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Appendix for ECM 7:
ECM 7 Retrocommissioning, Police HQ

I. Energy Savings Calculations

ECM 7 Retrocommissioning Police HQ Savings Calculation

Savings Estimate

Date:	5-Sep-12
Project:	City of Greeley Colorado
Location:	Police HQ
Measure:	ECM 8 Demand Controlled Ventilation

	ECM 8 Demand Controlled Ventilation	ECM 7 Retrocommissioning Savings
Estimated Savings (Therms/Yr):	3,901	2,869
Estimated Savings (Peak kW):	-	
Estimated Savings (kWh/Yr):	7,365	9,142

Note: Retrocommissioning savings are net of DCV Savings.

Savings Estimate
Date: 5-Sep-12
Project: City of Greeley Colorado
Location: Poilice HQ RTU-1
Measure: ECM 8 Demand Controlled Ventilation

RTU-1 CFM	16000	Design Value
RTU-1 OA CFM	10500	Design Value
RTU-1 OA Fraction	0.66	Design Value
Existing Htg Efficiency	0.8	
Existing EER	8.5	
Existing kW/Ton	1.41	

		EXISTING								PROPOSED								SAVINGS
	Average BIN Temp	BIN Hours	OSA %	RAT	MAT	SAT	Nominal % Full Load	BTU Required	Therms (kWh)	BIN Hours	OSA %	RAT	MAT	SAT	Nominal % Full Load	BTU Required	Therms (kWh)	Therms (kWh)
Heating	-17.5	5	66%	69	12	90	0.70	4,703,265	59	2	33%	69	41	90	0.70	896,002	11	48
	-12.5	26	66%	69	16	90	0.65	21,751,821	272	15	33%	69	42	90	0.65	7,936,356	99	173
	-7.5	26	66%	69	19	90	0.60	19,194,084	240	13	33%	69	44	90	0.60	6,070,359	76	164
	-2.5	48	66%	69	22	90	0.55	30,929,079	387	27	33%	69	46	90	0.55	11,388,289	142	244
	2.5	70	66%	69	25	90	0.50	38,938,271	487	41	33%	69	47	90	0.50	14,960,598	187	300
	7.5	88	66%	69	29	90	0.45	41,707,567	521	50	33%	69	49	90	0.45	15,967,540	200	322
	12.5	104	66%	69	32	90	0.40	41,331,851	517	59	33%	69	50	90	0.40	15,827,822	198	319
	17.5	264	66%	69	35	90	0.35	86,242,741	1,078	149	33%	69	52	90	0.35	33,709,550	421	657
	22.5	422	66%	69	38	90	0.29	110,444,093	1,381	244	33%	69	54	90	0.29	44,981,955	562	818
	27.5	630	66%	69	42	90	0.24	127,598,984	1,595	330	33%	69	55	90	0.24	48,026,599	600	995
	32.5	636	66%	69	45	90	0.19	94,855,380	1,186	371	33%	69	57	90	0.19	40,634,250	508	678
	37.5	745	66%	69	48	90	0.14	75,641,854	946	455	33%	69	59	90	0.14	34,754,240	434	511
	42.5	801	66%	69	52	90	0.09	47,823,785	598	524	33%	69	60	90	0.09	24,190,210	302	295
	47.5	788	66%	69	55	90	0.04	18,644,797	233	528	33%	69	62	90	0.04	9,975,130	125	108
	52.5	699	66%	69	58	90	0.00	-	-	479	33%	69	64	90	0.00	-	-	-
Subtotal HTG								759,807,573	9,498							309,318,900	3,866	5,631
Cooling	57.5	737	100%	76	58	55	0.70	22,286,880	2,622	470	100%	76	58	55	0.70	14,221,872	1,673	949
	62.5	755	100%	76	63	55	0.75	73,386,000	8,634	484	100%	76	63	55	0.75	47,054,520	5,536	3,098
	67.5	538	100%	76	68	55	0.80	92,966,400	10,937	409	100%	76	68	55	0.80	70,709,760	8,319	2,618
	72.5	390	100%	76	73	55	0.85	100,245,600	11,794	331	100%	76	73	55	0.85	85,131,648	10,015	1,778
	77.5	316	66%	76	77	55	0.90	108,068,360	12,714	301	33%	76	76	55	0.90	100,487,646	11,822	892
	82.5	283	66%	76	80	55	0.95	117,490,461	13,822	281	33%	76	78	55	0.95	106,727,483	12,556	1,266
	87.5	244	66%	76	84	55	1.00	120,544,589	14,182	244	33%	76	80	55	1.00	104,543,654	12,299	1,882
	92.5	129	66%	76	87	55	1.00	71,086,637	8,363	129	33%	76	81	55	1.00	58,949,078	6,935	1,428
	97.5	11	66%	76	90	55	1.00	6,688,915	787	11	33%	76	83	55	1.00	5,340,298	628	159
Subtotal CLG		983							83,855								69,784	14,070

