 4,209 second homeowners equals a total "population" of Frisco estimated as 5,455 people, or 18.1 percent of Summit County's total in 2004.

These numbers will be re-evaulated in future emissions estimates.

Cell: B32
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. CMS averages this to 2.0 tonne CO2-eq saved per tonne recycled.

Cell: J33
Comment: Rick Heede:
Summit County's aluminum recycling rate is ~17 tons / 30,094 population (2004, US Census Bureau) = 1.13 lb per capita per year.

By way of comparison: 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). Seattle's is 4.1 kg/cap-yr, Bergen County 6.8 kg/cap-yr. The U.S. average is 3.5 kg/cap-yr; 1996 data from EPA/Ackerman; www.tufts.edu/tuftsrecycles/energy.htm, Table 2.

Cell: B34
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.

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Notes

Frisco Emissions Inventory: halocarbon refrigerants

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started 23 April 2007
Last Modified: 3 October 2007

Update data on the number of households and vehicles in Frisco, and, if warranted, update leakage rates of refrigerants in various equipment types. All other computations are carried through to the sums below.

Data from:
Community Survey
US Census 2000
EIA RECS (household) data
US EPA

Table 1: Refrigerant unit calculation	# of Households	# of Refrigerators	# of Freezers	# of Room ACs	# of Central AC	Total home refrigerant units	# of Vehicles	# of Vehicles with air conditioning
	#	ave. fridges/HH	ave. freezers/HH	ave. Central ACs	ave. Room ACs/HH	#	ave. vehicles/HH	ave. vehicles/HH
		1.18	0.35	0.1367	0.0333		1.929	1.5432
Town of Frisco	2,697	3,182	944	369	90	4,585	5,203	4,162
Additional housing units contiguous to Town of Frisco	383	452	134	52	13	651	739	591
Total households, appliances, & vehicles in Frisco	**3,080**	**3,634**	**1,078**	**421**	**103**	**5,236**	**5,941**	**4,753**

Table 2a: Leakage rate calculation for appliances	# of Refrigerators	# of Freezers	# of Room ACs	# of Central AC	Total home refrigerant units	Tonnes of CO2 equivalent	Tons of CO2 equivalent
	leakage rate (g/unit-yr)					GWP coefficient	
	1.500	1.000	0.500	2.000		1,300	
	kg HFC-134	kg HFC-134	kg HFC-134	kg HFC-134	kg HFC-134	tonnes CO2-e	tons CO2-e
Refrigerant leakage from all fridges, freezers, and AC units in Frisco	5.45	1.08	0.21	0.21	6.95	9.03	**9.95**
Refrigerant leakage at disposal of regulated units	*not estimated*						

Table 2b: Leakage rate calculation for vehicle ACs	leakage rate (g/veh-yr)	Total vehicle AC leakage	Tonnes of CO2 equivalent	Tons of CO2 equivalent
	12		GWP coefficient	
	kg HFC-134	kg HFC-134	1,300	
			tonnes CO2-e	tons CO2-e
Refrigerant leakage from automobile AC units in Frisco's veh pop (see above)	57.04	57.04	74.15	**81.73**

Table 3: Total halocarbon emissions	Total Town of Frisco refrigerant leakage, in tons of CO2-eq	91.69

Cell: D14
Comment: Rick Heede:
Energy Information Administration (2005) Residential Energy Consumption Survey, Table D8. Appliances in Mountain Households, Selected Years, 1980-2001. www.eia.doe.gov/emeu/consumption/index.html

Data for 2001: 82 percent of 7 million "Mountain Households" have one refrigerator, and 18 percent have two or more. The average household thus has (assuming that none have three or more) 1.18 refrigerators. This does not include "separate freezers" (35 percent).

Cell: E14
Comment: Rick Heede:
Energy Information Administration (2005) Residential Energy Consumption Survey, Table D8. Appliances in Mountain Households, Selected Years, 1980-2001. www.eia.doe.gov/emeu/consumption/index.html

Data for 2001: 35 percent of 7 million "Mountain Households" have an additional freezer. The average household thus has 0.35 freezers (in additional, that is, to those in refrigerators).

Cell: F14
Comment: Rick Heede:
Energy Information Administration (2005) Residential Energy Consumption Survey, Table D8. Appliances in Mountain Households, Selected Years, 1980-2001. www.eia.doe.gov/emeu/consumption/index.html

Data for 2001: 41 percent of 7 million "Mountain Households" have Central AC. CMS has not verified the installation rate of Central air conditioning in Frisco's cooler high-altitude climate; CMS assumes that one-third of the Mountain Central AC rate for Frisco, The average household thus has 0.41/3 Central AC equals 0.137 per Frisco household.

Cell: G14
Comment: Rick Heede:
Ditto as for Central AC: 10 percent of Mountain Households have room AC units, of which CMS assumes one-third for Frisco's cooler climate, or 0.1/3 = 0.033.

Cell: B17
Comment: Rick Heede:
US Census Bureau (cited in Venturoni (2006) Town of Frisco 2006 Community Survey, section 3, p. 1 and 2.).

Cell: B18
Comment: Rick Heede:
CMS counted 383 parcels contiguous to Frisco Town Limits in unincorporated Summit County considered part of the Frisco community in the boundary definition agreed to with Frisco Town Planner Jocelyn Mills in May07.

Cell: F25
Comment: Rick Heede:
"Pin holes, corrosion, mechanical fatigue and other issues yield average leakage rates from 1 to 3 grams per year from world class production processes. Failures typically are early in life from manufacturing defects, or much later in life from cumulative wear out effects."

"Domestic refrigerators typically contain a 50 to 200 gram refrigerant charge."

Globally, "refrigerators annually consume approximately 17,500 metric tons of refrigerant. Two-thirds of this is required for the 75,000,000 new refrigerators. The other one-third is used during the 4.5 to 5 million field repair procedures necessary to service the approximate 1.5 billion units in the installed base."

McInerney et al (1999) "Refrigerant Emission Control Opportunities."

CMS assumes an average refrigerant charge of 150 grams and a leakage rate of 1.5 g per refrigerator (toward the lower end of the range cited above). CMS also assumes a lower leakage rate for freezers (1 g/yr) and room ACs (0.5 g/yr), and 2.0 g/yr for central AC units.

