B O N N E V I L L E   P O W E R   A D M I N I S T R A T I O N

Room-based Occupancy Sensors M&V
Grouse Mountain Lodge
Whitefish, MT

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Executive Summary

The purpose of this analysis is to perform measurement and verification (M&V) on a standard hotel energy conservation measures (ECM); room-based occupancy sensor (OCS). Data was collected over a three-month period at the Grouse Mountain Lodge in Whitefish, Montana, to determine electrical savings by installing room-based OCS on the existing packaged terminal air conditioners (PTAC) with electric resistance heating. The savings result from temperature setback during unoccupied periods using the occupancy sensors. However, the savings for this measure deviated from the anticipated result; the savings were lower than have been found in equivalent studies.

Typically in most common HVAC systems, the primary variable affecting operation and energy use is the ambient conditions. However, at this hotel, the primary variable that affected the PTAC operation was the staff operating management protocol. More specifically it is attributed to the manual override of the sensors. The staff had manually turned off the units after cleaning the rooms, which was typical protocol. As a result, this study demonstrates that the staff operating protocol has a larger impact than the room-based OCS for Grouse Mountain Lodge. Based on the collected data, the savings are only found during the summer months when the PTAC units are left on during unoccupied periods due to the high occupancy rate.

Table 1.0 shows the verified negative yearly savings based on metered data through implementing the ECM. The savings percentage from the baseline is estimated from the cooling and heating baseline load only, not the entire building energy consumption. The negative yearly savings is mainly attributed to the staff operating protocols and that the rooms with OCS were left on during unoccupied more consistently than the rooms without the sensors.

Table 1.0 Summary of Findings Grouse Mountain Lodge

Savings Analysis	Savings per Room per Year (kWh)	Total Savings for Hotel (kWh)	Savings Percentage from PTAC/PTHP Baseline (%)	Savings Percentage from Entire Hotel Baseline (%)
Savings from Sensor	(840)	-121,862	-48%	-6%

1.0 Background

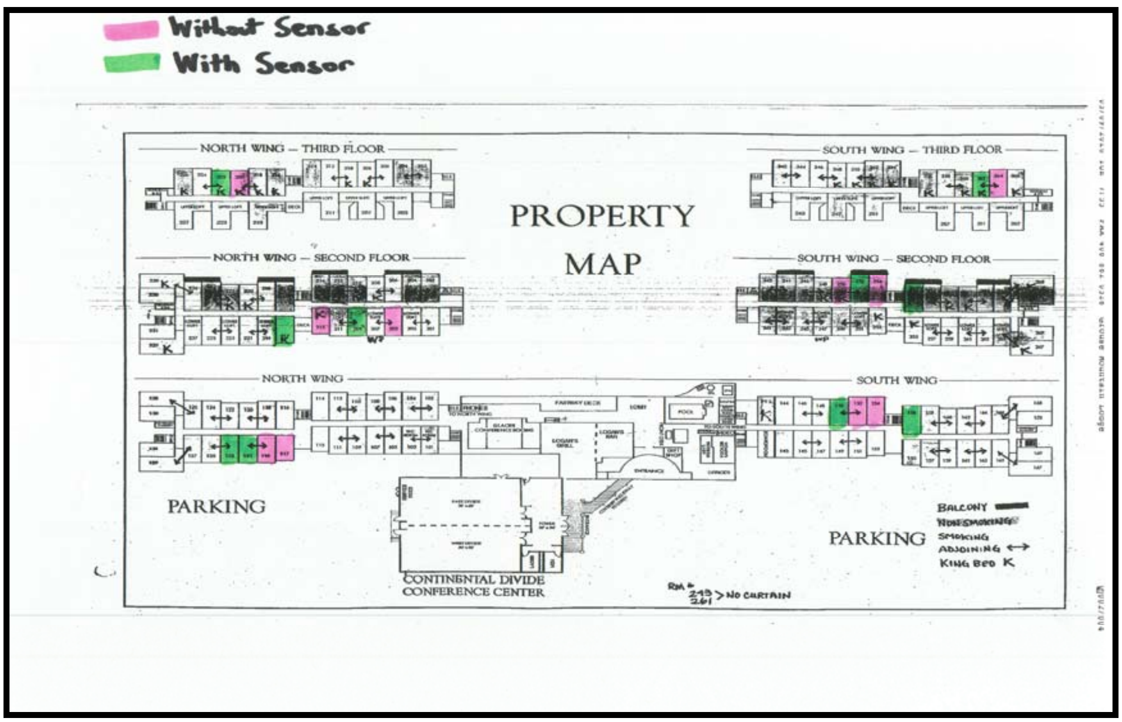
BPA EE is interested in developing a simplified incentive approach for Hotel room-based OCS. This is one of several hotels that is being used as a pilot project to verify energy savings through long-term measurements. Long-term measurements are needed to verify typical occupant behavior and staff operating procedures. The Grouse Mountain Lodge is a 120,000 square feet (approximated), three-story facility and has 145 guest rooms. Gem-Link, the room-based occupancy sensor manufacturer, in conjunction with BPA and EMP2, was able to meter 20 individual rooms. As illustrated in Table 1.1, to perform the study, the 20 rooms were divided in half: an experimental group with the OCS installed (Group #1) and a control group where no factors were changed (Group #2). Comparable rooms between the two groups were used to reduce variance in the data; the similarities comprising of room orientation, size, envelope losses, and infiltration effects between the two groups. Diagram 1.1 shows the rooms selected to be metered between the two groups and that Group #1 has similar room types as Group #2.

Below is a table of the intended and actual Group installations:

Table 1.1 Installed Group Descriptions

Group #	Equipment	Number of Rooms per Group
Group #1	PTAC Units with Room-Based Occupancy Sensor	10
Group #2	PTAC Units without Room-Based Occupancy Sensors	10

Diagram 1.1 Hotel and Group Layout



EMP2 has collected information on similar studies done on room-based OCS. It was found that the energy savings vary significantly from location to location and study to study. Based on EMP2's analysis of the Grouse Mountain Lodge, it was found that the staff operating protocol has a significant impact on the PTAC operations, subsequent energy usage and resulting energy savings. Table 1.2 displays energy savings ranging from 138 kWh/room/yr to 2,641kWh/room/yr. EMP2 believes that the primary variable effecting the energy savings is based on current hotel operating procedures; which is whether or not the cleaning staff manually overrides the function of the OCS by either shutting the PTAC unit off or leaving it on. When EMP2 compared the data from this study to comparable studies, the verified savings are far lower than any presented in Table 1.2. The cleaning staff's current operating procedures will potentially outweigh any energy savings that may be developed by the room-based OCS.