Reference Only	
9,027.17	1.05

Reference Only	
83,569	1.00

Note:
1. Estimate typical occupancy is 50% of design occupancy
2. Existing BIN Hours assumes 24/7 operation of RTU-1 and 2

Savings Estimate
Date: 5-Sep-12
Project: City of Greeley Colorado
Location: Police HQ RTU-2
Measure: ECM 8 Demand Controlled Ventilation

RTU-2 CFM	30000 Design Value
RTU-2 OA CFM	6000 Design Value
RTU-2 OA Fraction	0.20 Design Value
Existing Htg Efficiency	0.8
Existing EER	8.5
Existing kW/Ton	1.41

		EXISTING								PROPOSED								SAVINGS
	Average BIN Temp	BIN Hours	OSA %	RAT	MAT	SAT	Nominal % Full Load	BTU Required	Therms (kWh)	BIN Hours	OSA %	RAT	MAT	SAT	Nominal % Full Load	BTU Required	Therms (kWh)	Therms (kWh)
Heating	-17.5	5	20%	69	52	90	0.49	3,040,254	38		10%	69	60	90	0.49	2,353,617	29	9
	-12.5	26	20%	69	53	90	0.46	14,296,792	179		10%	69	61	90	0.46	11,172,962	140	39
	-7.5	26	20%	69	54	90	0.42	12,843,230	161		10%	69	61	90	0.42	10,136,599	127	34
	-2.5	48	20%	69	55	90	0.39	21,135,946	264		10%	69	62	90	0.39	16,854,869	211	54
	2.5	70	20%	69	56	90	0.35	27,227,340	340		10%	69	62	90	0.35	21,948,570	274	66
	7.5	88	20%	69	57	90	0.32	29,907,662	374		10%	69	63	90	0.32	24,384,175	305	69
	12.5	104	20%	69	58	90	0.28	30,474,662	381		10%	69	63	90	0.28	25,143,955	314	67
	17.5	264	20%	69	59	90	0.25	65,593,282	820		10%	69	64	90	0.25	54,800,777	685	135
	22.5	422	20%	69	60	90	0.21	87,000,026	1,088		10%	69	64	90	0.21	73,648,537	921	167
	27.5	630	20%	69	61	90	0.18	104,662,530	1,308		10%	69	65	90	0.18	89,838,315	1,123	185
	32.5	636	20%	69	62	90	0.14	81,642,557	1,021		10%	69	65	90	0.14	71,112,686	889	132
	37.5	745	20%	69	63	90	0.11	69,191,577	865		10%	69	66	90	0.11	61,207,934	765	100
	42.5	801	20%	69	64	90	0.07	47,778,368	597		10%	69	66	90	0.07	42,964,198	537	60
	47.5	788	20%	69	65	90	0.04	22,607,878	283		10%	69	67	90	0.04	20,686,655	259	24
	52.5	699	20%	69	66	90	0.00	-	-		10%	69	67	90	0.00	-	-	-
Subtotal HTG								617,402,104	7,718							526,253,849	6,578	1,139
Cooling	57.5	737	100%	76	58	55	0.42	25,311,528	2,978		100%	76	58	55	0.42	25,311,528	2,978	-
	62.5	755	100%	76	63	55	0.50	90,998,640	10,706		100%	76	63	55	0.50	90,998,640	10,706	-
	67.5	538	100%	76	68	55	0.57	123,761,520	14,560		100%	76	68	55	0.57	123,761,520	14,560	-
	72.5	390	100%	76	73	55	0.64	141,523,200	16,650		100%	76	73	55	0.64	141,523,200	16,650	-
	77.5	316	20%	76	76	55	0.71	155,271,479	18,267		10%	76	76	55	0.71	154,178,018	18,139	129
	82.5	283	20%	76	77	55	0.78	160,306,957	18,860		10%	76	77	55	0.78	155,634,333	18,310	550
	87.5	244	20%	76	78	55	0.86	157,675,611	18,550		10%	76	77	55	0.86	149,893,338	17,635	916
	92.5	129	20%	76	79	55	0.93	94,251,652	11,088		10%	76	78	55	0.93	87,851,848	10,336	753
	97.5	11	20%	76	80	55	1.00	9,016,920	1,061		10%	76	78	55	1.00	8,250,660	971	90
Subtotal CLG		983							112,720								110,283	2,437