Cell: B30
Comment: Rick Heede:
CMS has not estimated CFC or HFC refrigerant leakage from the disposal of domestic refrigerators, freezers, and air conditioners. Summit County Solid Waste Facility accepts such units, but only with a signed certifaction that refrigerants have been removed by a licensed facility, of which several exist in Summit County. Bonita at the Waste Facility provided the data that "in 2007 we have taken in 445 units that required certification." CMS assumes that certified refrigerant recovery centers do recover 100 percent of the contained gas. Future research may elucidate this issue, and apply a leakage rate to the refrigerant recovered from these 445 units accepted at the Landfill.

Cell: F33
Comment: Rick Heede:
EPA's Mobile Air Conditioning Climate Protection Partnership. "In the United States alone, vehicle air conditioners consume 7 billion gallons of gasoline every year, equivalent to over 16 million metric tons of carbon equivalent (MMTCE). Refrigerant leakage adds another 8.7 MMTCE to atmospheric emissions of greenhouse gases."

“The Mobile Air Conditioning Climate Protection partnership is making great progress. On Earth Day 2004, it announced the Improved Mobile Air Conditioning (IMAC) 30/50 project with ambitious goals to reduce vehicle air conditioning fuel consumption by at least 30 percent and cut refrigerant emissions by 50 percent.”

“The greenhouse gas reduction calculation is based on tests conducted by the Society of Automotive Engineers and industry data.
The new machines recover an average of 120 grams more HFC-134a refrigerant ea
AC systems are professionally repaired 20 to 25 million times per year
20 million repairs saving 120 grams each = one million metric tons of carbon equivalent.”

Overall, there were an estimated 243,023,485 registered passenger vehicles in the United States according to a 2004 DOT study. http://en.wikipedia.org/wiki/Passenger_vehicles_in_the_United_States

www.epa.gov/cppd/mac/

Frisco calculation: Assume that ten percent (24.3 of 243 million US passenger vehicles) of AC systems are professionally repaired annually. Since each repaired vehicle emits 120 g of HFC-134a refrigerant during servicing, on average 12 g of HFC-134a refrigerant per vehicle in the population. In Frisco’s case, its estimated 4,753 vehicles with AC times 12 g each equals 61.61 kg of HFC-134a refrigerant leakage per year.

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Notes

Town of Frisco Emissions: Town Fuel, Natural Gas, & Electricity Consumption, 2006

Future inventorists: update consumption and usage data in the grey cells (diesel, gasoline, natural gas, and electricity). Also update the emissions from application of fertilizers in Town Parks (see "Fertilizer" worksheet). Finally, update future year's "Credits and Offsets" in Table 5 below. Net Frisco emissions are automatically computed.

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started: 19 February 2008
Last Modified: 20 March 2008

Contacts			
Public Works	Tim Mack	668-0836, x1318	timm@townoffrisco.com
Town Clerk	Deborah Wolhmuth	668-5276, x3034	

Table 1 — Transportation & equipment fuel

	Vehicle miles traveled (VMT)	Fuel consumed	Fuel consumed	Fuel economy	Carbon factor	Attributed to Frisco	Carbon dioxide	CH4 (methane) emissions	N2O (nitrous oxide) emissions	Total GHG emissions	
	(if known)	Diesel	Gasoline	mpg	CO2/gallon	Percent	tons CO2	tons CO2e	tons CO2e	tons CO2e	
					diesel / gasoline						percent
Town of Frisco											of total
Trucks, graders, backhoes, plows (diesel)	57,990	11,598		5	22.38	100%	129.8	0.0	0.9	130.7	10.1%
Sheriff and other vehicles (gasoline)	426,844		19,402	22	19.59	100%	190.1	0.3	6.3	196.7	15.3%
Total Town of Frisco vehicles	**484,834**	**11,598**	**19,402**				**319.9**	**0.4**	**7.1**	**327.4**	

Table 2 — Natural gas

	Natural Gas		Emissions factor	Emissions				
	Consumption	Consumption		Carbon Dioxide	Methane	Methane	Total	Total
	Thousand cf (Mcf)	Billion Btu (10^9)	carbon per btu	short tons CO2	short tons CH4	tons CO2eq	tons CO2e	tonnes C-eq
	cubic feet/million btu		tonnes C/billion Btu	tons CO2/billion Btu	tons CH4/ton CO2	tons CO2e/ton CO	tons CO2e/billlion B	tonnes Ce/billlion Btu
	1,160		14.47	58.44	0.00568	0.11925	65.41	16.20
Town of Frisco	3,818	3.29		192	1.1	23	**215**	53
	if gas in therms:	**32,916**						

Table 3 — Electricity

	Electricity		Carbon factor	Emissions				
	Consumption	Consumption		Carbon Dioxide	Methane	Methane	Total	Total
	kWh	MWh	carbon/kWh	tons CO2	tons CH4	tons CO2-eq	tons CO2+CH4	tonnes C-eq
			lb CO2/kWh		lb CH4/kWh	CO2 x 21	lb CO2-equiv/kWh	kg C-eq/kWh
			1.816		0.006	21	1.953	0.242
Town of Frisco	**759,077**	**759**		**689**	**2**	**52**	**741**	**183**

Note: CMs uses more complete data from John Canfield's report to Frisco covering May05-Apr06, which includes Water Treatment Plant and Pump House.

Sum of Town of Frisco emissions — Table 4

	tons CO2e	Percent of total
Transportation & Equipment Fuel	327	25.39%
Natural gas	215	16.70%
Electricity	741	57.48%
Town of Frisco Parks (fertilizer)	6	0.43%
Sum	1,289	1.002% of total
Rest of Frisco's community-wide emissions	127,409	tons CO2e
Frisco total emissions, 2006	128,698	tons CO2e

Credits & Offsets — Table 5

	offset units	tons CO2e
Renewable Choice (2007)	(offset starts in 2007)	
Natural gas	no offsets	
Renewable Choice (2006), kWh	1,400,000	1,367
Fertilizer	no offsets	
Sum		1,367

Net Town of Frisco emissions — Table 6

	tons CO2e
Transportation	327
Natural gas	215
Electricity	(626)
Fertilizer	6
Sum	(78)

Cell: J13
Comment: Rick Heede:
Emissions of methane associated with fuel use and combustion in mobile sources. Factors from California Climate Action Registry (2007) General Reporting Protocol, Table C-4. CCAR estimates CH4 emissions rate, average of light duty diesel trucks (0.01 grams CH4/mile) and heavy duty diesel trucks (0.06 grams CH4/mile); average equals 0.035 grams CH4/mile. CMS has accounted for teh allocation to Frisco of the School Districts bus system (33 percent of total).