Table 1.2 Similar Studies Estimated Room-based Occupancy Savings*

Study/Utility	Occupancy Based Controller Savings (kWh/room/yr)	Baseline (kWh/room/yr)	% Savings
FEMP M&V Study	767	3,212	24%
PG&E	1,767	2,850	62%
BCHydro	252	663	38%
SDG&E (Hampton Inn)	345	1,240	28%
SDG&E (Navy Lodge)	384	3,020	13%
SDG&E (Doubletree)	1,437	2,485	58%
SDG&E (US Grant)	2,641	3,902	68%
BPA (Best Western)	138	1,150	12%
Average	**966**	**2,315**	**42%**

*See Section 7.0 for Bibliography

1.1 Technology Overview

This analysis investigates the energy savings associated with installing room-based OCS. Each room has a PTAC unit with electric resistance heat. Table 1.3 gives the specifications of a typical PTAC unit within the 145 rooms at Grouse Mountain Lodge.

Table 1.3 PTAC Equipment Specifications

PTAC Equipment Specifications		
Mode of Operation	**Description**	**PTAC**
	Manufacturer	Islandaire
	Model Number	EZ15EB
Cooling	Voltage	208
	Capacity (Btu/hr)	15,500
	Amps	8
	Watts	1,835
	EER	N/A
Heating (Electrical Resistance)	Voltage	208
	Capacity (Btu/hr)	10,700
	Amps	17
	Watts	3,598
	Electric Heat Size (kW)	3.6

The GemLink Wireless system developed by Lodging Technologies allows for automatic temperature setback based on room occupancy. GemLink Wireless is a guest room energy management system that reduces hotel/motel guestroom HVAC energy consumption by using the ZigBee wireless protocol. GemLink consists of wireless passive infrared (PIR) occupancy sensor, wireless entry door switches, and a transceiver control module connectable to any HVAC unit. GemLink utilizes a wireless hand-held Programmer Maintenance Module for each programming of System features. Diagram 1.2 displays the typical components of the GemLink System and how they are typically connected with the wireless controls.

Diagram 1.2 GEMLink Wireless Components and Connection

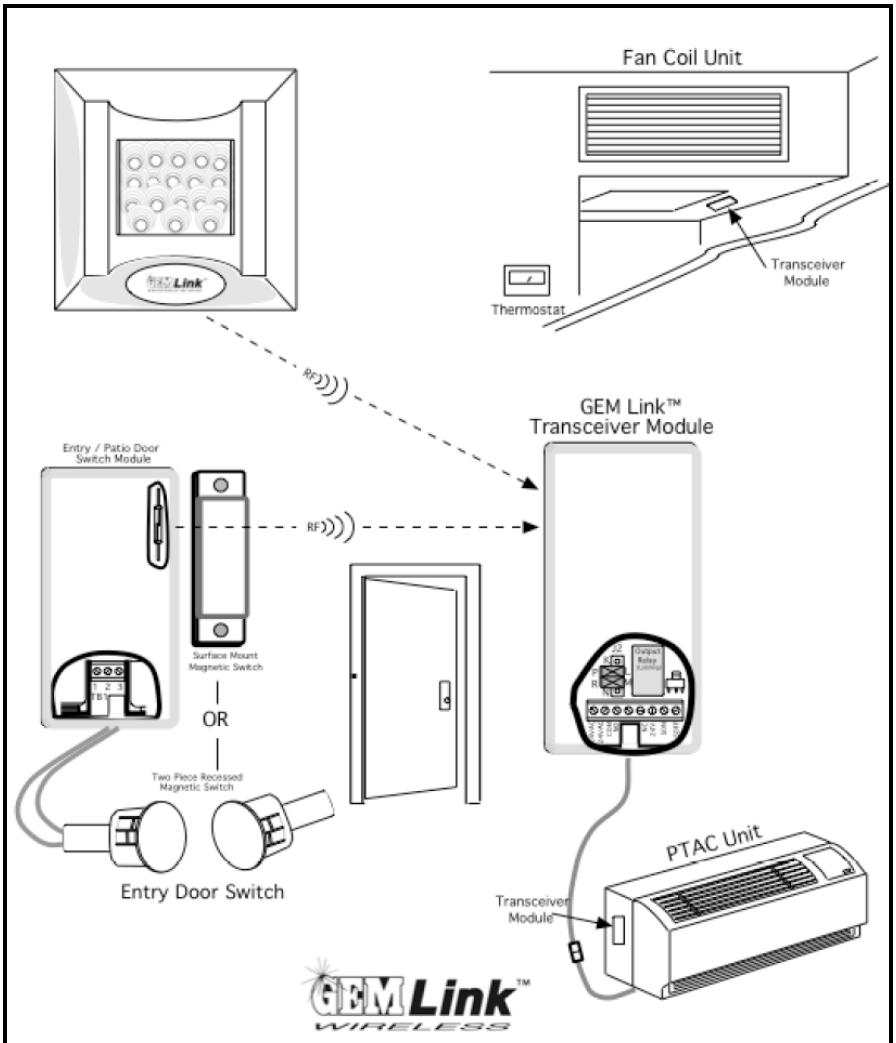


Figure 1 - Typical Connection of Components

When the room is unoccupied and no movement is sensed for a designated period of time, the room temperature is set back based on a pre-programmed schedule, as shown in Table 1.4. The temperature is allowed to setback immediately to the temperatures in Table 1.4 when the PTAC unit is operational and the room is occupied. This setback temperature can be varied for improved occupant comfort for additional energy savings. The temperature setback temperatures given in Table 1.4 are the standard setback temperatures recommended by Lodging Technologies. During occupied periods the occupant has the ability to adjust set point temperatures.

Table 1.4 Energy Management Control Set points

Setback Mode	Temperature
Heating Temperature Lower Limit	65°F
Cooling Temperature Higher Limit	78°F

1.2 Technology Cost

Data was collected from Lodging Technologies to verify the cost of installing a standard room-based occupancy sensor. Typically, the equipment is sold and shipped to the hotel and the maintenance staff is usually responsible for installing the equipment with some oversight from the supplier. However, a cost estimate of installing the GemLink system in each room is also included. It appears that once the system settings and configuration is set, it is typically not modified unless the occupant's comfort level drops. The cost of a standard Gem Link Wireless Energy Management Room Control System is estimated at $249/room. The installation cost is estimated at $60/unit, for a total cost of $309/unit including installation. The total cost for the entire hotel is estimated at $44,805 for all rooms to be installed with the GemLink Wireless System.

2.0 Savings Methodology (Field Evaluation)

The savings methodology is based on collecting data from 20 individual rooms using runtime Dent Loggers and amperage measurements with HOBO Loggers. The amperage loggers were set to one-minute increments and the Dent loggers collect unit runtime. A runtime and amperage logger was installed on all 20 rooms, ten without room-based OCS and ten with room-based OCS. The configuration of the installed units is given in Section 1.0. Based on this data, EMP2 was able to determine the current operating mode of the unit and runtime. The loggers did not include power measurements. Therefore, EMP2 used a separate power meter to verify each unit's power draw during various modes of operation. Three months of data were collected that was used to estimate savings for the room-based OCS. EMP2 also collected room rental information from the property owner in order to determine energy consumption for each group in both rented mode and unrented mode. Spot power measurements on the following modes of operation were collected for a standard PTAC unit at Grouse Mountain Lodge.