Reference Only	
7,431.45	1.04

Reference Only	
109,271	1.03

Note:
1. Estimate typical occupancy is 50% of design occupancy
2. Existing BIN Hours assumes 24/7 operation of RTU-1 and 2

Franktown Colorado

Latitude : 39° 23' 32" N
Longitude : 104° 45' 03" W
Elevation : 6158 ft.
Report Generated on: Aug. 3, 2012

Start Date : Jan. 1, 2011
End Date : Dec. 31, 2011
# of Days : 365 of 365
obs : poss : 8755 of 8760

Sub Interval Windows

	Start	End
Date	Jan. 01	Dec. 31
Hour	0	23

Average Air Temperature

Total number of Observations
Greater than or equal to initial interval value and Less than ending interval value.
Hour of day (L.S.T.)

Range Deg F		1 am	2 am	3 am	4 am	5 am	6 am	7 am	8 am	9 am	10 am	11 am	12 pm	1 pm	2 pm	3 pm	4 pm	5 pm	6 pm	7 pm	8 pm	9 pm	10 pm	11 pm	12 am	All Hrs.
-20 to -15	-17.5		1	2	1	1																				5
-15 to -10	-12.5	2	1	2	2	2	3	3	2	1	1									1	1	1	1	2	1	26
-10 to -5	-7.5	3	2				1			1		1				1	1	1	1	2	2	3	2	2	3	26
-5 to 0	-2.5	2	4	2	3	3	1	3	4		1	1	1	1	1			1	4	2	2	2	3	3	4	48
0 to 5	2.5	5	5	6	6	4	5	4	3	2	1	1	2	1	1	1	1	4	2	2	3	2	4	2	3	70
5 to 10	7.5	6	6	4	5	7	7	6	1	4	1	1	1	2	2	2	3	1	3	3	3	2	3	7	8	88
10 to 15	12.5	4	1	9	8	10	7	8	7	3	4	2	1				1	4	2	8	6	8	5	4	2	104
15 to 20	17.5	15	20	19	20	17	20	19	10	5	3	3	2	4	4	7	9	5	9	6	10	12	14	16	15	264
20 to 25	22.5	26	21	21	29	30	31	25	21	13	10	7	10	8	8	7	3	9	16	16	20	22	23	22	24	422
25 to 30	27.5	43	43	54	44	45	41	28	23	19	9	9	7	4	4	4	9	19	26	35	29	30	32	35	38	630
30 to 35	32.5	34	38	31	29	40	41	40	31	19	16	7	8	9	8	10	19	30	20	20	34	37	34	39	42	636
35 to 40	37.5	35	37	32	38	34	34	25	30	30	29	25	18	19	20	21	24	20	36	42	45	39	42	38	32	745
40 to 45	42.5	36	33	38	36	34	27	35	29	34	34	32	31	31	25	31	29	33	34	39	31	38	36	33	42	801
45 to 50	47.5	30	40	40	47	43	35	25	27	31	30	35	37	33	37	31	31	33	31	24	30	33	31	30	24	788
50 to 55	52.5	35	33	31	22	24	26	19	26	28	29	27	28	35	35	40	37	26	28	28	24	21	27	32	38	699
55 to 60	57.5	39	36	38	40	39	31	32	24	29	29	31	31	19	30	26	25	27	22	24	31	32	37	34	31	737
60 to 65	62.5	36	34	29	32	29	36	18	24	22	30	27	27	35	31	30	30	24	34	35	33	42	39	40	38	755
65 to 70	67.5	14	10	7	2	2	17	32	25	24	21	30	28	30	32	33	30	29	23	26	38	24	20	22	19	538
70 to 75	72.5				1		2	31	31	27	24	24	26	25	25	24	22	25	20	31	19	16	12	4	1	390
75 to 80	77.5							11	25	26	28	20	20	21	21	24	34	30	34	18	4					316
80 to 85	82.5								19	28	23	30	26	28	30	29	25	27	15	3						283
85 to 90	87.5								2	18	34	28	28	32	30	30	23	14	5							244
90 to 95	92.5									1	7	23	29	25	20	13	9	2								129
95 to 100	97.5										1	1	4	3	1	1										11
Total # obs.		365	365	365	365	364	365	364	364	365	365	365	365	365	365	365	365	364	365	365	365	364	365	365	365	8755
Average Deg F		40.9	40.2	39.5	39.1	38.6	39.8	44.1	49.6	54.4	58.1	60.8	62	62.3	61.6	60.6	58.5	54.6	50.9	47.7	45.4	44	43.1	42.2	41.3	49.1