CMS has used IPCC's GWP factor for methane of 21xCO2.

Formula: (C19*0.035*1.1023/1000000)*21*H19

For the community emissions estimate of commuting and driving around town, assume gasoline vehicles's average of 1994-1999 emissions rate (0.05 grams CH4/mile) and 2000-present rate (0.04 grams CH4/mile); average equals 0.045 grams CH4/mile.

Cell: K13
Comment: Rick Heede:
Emissions of nitrous exides associated with fuel use and combustion in mobile sources. Factors from California Climate Action Registry (2007) General Reporting Protocol, Table C-4. CCAR estimates N2O emissions rate, average of light duty diesel trucks (0.03 grams N2O /mile) and heavy duty diesel trucks (0.05 grams N2O /mile); average equals 0.045 grams N2O /mile. CMS has accounted for the allocation to Frisco of the School Districts bus system (33 percent of total). CMS has used IPCC's GWP factor for nitrous oxide of 296xCO2.

Formula: (C19*0.045*1.1023/1000000)*296*H19

For the community emissions estimate of commuting and driving around town, use gasoline vehicles's emissions rate of 0.04 grams N2O /mile (same 1990s and 2000-present).

Cell: B16
Comment: Rick Heede:
Tim Mack, Public Works Director, by email, 7May07: "Unleaded gasoline consumption for 2006 = 19,402 gallons; Diesel consumption in 2006 = 11,598 gallons (these amounts are for all Town owned vehicles/equipment)."

CMS has assumed (as we did for Summit County Public Works Dept vehicles) average fuel economy of 22 mpg for gasoline vehicles (town vehicles, police cruisers, etc) and 5 mpg for diesel vehicles and equipment.

Cell: E23
Comment: Rick Heede:
Xcel Energy supplied natural gas sales data in therms per year (albeit in ccf in years 1990-2002). 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 Carbon/Btu or, as it is usually reported, TgC/QBtu (teragrams of carbon perquadrillion Btu); in normal parlance this factor equals 14.47 kg of carbon per million Btu (kgC/million Btu), which, at average heating value, equals ~974 cubic feet of gas. Our calculation sidesteps the issue of how many ccf Xcel Energy sold in 2006 since the data is reported in units of million Btu (in XCel's parlance: "dekatherms"). 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 CMS 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. Xcel Energy 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 Btu/cf).

Cell: F24
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: G24
Comment: Rick Heede:
See notes in Table 2 below for methodology used to estimate fugitive methane emissions rate applied to Frisco's consumption of natural gas.

Cell: C26
Comment: Rick Heede:
Feb08: CMS has not updated this conversion factor for the Frisco inventory because Xcel supplied data in therms (100,000 Btu), not million cubic feet, and the emission calculations are based on CO2 per billion Btu. The conversion below from billion Btu to cf is thus a slight underestimate, since Frisco is at a higher elevation than Aspen (9040 ft and 7908 ft, respectively).

2005, for Aspen inventory: 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: D30
Comment: Rick Heede:
Jocelyn Mills or other Frisco staff: Data for 2007 natural gas consumption from Mills ("32,916 Therms"), 5Mar08. Update in future years.

Note: If natural gas usage is reported in therms, divide total therms (one therm is 100,000 Btu, or 10^5 Btu) by 10,000 in the cell below.

John Canfield data for May 2005 - April 2006 shows total gas consumption of 27,696 therms.

Cell: E34
Comment: Rick Heede:
The carbon factors -- the amount of carbon dioxide per average kWh delivered to customers -- varies depending on the fuel mix of the electricity provider serving Frisco. *

Xcel Energy estimated the carbon factor for its electricity generation in Colorado as 1,692 lb CO2 per MWh. 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 Xcel datum of 1.692 lb CO2/kWh x 1.0735 = 1.816 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), 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. CMS uses the factor estimated by Xcel Energy (7Dec07) as 7.35 percent to account for the relative proximity of Xcel's power plants to Frisco. Losses also occur in local grids, powerlines, and

transformers, and Xcel has included a grid loss factor for local distribution, too.

Cell: G35
Comment: Rick Heede:
CMS has calculated emissions of methane from coal mines supplying Colorado power plants -- diluted by the Xcel Energy's resource mix (59 percent coal, 35 percent gas, 3 percent each hydro and wind; Xcel, 17dec07) -- in order to estimate emissions of the greenhouse gas associated with the generation of electricity in Colorado. We have used Colorado's total emissions of methane from all 13 Colorado coal mines (0.233 million tonnes CH4) (estimated by Center for Climate Strategies (2007) Draft Emissions Inventory), electricity generation (46.72 billion kWh) and coal production (34.93 million tonnes) to estimate the emissions rate of 4.994 kg CH4 per MWh and 6.68 kg CH4 per tonne coal mined.

In the case of Xcel, 59 percent of its generation is by coal, hence we multiply 4.994 kg CH4/MWh x 0.59 = 2.946 kg CH4 per MWh of total Xcel generation. This, for the time being, ignores emissions of methane from natural gas generation and ancillary emissions upstream from gas-fired powerplants.

Cell: H35
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 21xCO2 (100 hundred year horizon, mole basis), per IPCC Second Assessment Report, and while adjusted in the Fourth Assessment Report this adjusted factor has been approved by the IPCC governing bodies for use in national inventories. CMS uses the SAR convention.

Note: Some practitioners use the GWP factor in IPCC's Fourth Assessment Report: 23xCO2 (100 hundred year horizon, mole basis),

Cell: I37
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 as well as fugitive 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 and excavators, nor the diesel fuel to run the mining and transportation modes. See the Boundary definition in the final report for details.

Cell: C40
Comment: Rick Heede:
Mills, 5Mar08: "Based on the 13 town structures (including some small historic buildings in the historic park and a public restroom at one of the town's parks) that I got info on from the facilities manager... Total energy consumption for 2007 for these were 32,916 THERMS and 480,300 kWh."

Note: CMs uses more complete data from John Canfield's report to Frisco covering May05-Apr06, which includes Water Treatment Plant and Pump House.