The operating modes consisted of the following:

- Low Fan
- Low Medium Fan
- Medium High Fan
- High Fan
- Cooling with High Fan
- Electric Heat High Fan

In order to determine the actual power consumption in each operating mode, the consumption for the individual operating modes were determined. It is understood that PTAC power consumption varies based on indoor and outdoor air temperature. Due to a relatively constant indoor air temperature during equipment runtime, it was determined that the parameter with the largest impact on unit power draw is outside air temperature. As a result, amperage measurements on PTAC units were performed over a three-month period to verify how power consumption varied with outside air temperature for each operating mode.

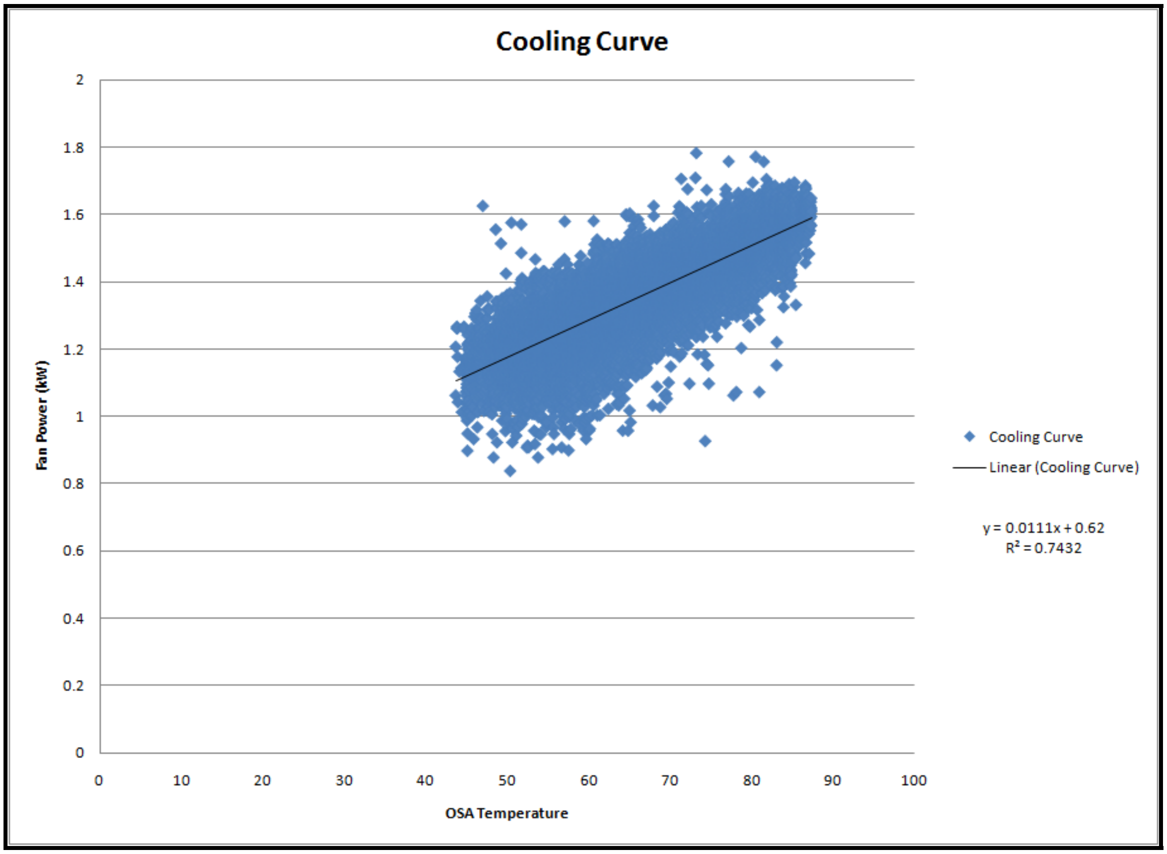
Fan Mode

The condensing fans run at a one speed and the power draw does not vary based on outside air temperature. Several spot measurements were taken to verify power draw in low, medium, and high fan speeds for the supply fan. It was found that there was only a slight increase in power consumption from low to high fan speed. It was found that the power factor dropped on the high fan speed setting, which reduced power consumption. With only a slight increase in power consumption from low to high fan speeds and a relatively low wattage draw when compared to the electric or compressor wattage, it was decided that the energy consumption between the high and low fan speed would be insignificant. Therefore the analysis used the same power draw for both fan speeds. The fan power for either fan speed was calculated to be 0.07 kW or 70 watts, with a 212 voltage reading, 0.3 amperage draw and an average power factor of 0.97.

Cooling Mode

For the PTAC units the actual power information was collected for a one-month period and amperage information was collected for over a three-month period. EMP2 used the short-term power measurements to verify the power factor and voltage. Based on the collected data EMP2 developed a power curve based on outdoor temperature. EMP2 had long-term amperage measurements but needed some verification of power factor and voltage to develop the power curve. The collected power measurements verified that EMP2's developed power curve using a correction factor of 204.67, which yielded the best correlation to power draw. The correction factor is a combination of voltage and power factor. The power curve was plotted against OSA temperature for the PTAC units. The data shown in Plot 2.1 is from the twenty PTAC units logged over a three-month period. A linear regression line was used to fit the data. It was found that the PTAC units are in cooling mode during low (below °45F) ambient temperatures. It was found that the PTAC would both operate in cooling mode during low ambient temperatures, but typically for only short-term intervals. Overall, the cooling energy consumption in the heating months was minimal.

Plot 2.1 Cooling Power Curves



Heating Mode (Electric Heat)

The electric heating elements within the PTAC are single stage; therefore the power draw does not vary with OSA temperatures. Spot measurements were used to verify power draw for the PTAC units. The measured power was 3.35 kW and this power draw was used for all PTAC units as all the units have the same heating capacity. This also pulls out the potential savings from reduced power draw between units and savings only account for reduced runtime.

Equipment Runtime

EMP2 installed a Dent logger on each unit to verify runtime, in hopes of verifying runtime for each unit in various modes of operation. However, EMP2 compared the estimated one-minute increment runtime to the collected Dent Loggers to determine if a large discrepancy between the Hobo amperage loggers and Dent runtime loggers existed. Based on past studies, it was found that a cooling compressor could cycle for on and off in 30 second increments. EMP2 and BPA wanted to verify runtime with Dent loggers as the Hobo U30 loggers have limited space capacity and can only collect for approximately 30 days using one-minute increment amperage measurements. EMP2 compared the runtime of each unit between the Hobo and Dent logger for the month of June to determine if a one-minute increment would be sufficient for runtime. The difficulty in making this comparison is the base “noise” or zero load amperage draw when the unit is not running and when the fan is running. In some cases, the difference between the no load “noise” amperage measurements and when the fan was operating was so small it was difficult to verify. Therefore, EMP2 developed a methodology that determined when the fan was operating. The base point or lowest amperage measurements plus .025 would be used to verify fan operation. It was found that this methodology provided a realistic operation of the fan mode. Table 2.1 shows the base point used and the point used to determine if the fan mode was operational.

