Field Performance of a Card Key Energy Saving System for Hotels and Motels

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ABSTRACT

A considerable amount of energy is wasted when hotel/motel guests leave the lights and air-conditioning on when they leave their rooms. Southern California Edison has completed six months of field monitoring of the energy usage of a standard guest room in the Comfort Inn in Palm Springs, California, and compared this to an identical room with an energy-saving system. The energy-saving system shut off the lights and cycled the heating, ventilating and air-conditioning (HVAC) unit when the guest removed the room key from the key holder next to the door.

To study the impact of the energy saving system, room temperatures were also monitored. The data showed that the energy usage in a guest room depends heavily on the behavior of the guests. Based on six months of data, some guests turned on more light than others did, and the number of lamps turned on was far less than the total number in the room. Some guests preferred cooler temperatures, and guests who only stayed for one day usually spent much less time in the room compared to those who stayed for several days. The energy used by lights in hotel and motel rooms accounts for approximately 12% of the total energy usage. Motels with unitary air conditioners or heat pumps with manual control cannot maintain constant room temperature. The air-conditioners or heat pumps tend to over-cool the rooms in the summer and over-heat the rooms in the winter. By using an energy-saving system, a hotel/motel owner could save as much as 44% of electricity and reduce operating costs significantly. Most of the savings occurred during the mid summer and mid winter when the heating and cooling demands were the greatest.

Background

Hotel/motel guests generally leave their lights and air-conditioning on when they go out to meetings or for other personal activities. Most of the electricity used in hotels and motels is for running the heating, ventilating, and air-conditioning (HVAC) systems. A considerable amount of energy is wasted when the room is unoccupied, especially in motels with unitary air-conditioners and heat pumps with manual control. Several energy-saving systems specifically designed for hotels and motels have been introduced in the market in the last few years. Most of these energy-saving systems basically turn off the HVAC units inside the room when it is unoccupied. Some of the systems also turn off the lights in the room when nobody is there. For the more sophisticated systems, instead of turning the air-conditioning unit off completely, they may change the operation of the HVAC unit from a fixed set point to a set back or setup mode when the room is unoccupied (Lockyer, 1998). Others may switch from a high cooling/heating level to a low cooling/heating level, and cycle the compressor (Okko, 1998). This will prevent the room temperature from drifting too far from the set-point. When the guests return or check in, it will only take a short time to bring the room temperature back to the original set point.

Typically, manufacturers claim savings based on the connected load of the lights and HVAC equipment without considering the actual pattern of usage of the guests. Very often the amount of saving is over exaggerated. None of those systems have been tested in the field to verify their actual savings. The main objective of this study was to learn the energy use profile in a hotel/motel room, and to determine the energy savings from such a system. Edison contacted the U.S. Import Export of America, Inc. that manufactures the energy-saving system in Mexico. The system has been tested by an independent test lab in the United States for safety, and the product is qualified for the Edison Testing Laboratories (ETL) label. This system will turn off the lights in the room and cycle the HVAC unit when the guest removes the card key from the controller as shown in Figure 1. The U.S. Import Export of America was willing to participate in the study by installing one of their systems in a motel room so that the energy usage by the controlled equipment could be monitored.

Figure 1 Energy Saving System Card Key Holder

Technical Approach

To determine the actual energy savings in a guest room with the energy-saving system, Edison decided to monitor the energy usage of two identical rooms next to each other. One room was outfitted with the energy-saving system, and the other was not. Since most of the energy usage in a guest room is the HVAC system, it was critical to have an accurate measurement of the energy usage of the HVAC systems that served the rooms. To avoid complicated and expensive monitoring of central plant equipment and air handling units, both Edison and U.S. Import Export of America searched for a hotel or motel with through-the-wall air-conditioning or heat pump units. By monitoring the power consumed by the air-conditioning or heat pump units, one can gather accurate energy usage of the

HVAC system with minimal monitoring costs. After two months of searching, Comfort Inn in Palm Springs, California was found to have individual heat pump units in each of their rooms, which provided both heating and cooling. The heat pumps were Carrier, Model 52SQC307-301AA which had an EER of 10.7, and COP of 3.1. The heat pumps had a cooling capacity of 7,100 Btu/hr. and a heating capacity of 6,100 Btu/hr. They could be turned on at the control panel by selecting high or low heating or cooling. There is no thermostatic control to maintain the room temperature at a set point. The management of the Comfort Inn agreed to participate in testing of the energy-saving system.