John Canfield of Trident Energy did an audit of Town energy for May05-Apr06, which shows 759,077 kWh for the 12-month period:
Water treatment - 66,072 kWh,
Public Works - 82,680 kWh
Rec Bldg - 30,737 kWh
Water Well - 142,075 kWh
Nordic Center - 54,331 kWh
Pump House - 155,280 kWh
Old Town Hall - 36,782 kWh, and
New Town Hall - 191,120 kWh
Total TOF - 759,077 kWh

Canfield's report also shows 27,696 Therms of natural gas consumption (chiefly Public Works and New Town Hall).

Cell: C44
Comment: Rick Heede:
Table 4 total emissions from Town of Frisco buildings, facilities, vehicles, and fertilizer applied to parks, etc. This table is linked to and automatically updated with sums from Tables 1-3, except fertlizer, which is linked to the nitrogenous worksheet.

Cell: H44

Comment: Rick Heede:
Table 5 sums Town credits and offsets for its emissions sources. Town purchased RECs for 1.4 million kWh for each year 2006 - 2008, and is planning to purchase additional offsets for its vehicle emissions starting with year 2007.

Cell: L44
Comment: Rick Heede:
In 2006, Town if Frisco has contracted for 1,367 tons CO2 offsets, vs 1,107 tons CO2 in emissions, for a net surplus of 350 tons CO2; I.e., a net negative emissions.

Cell: G49
Comment: Rick Heede:
Mills, Octo8: Town of Frisco contracted with Renewable Energy Choice in Boulder, Coloroado, for 3 years of windpower credits at 1.4 million kWh per year.

Cell: B50
Comment: Rick Heede:
Tim Mack, 16May07: "Buildings/Grounds Department applied 1200 lbs. of granular Nitrogen to 8 acres of turf area in 2006."
CMS calculates that this converts to an application rate of 3.44 lb N per 1,000 sf.

See the "Fertilizer N2O" worksheet for details and computation.

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Notes

Frisco emissions 1990 to 2050

This worksheet is used to forecast several future emissions scenarios for Frisco out to 2050 as well as estimating ("backcasting") emissions back to 1990-2005. Frisco staff will not need to modify this worksheet for future inventories. However, it may prove useful to modify the sheet if staff is interested in modeling different emission growth rates or adding an emission peak prior to 2012.

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started 13 November 2007
11-Mar-08

colored boxes below correspond to lines in the chart "Frisco emissions scenarios 1990-2050", Figure ES-2 in the SumRpt