Table 2.1 Base Amperage Point and Used Power Point for Fan Mode Operation

RM	Base Point	Used	Difference
117	0.055	0.08	0.025
119	0.403	0.428	0.025
121	0.134	0.159	0.025
152	0.134	0.159	0.025
154	0.134	0.159	0.025
209	0.067	0.092	0.025
215	0.134	0.159	0.025
217	0.134	0.158	0.024
250	0.043	0.068	0.025
252	0.079	0.104	0.025
254	0.055	0.08	0.025
256	0.134	0.159	0.025
320	0.055	0.08	0.025
322	0.055	0.08	0.025
362	0.055	0.08	0.025
364	0.067	0.092	0.025

In summary, excluding rooms 152, 154, 217, and 250 as it was found that the Dent logger demonstrated continuous cycling and the Hobo demonstrated continuous operation, the remaining rooms demonstrated less than a 1% difference between the Hobo logger and Dent logger. Therefore, it was determined that the Hobo logger would be sufficient to verify not only mode of operation but runtime for all modes of operation using one-minute increments. Table 2.2 shows the measured runtime between the Dent logger and Hobo logger for the month of July. It was found that for the rooms listed in Table 2.2 that the total operating hours were with 1% of the Dent Logger. Based on this data, EMP2 used the one-minute increment data as sufficient runtime period for the various modes of operation.

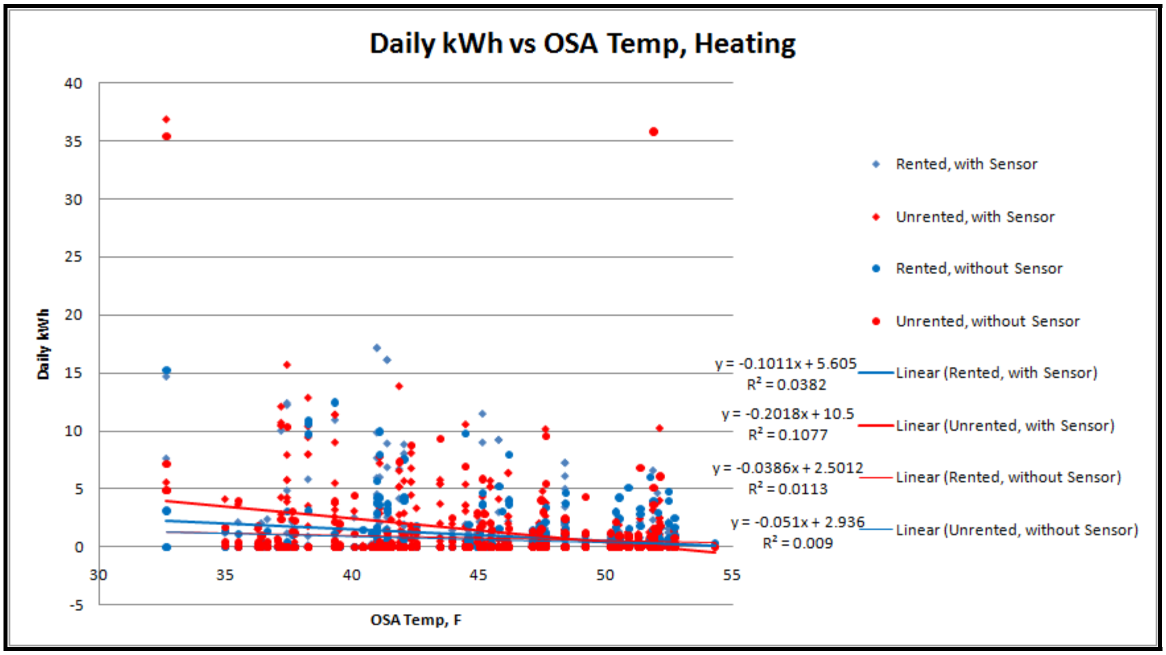
Table 2.2 Hobo vs. Dent Runtime

Logger	Rm 117	Rm 119	Rm 121	Rm 123	Rm 209	Rm 215	Rm 252	Rm 254	Rm 256	Rm 320	Rm 322	Rm 362	Rm 364	Total
Dent Runtime (hrs)	131.9	160.4	143.0	166.8	49.4	212.1	101.3	140.0	160.2	31.2	137.6	41.1	61.0	1535.9
Hobo Runtime (hrs, using 1-minute increments)	132.2	159.7	142.3	167.0	49.7	208.2	101.2	140.0	159.4	29.9	138.9	41.1	61.0	1530.3
Difference	-0.3	0.7	0.7	-0.2	-0.3	4.0	0.1	0.1	0.8	1.3	-1.3	0.0	0.0	0.4%

Once the cooling power curve and power consumption for each mode was determined, EMP2 was able to determine the actual unit's power draw at various outdoor air temperatures and modes of operation. The Hobo loggers were used to determine the mode of operation and mode runtime. EMP2 also collected two OSA measurements using one-minute increments and used the average of these measurements to verify OSA temperature. Based on the OSA temperature the Cooling Power curve was used to determine cooling energy consumption based on the OSA weather temperature. This was similarly done for heating energy consumption. EMP2 also collected room rent rates from the Hotel staff. EMP2 collected and matched the hotel rent rates to the one-minute increments recorded data. If the room was rented, then EMP2 estimated that the room was rented for the entire day, as it is difficult to estimate when occupants arrive and depart. It was assumed that the room would be rented for a 24-hour period, or from 12:00pm to 12:00pm the next day. By knowing the equipment operating mode, equipment mode runtime, OSA weather data, room rental status, and developed power curves based on OSA temperature, EMP2 was able to determine the power consumption for every minute and categorize the energy consumption as rented or unrented for 20 rooms over a three-month period.

In order to normalize the data for an entire year EMP2 developed another curve that summarized each Group's energy consumption based on OSA temperature. Due to the large amount of data and limitations with the current software, the one-minute data was not plotted against OSA temperature, however EMP2 summarized the data into daily averages to determine if a regression analysis was reasonable. EMP2 developed four curve fits for each Group in the attempt of normalizing daily energy consumption vs. OSA weather. EMP2 developed two plots each with four curves. The two plots consist of one for heating or temperatures below 55°F and the other is for the cooling season or temperatures above 55°F. Each chart consists of rented and unrented energy for the rooms with the OCS and also for the rooms without the OCS. Plot 2.2 shows the heating daily kWh vs. OSA for all 20 rooms and categorizes them as rented and unrented, with a sensor or without a sensor.