Two identical rooms, Room 104 and Room 106, on the first floor close to the swimming pool were selected for the test. It was decided to have the energy-saving system installed in Room 104. Due to the wiring system in the rooms, only the three portable lamps and the heat pump in each room could be controlled by the energy-saving system. The lights at the desk, lavatory, and in the bathroom had their wiring enclosed inside the walls and were not accessible for monitoring. It was decided that they would not be controlled by the energy-saving system, nor monitored for their usage.

Figure 2 shows the layout of identical rooms, 104 and 106, selected for evaluation. The three monitored lights and the monitored heat pump unit under the control of the energy-saving system are shaded. To assure that all of the lamps in both rooms are the same through out the test period, all the lamps in both rooms were replaced with 90 watt halogen lamps. These lamps have a lamp life of 2,000 hours. To assure that the lamps draw the same energy, the actual power to each lamp was measured. It was found that they only draw 84 watts instead of 90 watts as rated. As for the heat pump, the unit draws 805 watts in the high speed cooling mode. Since the energy-saving system cycles the heat pump when the room is not occupied, it was decided to monitor the room temperature to determine the impact of cycling the heat pump.

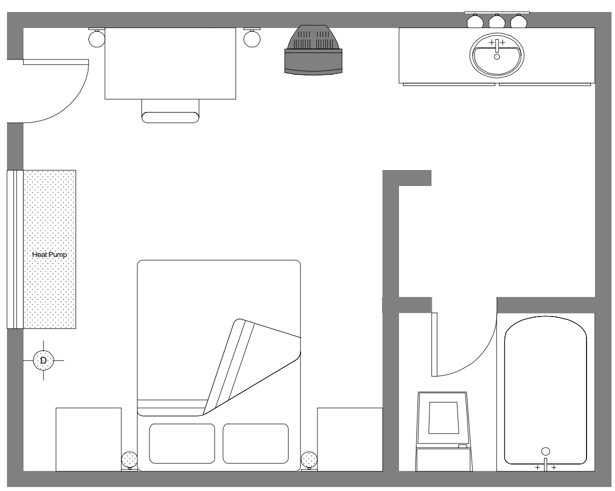

Figure 2. Floor Plan of Typical Guest Room with Furniture Arrangement

Data Collection

To determine the impact of the energy-saving system on the electric usage in the hotel/motel rooms, it would be better to monitor the electric usage over a one year period. This would provide annual savings. Due to a limited budget, it was decided that six months would be sufficient if the monitoring period started in mid-summer and ended in mid-winter. The monitoring systems were installed in both hotel rooms on July 14, 1998. The power consumption of the three lamps and the heat pump were measured by using power transducers, and the room temperature was measured with a temperature sensor. Since the performance of the heat pumps was not the main objective of the project, it was decided that the outdoor temperature would not be monitored. The data loggers collected the data every second. The data logger then processed the data and stored the data in memory for future investigation. Table 1 lists all the components used in the monitoring system.

Table 1. Monitoring Equipment List

Item	Model Number	Manufacturer
Data Logger	CR500	Campbell Scientific
Battery Power Supply	PS-110-LA1	Severson
Battery Charger	PS-101-AC1	Severson
Enclosure	A20N16BLP	Hoffman Engineering
Temperature Sensor	107-25	Campbell Scientific
Power Transducer	PC5-110A	Ohio Semitronics
Power Transducer	PC5-117A	Ohio Semitronics

To assure the data were accurate, and to fully understand the behavior of the guests, data was logged every 15 minutes on the data loggers. Due to the limitation of the memory in the data loggers, the data were down loaded once a week for analysis. After four week's of data verification for accuracy and reasonableness, the data collection was switched to hourly. The hourly data were down loaded once a month from the data loggers for the remaining five months.

Results

The Comfort Inn has a check out time at noon, and a check in time of 3:00 p.m. For a complete occupancy cycle for the room, the lighting and heat pump power consumption and room temperature were presented from noon to noon.