	Buildings						Transportation						Other	Local Growth Business-as-usual Total		Blended BAU average of local growth and A1 Scenario	B1 Scenario	A1 Scenario	Frisco to 20% of 2006 by 2050	Frisco to 1990 by 2012	Frisco to 93% of 1990 by 2012
	Population	Computed population by year	Emissions based on Population growth (Elec+Gas+Propane) No elec C factor	Energy carbon intensity (+/- 0.5% pa)	Elec & Gas growth factor per Xcel sales 1990-2006	Resulting Building emissions	Traffic CDOT AADT	Computed AADT by year	Emissions based on Traffic growth CDOT AADT growth No fuel C factor	Fuel carbon intensity (not applied)	Resulting Transport emissions		Emissions boat fuel, N2O, Landfill, etc.	Emissions: Buildings, Transport, & Other						9.555551% reduction/year 2007-2012	10.642898% reduction/year 2007-2012
Year			tons CO2e	factor	factor	tons CO2e			tons CO2e	factor	tons CO2e		tons CO2e	tons CO2e	Year	tons CO2e	tons CO2e	tons CO2e	tons CO2e	tons CO2e	tons CO2e
1990	1,628	1,628	23,995	1.080	0.660	39,264		12,414	31,058	1.00	31,058		125	70,447	1990	80,229	98,144	90,010	70,447	70,447	70,447
1991		1,738	26,717	1.075	0.700	41,030		13,157	32,916	1.00	32,916		139	74,086	1991	82,728	99,626	91,370	74,086	74,086	74,086
1992		1,848	29,440	1.070	0.740	42,568		13,900	34,775	1.00	34,775		154	77,496	1992	85,113	101,109	92,730	77,496	77,496	77,496
1993		1,958	32,162	1.065	0.780	43,913		14,643	36,633	1.00	36,633		168	80,714	1993	87,402	102,592	94,090	80,714	80,714	80,714
1994		2,068	34,884	1.060	0.817	45,272		15,386	38,492	1.00	38,492		182	83,945	1994	89,698	104,075	95,450	83,945	83,945	83,945
1995		2,178	37,607	1.055	0.872	45,501		16,129	40,350	1.00	40,350		196	86,048	1995	91,429	105,558	96,810	86,048	86,048	86,048
1996		2,287	40,329	1.050	0.912	46,448		16,871	42,208	1.00	42,208		210	88,867	1996	93,519	107,041	98,170	88,867	88,867	88,867
1997		2,397	43,051	1.045	0.841	53,463		17,614	44,067	1.00	44,067		225	97,755	1997	98,642	108,524	99,530	97,755	97,755	97,755
1998		2,507	45,774	1.040	0.871	54,652		18,357	45,925	1.00	45,925		239	100,816	1998	100,853	110,006	100,890	100,816	100,816	100,816
1999		2,617	48,496	1.035	0.906	55,379		19,100	47,784	1.00	47,784		253	103,416	1999	102,833	111,489	102,250	103,416	103,416	103,416
2000	2,727	2,727	51,219	1.030	0.928	56,862		19,843	49,642	1.00	49,642		267	106,771	2000	105,190	112,972	103,610	106,771	106,771	106,771
2001		2,871	53,941	1.025	0.950	58,180		20,586	51,501	1.00	51,501		281	109,962	2001	108,876	115,593	107,791	109,962	109,962	109,962
2002		3,023	56,663	1.020	0.958	60,314		21,329	53,359	1.00	53,359		296	113,969	2002	112,971	118,214	111,973	113,969	113,969	113,969
2003		3,182	59,386	1.015	0.970	62,141		22,071	55,218	1.00	55,218		310	117,668	2003	116,911	120,835	116,154	117,668	117,668	117,668
2004	3,350	3,350	62,108	1.010	0.980	64,009		22,814	57,076	1.00	57,076		324	121,409	2004	120,872	123,456	120,335	121,409	121,409	121,409
2005		3,527	64,831	1.005	0.990	65,813		23,557	58,934	1.00	58,934		338	125,086	2005	124,801	126,077	124,517	125,086	125,086	125,086
2006		3,713	67,553	1.000	1.000	67,553	24,300	24,300	60,793	1.00	60,793		352	128,698	2006	128,698	128,698	128,698	128,698	128,698	128,698
2007		3,909	70,275	0.995		69,924		25,043	62,651	1.00	62,651		371	132,946	2007	132,913	131,319	132,880	124,076	116,400	115,001
2008		4,116	73,107	0.990		72,376		25,808	64,567	1.00	64,567		391	137,334	2008	137,197	133,940	137,061	119,619	105,278	102,762
2009		4,333	76,054	0.985		74,913		26,597	66,540	1.00	66,540		411	141,864	2009	141,554	136,561	141,243	115,323	95,218	91,825
2010		4,562	79,119	0.980		77,536	27,410	27,410	68,574	1.00	68,574		433	146,544	2010	145,984	139,182	145,424	111,181	86,119	82,052
2011		4,803	82,307	0.975		80,249		28,248	70,671	1.00	70,671		456	151,376	2011	150,235	141,640	149,093	107,188	77,890	73,319
2012		5,056	85,624	0.970		83,055		29,112	72,831	1.00	72,831		480	156,367	2012	154,565	144,097	152,763	103,338	70,447	65,516
2013		5,323	89,075	0.965		85,957		30,002	75,058	1.00	75,058		505	161,520	2013	158,976	146,554	156,432	99,626		
2014		5,604	92,664	0.960		88,958		30,919	77,352	1.00	77,352		532	166,842	2014	163,472	149,011	160,102	96,048		2012 of 2006: 50.91%
2015		5,900	96,399	0.955		92,061		31,864	79,717	1.00	79,717		560	172,338	2015	168,054	151,468	163,771	92,598		
2016		6,212	100,284	0.950		95,269		32,838	82,154	1.00	82,154		590	178,013	2016	172,727	153,926	167,441	89,272		
2017		6,540	104,325	0.945		98,587		33,842	84,665	1.00	84,665		621	183,873	2017	177,492	156,383	171,110	86,066		2006 of 1990: 182.69%
2018		6,885	108,529	0.940		102,018		34,877	87,253	1.00	87,253		654	189,925	2018	182,352	158,840	174,779	82,974		
2019		7,249	112,903	0.935		105,564		35,943	89,921	1.00	89,921		688	196,173	2019	187,311	161,297	178,449	79,994		
2020		7,631	117,453	0.930		109,231		37,042	92,670	1.00	92,670		724	202,625	2020	192,372	163,755	182,118	77,121		
2021		8,034	122,186	0.925		113,023		38,174	95,503	1.00	95,503		763	209,288	2021	197,122	165,720	184,957	74,351		
2022		8,459	127,111	0.920		116,942		39,341	98,422	1.00	98,422		803	216,167	2022	201,981	167,686	187,795	71,681		# 128,698
2023		8,905	132,233	0.915		120,993		40,544	101,431	1.00	101,431		845	223,269	2023	206,952	169,652	190,634	69,106		# 115,001
2024		9,375	137,562	0.910		125,182		41,783	104,532	1.00	104,532		890	230,603	2024	212,038	171,618	193,473	66,624		# 102,762
2025		9,870	143,106	0.905		129,511		43,060	107,727	1.00	107,727		937	238,175	2025	217,243	173,583	196,311	64,231		# 91,825
2026		10,391	148,873	0.900		133,986		44,377	111,020	1.00	111,020		986	245,992	2026	222,571	175,549	199,150	61,924		# 82,052
2027		10,940	154,873	0.895		138,611		45,733	114,414	1.00	114,414		1,038	254,064	2027	228,026	177,515	201,989	59,700		# 73,319
2028		11,518	161,114	0.890		143,392		47,131	117,912	1.00	117,912		1,093	262,397	2028	233,612	179,481	204,827	57,556		# 65,516
2029		12,126	167,607	0.885		148,332		48,572	121,516	1.00	121,516		1,151	271,000	2029	239,333	181,447	207,666	55,488		
2030		12,766	174,362	0.880		153,438		50,057	125,231	1.00	125,231		1,212	279,881	2030	245,193	183,412	210,504	53,495		Column BO:
2031		13,440	181,388	0.875		158,715		51,587	129,059	1.00	129,059		1,276	289,050	2031	250,479	185,050	211,907	51,574		89.36%
2032		14,150	188,698	0.870		164,167		53,164	133,005	1.00	133,005		1,343	298,515	2032	255,913	186,689	213,310	49,722		10.64% reduction/year 2007-2012
2033		14,897	196,303	0.865		169,802		54,790	137,071	1.00	137,071		1,414	308,287	2033	261,500	188,327	214,713	47,936		
2034		15,684	204,214	0.860		175,624		56,465	141,261	1.00	141,261		1,489	318,374	2034	267,245	189,965	216,115	46,214		
2035		16,512	212,444	0.855		181,639		58,191	145,579	1.00	145,579		1,567	328,786	2035	273,152	191,603	217,518	44,554		
2036		17,383	221,005	0.850		187,854		59,970	150,030	1.00	150,030		1,650	339,534	2036	279,228	193,241	218,921	42,954		
2037		18,301	229,912	0.845		194,275		61,803	154,616	1.00	154,616		1,737	350,629	2037	285,476	194,879	220,324	41,411		
2038		19,268	239,177	0.840		200,909		63,692	159,343	1.00	159,343		1,829	362,080	2038	291,903	196,517	221,726	39,924		
2039		20,285	248,816	0.835		207,761		65,639	164,214	1.00	164,214		1,925	373,901	2039	298,515	198,156	223,129	38,490		
2040		21,356	258,843	0.830		214,840		67,646	169,234	1.00	169,234		2,027	386,101	2040	305,316	199,794	224,532	37,107		
2041		22,484	269,274	0.825		222,151		69,714	174,407	1.00	174,407		2,134	398,693	2041	312,412	198,975	226,131	35,775		
2042		23,671	280,126	0.820		229,704		71,845	179,739	1.00	179,739		2,247	411,689	2042	319,710	198,156	227,730	34,490		
2043		24,921	291,415	0.815		237,503		74,041	185,234	1.00	185,234		2,366	425,103	2043	327,216	197,337	229,329	33,251		
2044		26,236	303,159	0.810		245,559		76,305	190,896	1.00	190,896		2,490	438,946	2044	334,937	196,517	230,929	32,057		
2045		27,622	315,377	0.805		253,878		78,637	196,732	1.00	196,732		2,622	453,232	2045	342,880	195,698	232,528	30,905		
2046		29,080	328,086	0.800		262,469		81,041	202,746	1.00	202,746		2,760	467,975	2046	351,051	194,879	234,127	29,795		
2047		30,615	341,308	0.795		271,340		83,519	208,944	1.00	208,944		2,906	483,190	2047	359,458	194,060	235,726	28,725		
2048		32,232	355,063	0.790		280,500		86,072	215,331	1.00	215,331		3,060	498,891	2048	368,108	193,241	237,325	27,693		
2049		33,934	369,372	0.785		289,957		88,703	221,914	1.00	221,914		3,221	515,092	2049	377,008	192,422	238,924	26,699		
2050		35,726	384,258	0.780		299,721		91,415	228,698	1.00	228,698		3,391	531,810	2050	386,167	191,603	240,524	25,740		
Cumulative emissions			8,953,539			7,909,840			6,441,117		6,441,117		64,649	14,415,606		12,447,712	9,584,757	10,479,818	4,450,747	2,238,506	2,876,805
			growth rate 1990-2000 at 3.45% pa						growth rate 1990-2000 at 3.06% pa				growth rate 1990-2000 at 4.03% pa	12,857,151	2006-2050	10,845,645	7,819,445	8,834,139	2,892,291		
			growth rate 2000-2040 at 4.03% pa						growth rate 2000-2040 at 3.06% pa				growth rate 2000-2040 at 5.28% pa								
													same as Buildings								