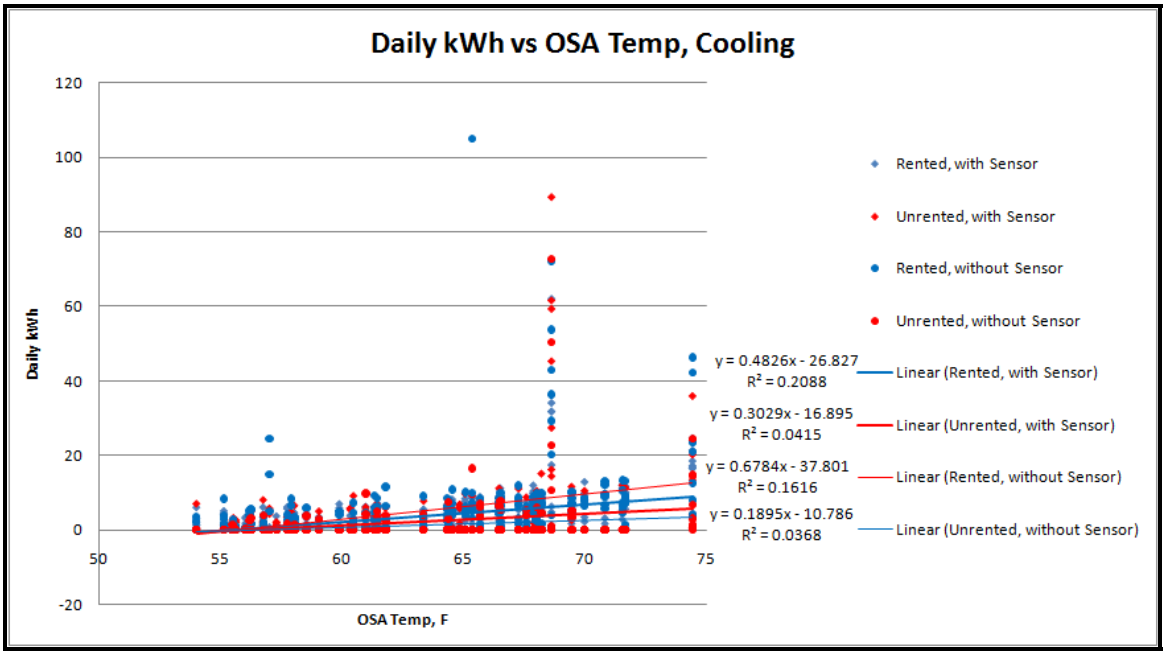
Plot 2.2 PTAC Rented/Un-Rented Normalized Curves for Heating



In Plot 2.2, it can be seen that even during rented days, the energy consumption can be zero. This is believed to be due to the cleaning staff's operating procedure of turning the units off after cleaning, however as the data demonstrates, the staff is inconsistent in turning the units off after each cleaning. It can also be seen that during unrented periods the number of days the energy consumption is at zero is more frequent except for the rooms with the occupancy sensors. It was actually found that during the heating season that the rooms with the occupancy sensors consumed more energy during unrented periods. This is believed to be due to the staff leaving these units on more than the rooms without the sensors. This may describe why the energy savings for the OCS were found to be negative and that any potential savings with the occupancy sensors is overshadowed by the fact that cleaning staff accidently leaves some units on during unrented periods. The zero energy usage during rented and unrented periods reduces energy consumption, and consequent energy savings, significantly.

Plot 2.3 shows the average daily kWh consumption per room for temperatures above 55°F or during the cooling season.

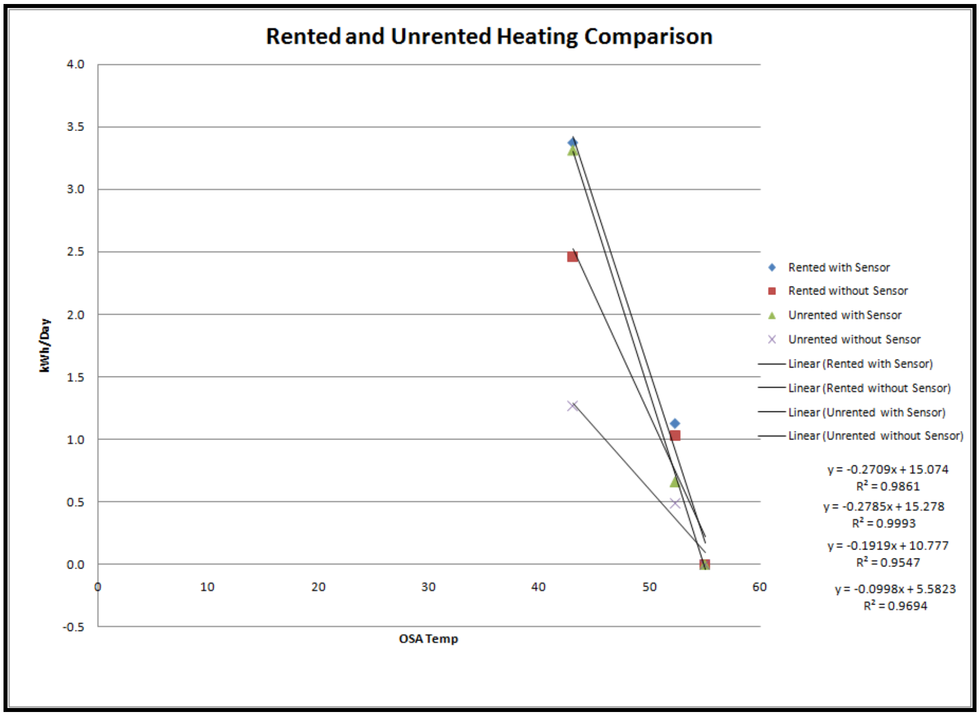
Plot 2.3 Rented/Un-Rented Normalized Curves for Cooling