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-20 to -15	-17.5	0	0.3	0.6	0.3	0.3														0	0	0	0	0	0	1.5
-15 to -10	-12.5	0.6	0.3	0.6	0.6	0.6	3	3	2	1	1									0.3	0.3	0.3	0.3	0.6	0.3	14.8
-10 to -5	-7.5	0.9	0.6	0	0	0	1			1		1				1	1	1	1	0.6	0.6	0.9	0.6	0.6	0.9	12.7
-5 to 0	-2.5	0.6	1.2	0.6	0.9	0.9	1	3	4		1	1	1	1	1			1	4	0.6	0.6	0.6	0.9	0.9	1.2	27
0 to 5	2.5	1.5	1.5	1.8	1.8	1.2	5	4	3	2	1	1	2	1	1	1	1	4	2	0.6	0.9	0.6	1.2	0.6	0.9	40.6
5 to 10	7.5	1.8	1.8	1.2	1.5	2.1	7	6	1	4	1	1	1	2	2	2	3	1	3	0.9	0.9	0.6	0.9	2.1	2.4	50.2
10 to 15	12.5	1.2	0.3	2.7	2.4	3	7	8	7	3	4	2	1				1	4	2	2.4	1.8	2.4	1.5	1.2	0.6	58.5
15 to 20	17.5	4.5	6	5.7	6	5.1	20	19	10	5	3	3	2	4	4	7	9	5	9	1.8	3	3.6	4.2	4.8	4.5	149.2
20 to 25	22.5	7.8	6.3	6.3	8.7	9	31	25	21	13	10	7	10	8	8	7	3	9	16	4.8	6	6.6	6.9	6.6	7.2	244.2
25 to 30	27.5	12.9	12.9	16.2	13.2	13.5	41	28	23	19	9	9	7	4	4	4	9	19	26	10.5	8.7	9	9.6	10.5	11.4	330.4
30 to 35	32.5	10.2	11.4	9.3	8.7	12	41	40	31	19	16	7	8	9	8	10	19	30	20	6	10.2	11.1	10.2	11.7	12.6	371.4
35 to 40	37.5	10.5	11.1	9.6	11.4	10.2	34	25	30	30	29	25	18	19	20	21	24	20	36	12.6	13.5	11.7	12.6	11.4	9.6	455.2
40 to 45	42.5	10.8	9.9	11.4	10.8	10.2	27	35	29	34	34	32	31	31	25	31	29	33	34	11.7	9.3	11.4	10.8	9.9	12.6	523.8
45 to 50	47.5	9	12	12	14.1	12.9	35	25	27	31	30	35	37	33	37	31	31	33	31	7.2	9	9.9	9.3	9	7.2	527.6
50 to 55	52.5	10.5	9.9	9.3	6.6	7.2	26	19	26	28	29	27	28	35	35	40	37	26	28	8.4	7.2	6.3	8.1	9.6	11.4	478.5
55 to 60	57.5	11.7	10.8	11.4	12	11.7	31	32	24	29	29	31	31	19	30	26	25	27	22	7.2	9.3	9.6	11.1	10.2	9.3	470.3
60 to 65	62.5	10.8	10.2	8.7	9.6	8.7	36	18	24	22	30	27	27	35	31	30	30	24	34	10.5	9.9	12.6	11.7	12	11.4	484.1
65 to 70	67.5	4.2	3	2.1	0.6	0.6	17	32	25	24	21	30	28	30	32	33	30	29	23	7.8	11.4	7.2	6	6.6	5.7	409.2
70 to 75	72.5	0	0	0	0.3	0	2	31	31	27	24	24	26	25	25	24	22	25	20	9.3	5.7	4.8	3.6	1.2	0.3	331.2
75 to 80	77.5	0	0	0	0	0		11	25	26	28	20	20	21	21	24	34	30	34	5.4	1.2	0	0	0	0	300.6
80 to 85	82.5	0	0	0	0	0			19	28	23	30	26	28	30	29	25	27	15	0.9	0	0	0	0	0	280.9
85 to 90	87.5	0	0	0	0	0			2	18	34	28	28	32	30	30	23	14	5	0	0	0	0	0	0	244
90 to 95	92.5	0	0	0	0	0				1	7	23	29	25	20	13	9	2		0	0	0	0	0	0	129
95 to 100	97.5	0	0	0	0	0					1	1	4	3	1	1				0	0	0	0	0	0	11
Total # obs.		365	365	365	365	364	365	364	364	365	365	365	365	365	365	365	365	364	365	365	365	364	365	365	365	5945.9
Average Deg F		40.9	40.2	39.5	39.1	38.6	39.8	44.1	49.6	54.4	58.1	60.8	62	62.3	61.6	60.6	58.5	54.6	50.9	47.7	45.4	44	43.1	42.2	41.3	49.1