Cell: I10
Comment: Rick Heede:
Building emissions are linked to worksheet "FriscoSum.xls" total emissions for electricity, natural gas, and propane at 2006. Prior years are backcast on the basis of population growth shown in US Census data between 1990 and 2000 (4.03 percent per annum). Post-2000 growth is also based on Census population growth between 1990 and 2000 (4.03 percent per annum), even though Venturoni reports Census data for 2004 that indicate population growth 5.28 percent per annum.

Note: CMS has applied a factor of 0.5 percent reduction in carbon intensity for all building energy, 67.5 percent of which comes from the electricity sector, which in turn implies a 1.09 percent annual reduction in the carbon intensity of electricity if the carbon (and methane) intensity of natural gas is unchanged. The gas sector, however, has reduced its emissions intensity, particularly in reducing the methane associated with gas production and processing, and this can be expected to see continued improvement. CMS has also modified the earlier assumption that energy is linked to population growth (based on Census data back to 1990) after reviewing electricity and natural gas sales data 1990-2005, although not deemed reliable, but used here as more reliable than no energy data at all; see notes under column "H": Elec & Gas growth factor.

Note: CMS has NOT modeled increased efficiency in energy use in Frisco, which will clearly be a primary emissions reduction strategy.

CMS has applied a modest carbon intensity factor to reflect Xcel Energy's declining carbon coefficient since 1990 (although Xcel has yet to document the actual rate of decline). CMS anticipates further decrease in carbon intesity of its electricity supply from government, public, and business pressure as well as increasead competitiveness of lower carbon options, such as windpower and solar photo- or thermal-electric generation, or geothermal. Column "G" can be used to model emissions reduction scenarios.

Cell: O10
Comment: Rick Heede:
Transportation emissions are linked to worksheet "FriscoSum.xls" total emissions for all ground transportation in 2006. Prior years are backcast on the basis of CDOT's "Twenty Year Factor" for the AADT count at CO Route 9 and I-70, which is 1.64 and means an annual rate of growth of 3.06 percent per annum. CMS has not modeled the introduction and increased use of lower carbon fuels in this simple exercise. Column "M" can be used to model emissions reduction scenarios. Nor has CMS modeled transportation efficiency scenarios, such as increased reliance on transit and non-driving efforts, nor fuel substitution to cellulosic ethanol and other fuels that show promise to reduce emissions. Corn ethanol, if viewed from a life-cycle or cradle to grave perspective, shows a poor carbon-reduction potential (a zero to 30 percent improvement; some studies show increased greenhouse gas emissions from the corn cycle compared to gasoline). Biodiesel shows a good emissions reduction potential. (CMS has used the NREL study, which shows 78 percent emissions reduction compared to petroleum diesel.)

Cell: Q10
Comment: Rick Heede:
This miscellaneous category is the sum of boat fuel, HFC leakage from autmobile ACs, landfiill emissions, and fertilizer application, and this sum is linked to the worksheet "FriscoSum.xls."

Cell: S10
Comment: Rick Heede:
All emissions in 2006 are linked to the "FriscoSum.xls" worksheet and is automatically updated if revisions are made. The emissions data for buildings, transportation, and miscellaneous emissions sum to the correct total.

This total represents the "business-as-usual" scenario. It must be pointed out that population growth, although based on US Census data for 1990, 2000, and 2004, also drive building emissions 2004 to 2050 at what are probably unsustainable (and unrealistic) rates. E.g., there is not enough buildable land to result in a Frisco population of nearly 36,000 people in 2050.

It is thus best to consider the BAU scenario as the "things gone amuck" scenario. This scenario also does not incorporate likely national and global successes in reducing the emissions intensity of electricity and fuel delivery, much less advanced end-use technology that will (we hope, inevitably) improve the performance of buildings and vehicles.

Note: This assemblage of local growth factors has been modified by applying an improvement in the carbon intensity of electricity supply (see cell note under "Buildings"), assuming that Xcel Energy's generation will increasingly displace coal-fired generation with low or zero-carbon power. CMS has not modeled lower carbon intensity of transportation fuels. Lower carbon intensity can be modeled in future emissions inventories and in the Town of Frisco's emissions reduction strategies.

Cell: W10
Comment: Rick Heede:
This CMS "Blended BAU" scenario averages the emissions paths of Frisco under local growth rate factors in building energy and transportation fuels and the emissions path of IPCC's A1 scenario. While still very high, and no emissions peak within the 2050 time horizon, CMS considers this emissions path the "business-as-usual" (BAU) scenario. Even though many of the local growth rates in electricity, natural gas, propane, and transportation fuels are based on (a) population growth using Census data for 1990 and 2000 (4.03 percent per annum), and (b) CDOT "twenty year factor" (3.06 percent per annum), such growth rates cannot plausibly be sustained. One reason is exhaustion of land in Frisco upon which to build new homes and businesses, thus curbing the rate of population growth.