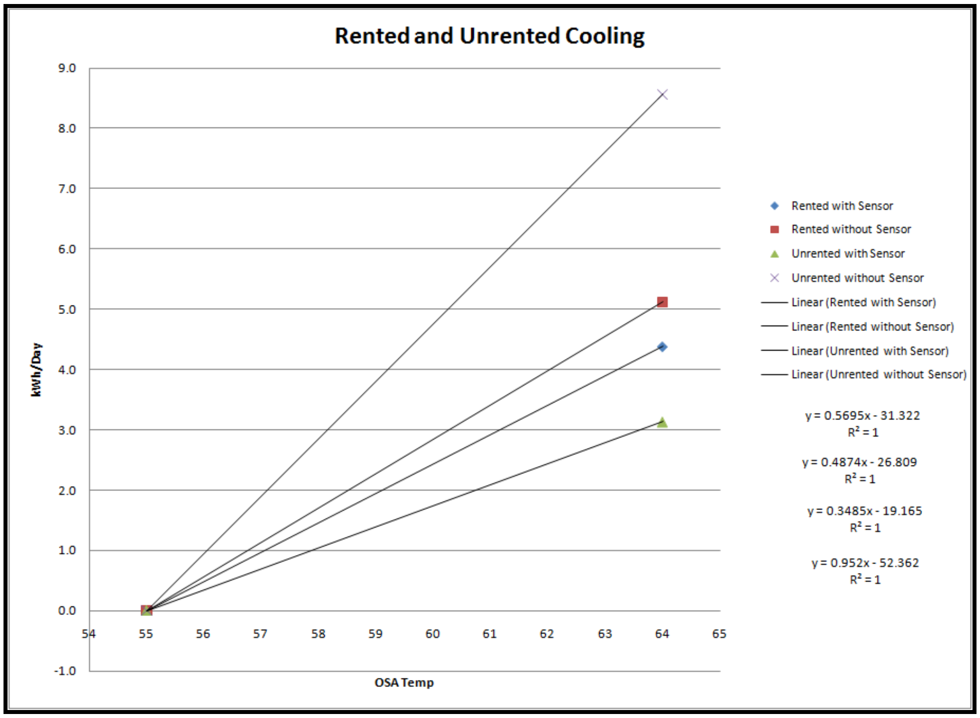
It can be seen from Plot 2.2 and Plot 2.3 that the R^2 values are demonstrating a poor correlation between average daily temperatures and daily energy consumption. The poor R^2 values are somewhat expected due to the staff operating procedures and occupant behavior. It can be seen in the data that energy consumption at a given OSA temperature varies significantly from zero to the maximum energy consumption at that OSA temperature. There are multiple factors that effect energy consumption regardless of temperature, but a big driver is understood to be staff operating procedures. Based on discussions with the staff and the facility maintenance manager, the cleaning staff manually turns each unit off after cleaning the room except for periods of high occupancy and during warmer periods. This was adopted as a facility policy in order to conserve energy. This policy is theorized to develop a large scatter in the data due to some rooms whether rented or unrented to consume zero energy. If the staff was to leave each unit on, then an improved R^2 value would be expected since the units would consume consistent energy consumption as OSA temperature varies.

Since the daily energy consumption data was inconsistent, EMP2 then formatted the data to monthly energy consumption and monthly average temperature. Based on the poor R^2 values by looking at daily kWh consumption vs. daily OSA temperature any further break down of time increments was assumed to only further reduce the R^2 values due to additional scatter. This is why EMP2 reduced the time increments to monthly data rather than a breakdown of additional time increments such as hourly or 1 minute data. The monthly energy consumption was plotted for two Groups for the months of April, May, and July. It was also speculated that the balance point of the facility was approximately 55°F, therefore this point was added to the plots below. By plotting the average monthly OSA temperature and monthly average energy consumption for the 2 months during the heating season and 1 month during the cooling season it can be seen that a very good correlation exists, typically with an R^2 value above 0.9, which demonstrates a reasonable correlation, which can be seen in Plots 2.4 and 2.5.

Plot 2.4 Regression Analysis During the Heating Season



Plot 2.5 Regression Analysis During the Cooling Season



All R^2 values are above 0.9, showing a strong correlation between average monthly room energy consumption and OSA temperature. The R^2 value for the cooling regression analysis is 1, due to only two points being plotted. Only one month's worth of cooling data was collected, but due to the strong R^2 values during the heating season and past project experience, EMP2 believes the regression analysis will provide reasonable results for the cooling season. The months of June, July, and August include the cooling season and each month has a high occupancy rate that is above 65%. Due to the regular high occupancy rates during these months and a relatively average consistent monthly temperature, the extrapolated data for the remaining two cooling months should provide reasonable results.

By using the trend lines given in Plot 2.4and Plot 2.5, the data could be normalized to typical occupancy rate and typical weather data for Whitefish, MT. Table 2.3 shows the average 30-year monthly weather data for Kalispell, MT using TMY3 average monthly data. Kalispell is within 30 miles of Whitefish and provides a reasonable weather profile when compared to Whitefish, MT.

Table 2.3 Average Monthly Temperatures

Month	Average Monthly Temp
Jan	25.1
Feb	27.7
March	31.0
April	45.0
May	52.0
June	59.6
July	65.5
Aug	67.3
Sept	54.7
Oct	41.3
Nov	31.5
Dec	24.4
Total/Average	43.7

EMP2 also collected the average monthly occupancy rates from the Grouse Mountain Lodge. As previously discussed the data was separated into two Groups, rooms with sensors and rooms without sensors. Each of the two groups also includes energy data for rented periods and unrented periods. Therefore, the average monthly occupancy rates will be used to determine the average monthly energy consumption based on weather and occupancy. Table 2.4 shows the average monthly occupancy rates for the Lodge.

Table 2.4 Average Monthly Occupancy Rates

Average Monthly Occupancy or Rent Rates (%) for Grouse Mountain Lodge							
	2004	2005	2006	2007	2008	2009	Ave
JAN	36%	38%	32%	23%	36%	21%	31%
FEB	59%	49%	49%	40%	51%	33%	47%
MAR	49%	50%	56%	43%	38%	28%	44%
APR	37%	44%	38%	29%	26%	32%	34%
MAY	48%	55%	56%	52%	43%	31%	48%
JUN	63%	79%	76%	72%	65%	45%	67%
JUL	93%	92%	90%	93%	92%	73%	89%
AUG	83%	88%	86%	87%	85%	62%	82%
SEP	71%	75%	78%	78%	71%		75%
OCT	63%	66%	63%	46%	43%		56%
NOV	24%	31%	23%	19%	12%		22%
DEC	32%	29%	26%	39%	18%		29%

The monthly energy consumption for rented and un-rented rooms was then analyzed for both Groups as shown in Table 2.5. The equations used to develop the findings as shown in Table 2.5 are given below. Some sections of Table 2.5 are highlighted light blue. These sections are for the cooling season and the appropriate cooling regression analysis curves. The three bottom rows demonstrate the average daily energy consumption per room, average yearly energy consumption per room, and the average yearly energy consumption if all rooms were specified as one Group.

Equations 1 though 4 used in Table 2.5

1.0 Rented Heating Energy Consumption (kWh/Room-Day) = Unit Rented Trend Line based on OSA temperature * Rent Rate (%)

2.0 Un-Rented Heating Energy Consumption (kWh/Room-Day) = Unit Un-Rented Trend Line based on OSA temperature * (1-Rent Rate (%))

3.0 Rented Cooling Energy Consumption (kWh/Room-Day) = Unit Rented Trend Line based on OSA temperature * Rent Rate (%)

4.0 Un-Rented Cooling Energy Consumption (kWh/Room-Day) = Unit Un-Rented Trend Line based on OSA temperature * (1-Rent Rate (%))