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Data are subject to further review and editing. Please refer any questions to the Western Regional Climate Center.

Building: Police HQ

CBECS Data

Electricity

Electric Intensity:	15.8 kWh/sqft		
	End-use %	End-use Intensity (kWh/sqft)	% Difference from CBECS data
Lighting	31%	5.0	-8.0%
Cooling	19%	3.0	3.7%
Ventilation	17%	2.7	9.3%
Office Equip.	12%	1.9	0.0%
Other	9%	1.4	0.0%
Heating	6%	1.0	-3.1%
Water Heating	2%	0.3	-1.9%
Cooking	2%	0.3	0.0%
Refrigeration	1%	0.2	0.0%
	100.0%	15.8	

Natural Gas

Natural Gas Intensity:	38.7 kBtu/sqft		
Heating	72%	27.7	2.0%
Water Heating	20%	7.6	2.0%
Cooling	5%	1.9	-5.0%
Other	3%	1.2	0.0%
Cooking	1%	0.2	1.0%
	100%	38.7	

Estimated Building End Use

Electricity

Basline Consumption:	955,680 kWh/yr	
	End-use %	End-use (kWh)
Lighting	23%	223,629
Cooling	23%	219,806
Ventilation	27%	254,211
Office Equip.	12%	117,549
Other	9%	82,188
Heating (pumping)	3%	29,626
Water Heating	0%	0
Cooking	2%	15,291
Refrigeration	1%	13,380
Total	100.0%	955,680

Natural Gas

Basline Consumption:	25,336 Therms	
Heating	74%	18,647
Water Heating	22%	5,498
Cooling	0%	-
Other	3%	811
Cooking	2%	380
Total	100.0%	25,336

Unit	Clg Tons	Htg MBH
RTU-1	50	1000
RTU-2	65	812
RTU-3	16	240
TOTAL	130	2045

	Clg Allocation		Htg Allocation	
Unit	% Load	kWh	% Load	Therms
RTU-1	0.38	83,569	0.48	9,027.17
RTU-2	0.5	109,271	0.4	7,431.45
RTU-3	0.12	26,967	0.12	2,188.40
TOTAL	1	219,806	1	18,647.02

Note: Assume mini split systems energy is negligible