There are many other reasons why such a BAU scenario is not likely even under no action by Frisco's government, citizens, and business owners. The carbon intensity of electricity and fuel supply is likely to decline over time (note: CMS has modeled a 0.5 percent per year decrease in the carbon intensity of electricity, but no change in natural gas or transportation fuels). Energy-using technology is also likely to advance regardless of Friscos' local policies, public participation in mass transit, and homeowner and business investment in energy efficiency is highly likely to proceed even without a concerted effort by the Town of Frisco to improve end-use efficiency.

Thus this BAU scenario represents a world in which climate concerns fade away, and is presented more as an upper bound on human inaction than an estimate of where Frisco -- or the world at large -- is likely to go.

Cell: Y10
Comment: Rick Heede:
CMS has applied the global emissions growth scenarios of IPCC's B1 to Frisco's baseline emissions of 2006. B1 is a relative slow growth model in which emissions peak in 2040 at ~30 percent higher than in 2006 and decline thereafter to less than half of peak by 2100 AD. Global emissions have grown more slowly than Frisco's emissions have done (based on CMS' model of local growth rates in population and vehicle travel), and since all models are indexed to 2006, this B1 scenario shows higher Frisco emissions in 1990 to 2006 than the CMS scenario does.

Interested readers may consult: IPCC (2001) Special Report on Emissions Scenarios (SRES), rpt at Columbia University Center for International Earth Science Information Network (CIESIN), sres.ciesin.columbia.edu

Cell: AA10
Comment: Rick Heede:
CMS has applied the global emissions growth scenarios of IPCC's A1 to Frisco's baseline emissions of 2006. A1 is a relative high growth model in which emissions peak in 2050 at ~66 percent higher than in 2006 and decline gradually thereafter to about 80 percent of peak by 2100 AD. Global emissions have grown more slowly than Frisco's emissions have done (based on CMS' model of local growth rates in population and vehicle travel), and since all models are indexed to 2006, this A1 scenario shows higher Frisco emissions from 1990 to 2006 than the CMS scenario does.

Interested readers may consult: IPCC (2001) Special Report on Emissions Scenarios (SRES), rpt at Columbia University Center for International Earth Science Information Network (CIESIN), sres.ciesin.columbia.edu

Cell: AC10
Comment: Rick Heede:
This CMS scenario models Frisco's emissions path required to reduce emissions to a common federal or state emissions target for 2050, namely, that emissins be reduced to twenty percent of the baseline year by 2050 (to 0.2 of 2006 by 2050). Assumes emissions reductions start in 2007 (requiring implementation in 2006) rather than more plausibly in, say, 2008 or 2009.

As modeled, the required emissions reduction rate is 3.5917236 percent per year from 2006 through 2050.

Cell: AE10
Comment: Rick Heede:
This CMS scenario models Frisco's emissions reductions required to reduce emissions to the estimated 1990 value by 2012. Assumes emissions reductions start in 2007 -- clearly not likely -- rather than more plausibly in, say, 2009 or so.

As modeled, the required emissions reduction rate is 9.5556 percent per year from 2006 through 2012; shown in column BM off the printed worksheet.

Cell: AG10
Comment: Rick Heede:
This CMS scenario models Frisco's emissions reductions required to meet the Mayors Climate Agreement by 2012 (that is, a seven percent reduction from 1990 by 2012). It assumes, implausibly, that emissions reduction efforts (or other causes for reduced emissions) have been implemented in 2006. Otherwise, CMS would assume Frisco's emissions to peak not in 2006 but more plausibly in, say, 2009, which would mean a much higher reduction rate than that required for a peak in 2006. Furthermore, the Mayor's Agreement stipulates achieving the target by 2010, which, of course, would also mean a much steeper reduction rate.

As modeled, the required emissions reduction rate is 10.6429 percent per year from 2006 through 2012; shown in column "BO" off the printed worksheet.

Cell: H11
Comment: Rick Heede:
CMS, 5Mar08, reviewed the growth in sales of electricity and natural gas provided by Xcel Energy in Aug07, subsequently deemed unreliable by Xcel's Todd Anderson. Given the data gaps (elec 1990-93, 2005) and partial data (elec 1993, 1997, 2003, gas 2004-05), and the overall questionable accuracy, a thorough analysis is not possible. Even so, CMS has calculated growth in both gas and electricity and estimated combined sales relative to 2006. Since the growth in sales suggests that energy consumption is slower than growth in population (based on the Census data and interpolation in column "D"), CMS increases estimated emissions from buildings by dividing by the energy growth factors in column "H". The factors in 1990-1993 and 2003-2005 are in red ink and indicate assumed factors based on the trends in other years.

While this adjustment is somewhat arbitrary, it is done to make a reasonable estimate of emissions from 1990 to 2006. Note also that CMS has not made a full estimate of 1990 emissions. The Town of Frisco requested that a reasonable estimate be made, and the adjusted estimate is more reasonable.

Conclusion: this adjustment increases emissions from electricity and natural gas in 1990, with the result that the Kyoto target and Mayors' Agreement target for 2010 -- seven percent below 1990 by 2012 -- is lowered compared to the calculation made prior to this adjustment.

Cell: K33
Comment: Rick Heede:
CDOT 2006 AADT data for CO Route 09 from Swan Mtn Rd to I-70. "Twenty Year Factor" ranges from 1.59 to 1.64; SH 9 at I-70 is 1.64, and 1.62 at main Street, and 1.62 at Swan Mtn Rd.

Cell: K37
Comment: Rick Heede:
CDOT 2010 Forecast for Frisco's sections of CO Route 09. Also forecasts single and combination truck traffic. 2006 and 2010 data in file: CDOTAADTatFrisco.doc

Cell: F81
Comment: Rick Heede:
Based on the modified and hence variable growth of electricity and natural gas backcast to 1990-2005, the average rate is 3.45 percent per annum (from 39,264 tons in 1990 to 67,553 tons in 2006).