Table 2.5 Monthly Energy Savings for Groups #1 through #3

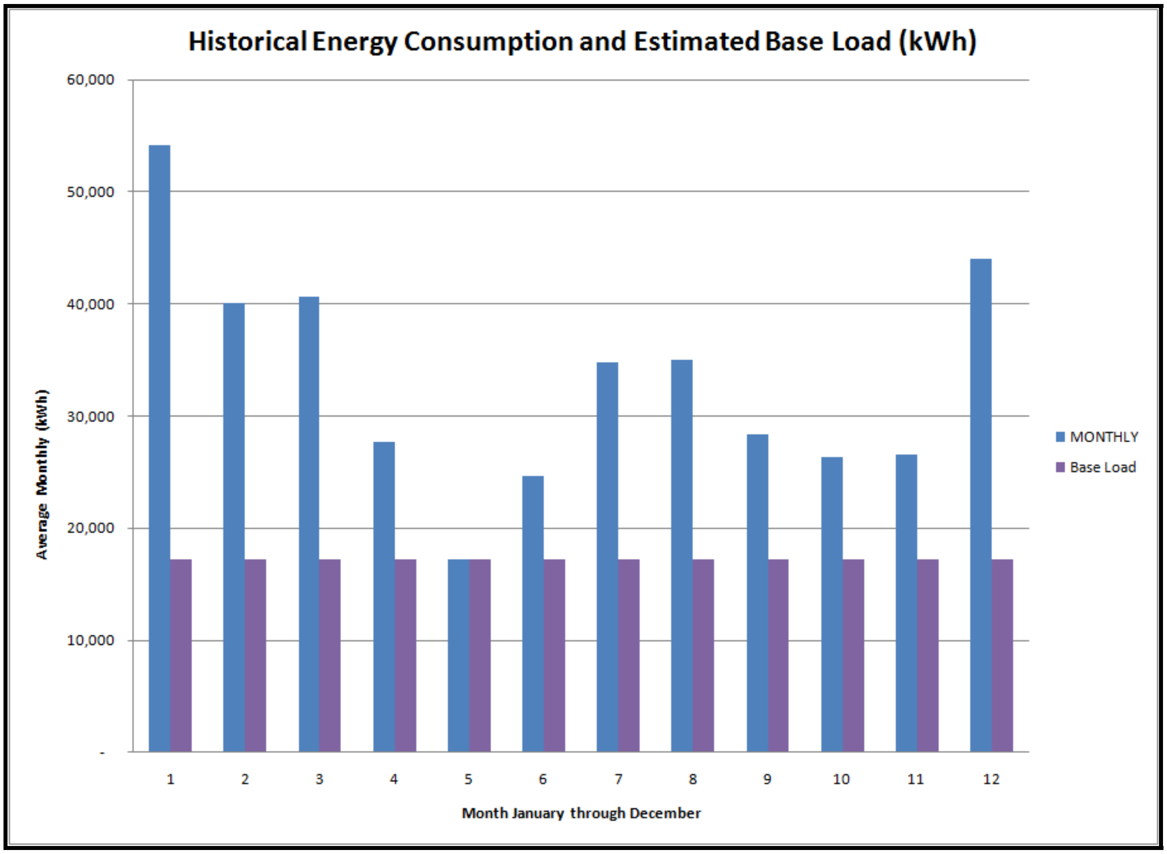
Month	Average Temp	Rent Rate	Rented with Sensor (kWh/Room-Day)	Unrented with Sensor (kWh/Room-Day)	Rented without Sensor (kWh/Room-Day)	Unrented without Sensor (kWh/Room-Day)
Jan	25.1	31%	2.56	5.72	1.84	2.12
Feb	27.7	47%	3.55	4.02	2.55	1.50
March	31.0	44%	2.94	3.72	2.12	1.39
April	45.0	34%	0.99	1.81	0.74	0.72
May	52.0	48%	0.47	0.41	0.37	0.20
June	59.6	67%	1.48	0.53	1.73	1.44
July	65.5	89%	4.54	0.41	5.31	1.11
Aug	67.3	82%	4.89	0.78	5.71	2.12
Sept	54.7	75%	0.19	0.01	0.20	0.03
Oct	41.3	56%	2.18	1.65	1.60	0.64
Nov	31.5	22%	1.43	5.10	1.03	1.91
Dec	24.4	29%	2.44	6.05	1.76	2.24
Total/Average	43.7	52%	2.30	2.52	1.23	1.29
kWh Consumption per Room Day			4.82		2.52	
kWh Consumption per Room per Year			1,760		919	
Energy Usage for 145 Rooms			255,185		133,323	

*The highlighted blue columns represents the months defined as cooling with the remaining months defined as heating due to the average monthly temperatures being below 55°F.

2.1 Utility Data

The utility data was collected for six years to determine the average monthly kWh consumption contributed towards heating and cooling energy and how the utility energy consumption compared to the metered energy consumption. Based on six years worth of data and plotting, the average monthly kWh consumption versus month during the winter and cooling months increase in energy consumption. In the shoulder months of May and October, the energy consumption is at the minimum. This represents the base load of the facility with minimal heating or cooling requirements. Anything above the base load is estimated as either cooling or heating energy that is contributed to by the existing PTAC units and the conditioning of the halls, foyer, conference rooms, recreation areas, and offices. By applying this approach to the utility data, it appears that the base load is approximately 17,000 kWh when looking at the low point in Graph 2.1.

Graph 2.1 Historical Average Energy Consumption



When subtracting the estimated base load of 17,000 kWh from the average historical monthly energy consumption, the actual energy contributed from the PTAC units and other facility HVAC equipment can be estimated from the utility history. By performing this utility analysis it can be seen that the estimated cooling and heating is estimated at 195,000 kWh which is 44% higher of the calculated baseline of the PTAC units. This is expected as the Grouse Mountain Lodge also includes multiple conference rooms, a dining area, foyer, recreational areas, offices, and hallways that should be deducted from the calculated 195,000 kWh. This demonstrates that the calculations developed by EMP2 as described in the savings methodology are reasonable when compared to the utility analysis as described in this section.

Table 2.6 Utility Heating/Cooling Analysis

Month	2003 (kWh)	2004 (kWh)	2005 (kWh)	2006 (kWh)	2007 (kWh)	2008 (kWh)	Heating/Cooling Loads (kWh)
JANUARY		60,480	66,240	45,440	46,720	52,000	37,176
FEBRUARY	34,880	44,480	33,280	35,040	45,920	47,200	23,133
MARCH	43,040	38,400	41,760	50,080	38,080	32,640	23,667
APRIL	30,240	19,200	36,720	26,720	19,040	34,240	10,693
MAY	15,200	16,320	15,680	15,680	17,280	23,360	253
JUNE	22,240	16,640	25,920	24,640	22,720	36,000	7,693
JULY	30,720	36,320	32,640	34,560	36,800	37,760	17,800
AUGUST	33,760	36,160	33,280	35,200	34,720	37,120	18,040
SEPTEMBER	23,360	26,240	32,640	30,240	26,720	30,880	11,347
OCTOBER	26,400	27,680	33,280	23,200	21,920	25,280	9,293
NOVEMBER	40,160	31,520	27,680	27,200	11,680	21,280	9,587
DECEMBER	48,000	41,280	57,120	48,960	18,720	50,080	27,027
YEARLY TOTAL	**348,000**	**394,720**	**436,240**	**396,960**	**340,320**	**427,840**	**195,709**

It appears based on this hotel that during the shoulder months of May and October that the hotel room heating and cooling energy is estimated to be close to zero energy consumption. It was originally estimated that even during the shoulder months, some heating or cooling energy was present. However, based on the verified findings of the this report, little or no cooling/heating energy exists during the shoulder months and only the increased energy consumption from the shoulder months demonstrates cooling/heating energy consumption. In summary, when using utility data, it is difficult to determine hotel room PTAC energy consumption. Despite this scenario, investigation of other facilities may show that utility data can be used to estimate hotel room heating/cooling energy usage and should not be ruled out as a possibility at this time.