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Notes

Frisco emissions by GHG gas

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started 17 October 2007
Last Modified: 29 December 2007

Sources with other GHGs		Carbon dioxide tons CO2	Methane tons CO2-e	Nitrous tons CO2-e	Halocarbons tons CO2-e	Total tons CO2-e	Non-CO2 Percent
Commuting and commercial vehicles		34,866	61	745		35,672	2.26%
Tourist travel to & from Frisco		7,779	15	191		7,985	2.58%
Driving around town, 2006		14,384	26	324		14,734	2.37%
Frisco Govt, School District, Marina etc		1,463	1	17		1,480	1.19%
Nitrous oxide from fertilizers		-	-	10		10	100%
Refrigerant leakage: fridges etc					10	10	100%
Refrigerant leakage: automobile ACs					82	82	100%
Xcel Energy: Electricity		42,396	3,184			45,580	6.99%
Xcel Energy: Natural gas		19,423	2,316			21,739	10.65%
Propane		215	10			224	4.27%
Subtotal, all sources with other GHGs		120,525	5,613	1,286	92	127,516	5.48%
Inventory total						128,698	0.00%
CO2 sources not listed above		1,182				1,182	0.00%
Total of all sources		121,707	5,613	1,286	92	128,698	5.43%
Percent, by GHG gas		**94.57%**	**4.36%**	**1.00%**	**0.07%**	**100%**	**5.43%**

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Notes

Frisco & Summit County population data

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started 23 April 2007
Last Modified: 3 October 2007

		Frisco	Summit	Percent Frisco
Households				
	1970	460		
	1980	1,200		
	1990	1,601	12,881	12.4%
	2000	2,443	23,548	10.4%
	2004	2,697	27,443	9.8%
Population				
	1970			
	1980			
	1990	1,628	17,091	9.5%
	2000	2,727	24,201	11.3%
	2004	3,350	30,094	11.1%
Frisco data	2006			
	Residents	3,350		
	one-half of 2nd homeowne	2,105		
	Frisco population total	**5,455**	**30,094**	**18.1%**

US Census & Venturoni data

Frisco per capita emissions

Pop estimates	**tons CO2e**	tons CO2e/capita
2,697	128,698	47.72
5,455	128,698	23.59
6,693	128,698	19.23
6,906	128,698	18.64

Frisco taxable retail sales
2006, $
$ 123,979,192
lb Co2e per $
2.08

Cell: E12
Comment: Rick Heede:
2004 US Census data cited in Venturoni (2006) Town of Frisco 2006 Community Survey, section 3, p. 1 and 2.

Cell: B28
Comment: Rick Heede:
Frisco data (viewed Oct07): www.townoffrisco.com/visitors/frisco-fast-facts.html. Population: 2,697 year round; 4,209 second homeowners; Combined approx. 6,906 people. Elevation: 9,100 feet above sea level. Size: 3 square miles (= 1,920 acres = 83,635,200 sf).

However, for many calculations derived from population data -- such as recycling activity and driving and lawncare and snowplowing -- occupancy as well as tourism and second homeowners must be accounted for. Even though it is not possible to estimate "average occupancy" in town over the year, CMS adds one-half of the second homeowners as a population proxy for such calculations. This number does not account for residents in the wider community of Frisco (those ~383 properties in unincorporated Summit County near and/or contiguous to Frisco's town limits). CMS does use the US Census Bureau population estimates for Frisco -- 3,350 souls -- for 2006 Frisco resident population, plus 0.5 of 4,209 second homeowners equals a total "population" of Frisco estimated as 5,455 people, or 18.1 percent of Summit County's total in 2004.

These numbers will be re-evaulated in future emissions estimates.

Cell: C34
Comment: Rick Heede:
Section 3: charts
Page 1: Frisco population 1970: ~460, 1980: ~1,200, 1990: 1,601, 2000: 2,443, 2004: 2,697.
Summit County: 1990: 12,881, 2000: 23,548, and 2004: 27,443.
Page 2: Frisco Housing Units: 1990: 1,628; 2000: 2,727; and 2004: 3,350.
Summit Housing Units: 1990: 17,091; 2000: 24,201; and 2004: 30,094.
US Census year 2000 section (#10): All four sheets are copied.
Total population in 2000: 2,443; (1990: 1,601).
Average household size: 2.32 (2.37 in 1990); average family size: 2.66 (2.63 in 1990).
Total Housing units: 1990: 1,628 HH, of which 673 are occupied and 955 are "vacant";
2000: 2,727 HH; of which 1,053 are occupied and 1,674 are "vacant."
However, of 2,727 HH 1,485 (61.4 percent) are also listed as "seasonal, recreational, or occasional use."
Commuting to work: workers 16 yrs and over: total 1,687, of which 1,090 drove alone (64.4 percent), 225 carpooled 13.3%), 60 used transit (3.6%), 158 walked 9.4%), 20 other, 134 worked at home (10.4%).
Mean travel time to work: 15.7 minutes.
Median HH income: $62,267.
Median family income: $70,556.
Per capita income: $31,232. (also lists full-time male vs female income: $36,989 vs $29,766.
Of 2,727 total HH units, 481 (17.4%) are single detached, 679 (24.6%) are single attached, 148 (5.4%) are "2 units," 304 (11.0%) are "3 or 4 units,", 360 (13.1%) are "5 to 9 units," 291 (10.6%) are "10 to 19 units," 480 (17.4) are "20 or more units," and 14 (0.5%) are "mobile homes."
Media number of rooms: 4.7;
Of those listing house heating fuel: 695 (68.1%) use natural gas, 309 (30.3%) use electricity, 6 (0.6%) use fuel oil or kerosene, and 11. (1.1%) use wood.
Median value of owner-occupied homes: $298,800.
Venturoni "Analysis of County Assessor's Records": Frisco, 2006: 3,325 total HH units (as in our survey of Aspen Assessor's records, the number of parcels is higher than likely housing units). LV lists owners by state, total out-of-state (799), foreign (12), Colorado (2,492, of which 1,282 are within County), Front Range (1,148, or 34.5%), and other Colorado (62, or 1.9%). Sheets also copied.

Cell: C39
Comment: Rick Heede:
Frisco data (viewed Oct07): www.townoffrisco.com/visitors/frisco-fast-facts.html. "Population: 2,697 year round; 4,209 second homeowners; Combined ~6,906 people

Cell: C41
Comment: Rick Heede:
Another way to equitably distribute Frisco's emissions among the wider population contributing to emissions is to include residents, second homeowners, visitors, day workers, students, skiers, and so forth. Wastewater treatment flows is tracked daily and can be used to estimate total inhabitants: assuming (as the Aspen Consolidated Sanitation Dept does) that each person uses 90 gallons of water per day, then the average population in Frisco is 6,693 persons (ranging from a low of 5,165 in November to a high of 9,005 in July). Frisco's total emissions of 128,698 tons CO2e divided by 6,693 inhabitants = 19.2 tons CO2e/capita.