2.2 Major Assumptions

- Three months of data collection would normalize occupant behavior and staff operating procedures.
- The distribution of rooms will provide consistent results even though the numbers and orientation is not consistent.
- One month of cooling data would be sufficient to extrapolate energy consumption to the remaining cooling months due to an overall similar average temperature.
- PTAC cooling energy is calculated to be the same.
- The measured power data would apply to all remaining units.
- The setback control and temperature limits were assumed to be constant through out the M&V period.

3.0 Project M&V Findings

This section will discuss the M&V findings of PTAC and room-based OCS.

3.1.0 Occupancy Sensors

This measure proposes installing a room-based occupancy sensor that is used to setback room temperatures when the room is unoccupied. Savings from this measure is found from the reduced heating and cooling loads during unoccupied periods when the PTAC is left in operating mode. This analysis focused on typical expected savings by installing a room-based occupancy sensor used to control room temperatures.

3.1.1 Baseline

The baseline was developed by logging ten typical rooms in the Grouse Mountain Lodge without room-based OCS. Ten additional rooms were logged with the room-based OCS. An amperage logger that collected one-minute increment data was used to determine runtime and mode of operation. The room rent data was also used to determine if the energy should be categorized as rented or non-rented. Based on amperage measurement, the mode of operation was determined and the power draw for each mode of operation was determined using spot measurements or the developed cooling power curve. When the amperage measurement demonstrated a mode of operation then it was assumed that the unit ran in that mode for the entire one-minute duration. This was deemed reasonable as the comparison between the amperage logger and Dent runtime logger showed less than a 1% difference. Data was collected over a three-month period for the months of April, May, and July in 2010. Based on this information, the baseline is 919 kWh per room per year or a total of 133,323 kWh per year.

3.1.2 Post Condition

Ten additional rooms were logged simultaneously with the baseline rooms over the same time period in similar rooms to estimate post condition energy consumption. The post condition energy usage is 1,760 kWh per room per year or is estimated at 255,185 kWh per year if the hotel installed occupancy based sensors throughout the hotel.

3.1.3 Savings

The data shows that the room-based OCS had an increase in energy consumption during the winter months and decreased energy consumption during the summer months. The summer months demonstrate energy savings as the hotel is typically above 75% occupied and it appears based on the month of July that the units are in operation during unrented periods. This results in energy savings during unrented periods. However, during the winter months it appears that more of the rooms with occupancy based sensors were left in operation during unoccupied periods than the baseline rooms without sensors. The reason for this is not known, however, it is speculated to be a random occurrence as both rooms should have been operated the same. The result of this shows that the cleaning staff has a larger impact on energy consumption than the occupancy sensor’s ability to save. Consequently, the winter time operation does not show any energy savings, but rather actually an increase in energy consumption.

4.0 Discussion

EMP2 believes that the energy savings associated with the OCS at Grouse Mountain Lodge is lower than what would be expected due mainly due to staff operating procedures. The cleaning staff currently turns off the PTAC equipment after cleaning the room, leaving the units shutoff until an occupant enters the room and turns the unit on. If a hotel did not have this procedure, the energy savings would be significantly higher. It is also estimated that additional data collection would help minimize the staff operating effect as additional data points would eventually normalize to standard operating procedures and the random occurrence of equipment being left on during unrented periods would be the same for the base case and post-condition case. This analysis found that by random occurrence, more rooms with the occupancy sensors were left in operational mode than the rooms without the sensors causing negative savings to exist for this study. Based on this analysis there are four main parameters that effect hotel room PTAC energy consumption:

1. Occupant Behavior (assumed to be similar over a 3-month period)
2. Room Rent Status (Considered within the analysis and Normalized to a typical year)
3. Outside Weather data (Considered within the analysis and Normalized to a typical year)
4. Staff operating Procedures (Turning the units off after cleaning)

It is assumed that the occupant behavior has minimal impact over a three-month period as typical room temperatures are set between 65°F and 75°F. This is a relative small increment in space temperature, which has a minimal impact on energy consumption. Room rental status does appear to have an impact on energy consumption, but the analysis accounted for this by separating each group into further segments including rented periods and unrented periods. Outside weather data has a large impact on energy consumption and can be seen within EMP2's regression analysis. This was counted for within the analysis and normalized to a typical year. However, the main parameter that appeared to affect the potential energy savings for this study is staff operating procedures. If a staff member accidently left a PTAC in operational mode during low occupancy and unrented periods over any extended period of time then any savings from the occupancy sensor would virtually be undone. It would be expected that this parameter would be normalized over a three-month period between the baseline and post condition, however it was found that by random, especially for the month of April, that more of units with the sensors were left on during unrented times which demonstrated additional energy consumption in comparison with the rooms without sensors. This is why the savings are reported negative for this analysis. In summary, the staff operating procedure has such a large impact on energy consumption that it outweighs or overshadows any potential savings found from the room-based occupancy sensor.

5.0 Conclusion

Room-based OCS

In summary, the results demonstrate that the OCS at the GML provides no savings, and in fact, the data demonstrates increased energy consumption for the rooms with OCS. The increase in energy consumption is due to staff operating procedures and the random occurrence of increased operation of the PTAC units for the OCS base of rooms metered. If OCS were installed throughout the hotel it is expected that savings would minimal, if any. The results of this study demonstrate that weather and staff operating procedures have a larger impact than room-based OCS.

However, theoretically, if room-based OCS were installed throughout the hotel then overtime it is expected that the facility would see energy savings, however it would be difficult to quantify since the key parameter for unrented energy consumption appears to be staff operating procedures.
In general, it could be stated that the cleaning staff has a larger impact on energy consumption than the room-based occupancy sensors for Grouse Mountain Lodge.

6.0 Recommendations

For future analysis and studies it is recommended to collect additional data if possible including additional rooms to be logged over a longer time period. This would further improve the quality and regression analysis within the report and reduce the impact of staff operating procedures. It is recommended to collect data in the most extreme weather conditions. The energy consumption for the cooling and heating equipment is directly related to ambient conditions as can be seen in the utility history. This methodology would demonstrate the potential maximum amount of energy that can be saved with the occupancy sensor units. It is also recommended to review typical occupant check in and checkout times and maybe averaging a large set of data to estimate the actual check in and checkout times. EMP2 estimated a daily rented status although it is expected that an actual rented day might be a shorter duration than a typical day. This would improve the breakout of rented and un-rented energy use.

7.0 Bibliography

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