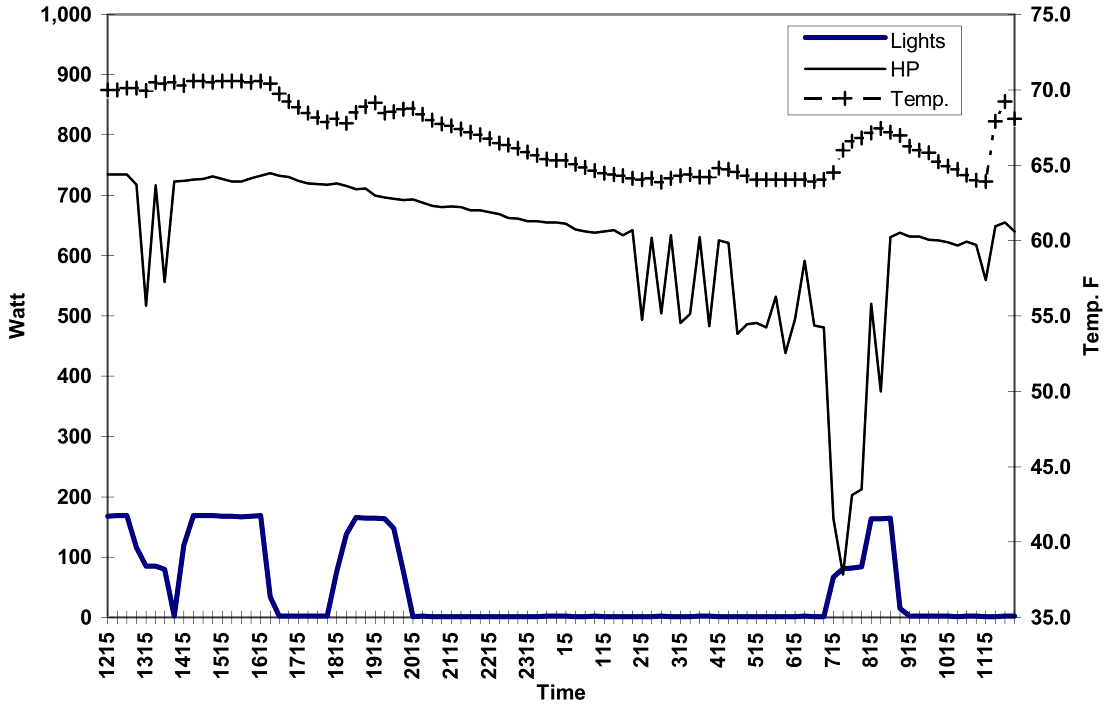

Figure 3. Lighting and Heat Pump Power, and Room Temperature of Room 106 on July 17-18, 1998

Figure 3 shows the 15 minute load profile of Room 106, on July 17-18, 1998. It appeared that the guest in Room 106 did not checked out at noon. He had two of the lamps turned on, and the heat pump unit was at high speed. The room temperature was about 70°F. Around 1:00 p.m., judging from the power reduction, the guest turned off one of the lamps. At 2:00 p.m. the guest left the room for about 15 minutes, then returned to the room. He stayed in the room until 4:30 p.m. When the guest left the room, the heat pump unit was left running at high speed. The guest then returned to the room around 6:30 p.m. At 8:00 p.m. all the lights were turned off, but the heat pump unit was kept at high speed. Since the heat pump was not thermostatically controlled, the unit remained running at high cooling. By about 2:00 a.m. the room temperature dropped to 65°F, and the heat pump unit began to cycle. The heat pump provided maximum cooling throughout the night, so that when the guest got up in the morning at 7:00 a.m., the room temperature had dropped to 64°F. He turned on one of the lamps, and turned on the heat pump for fan only. The room temperature began to warm up to about 65°F. By 8:00 a.m., the guest turned the heat pump to heating mode. The room temperature started to climb to about 68°F. Around 8:30 am, the guest turned the heat pump back to high cooling mode and also turned off the lights. By 11:15 a.m. the room temperature dropped to 64°F. The guest switched the heat pump from cooling mode to heating mode. The temperature went up to 70°F in half an hour.

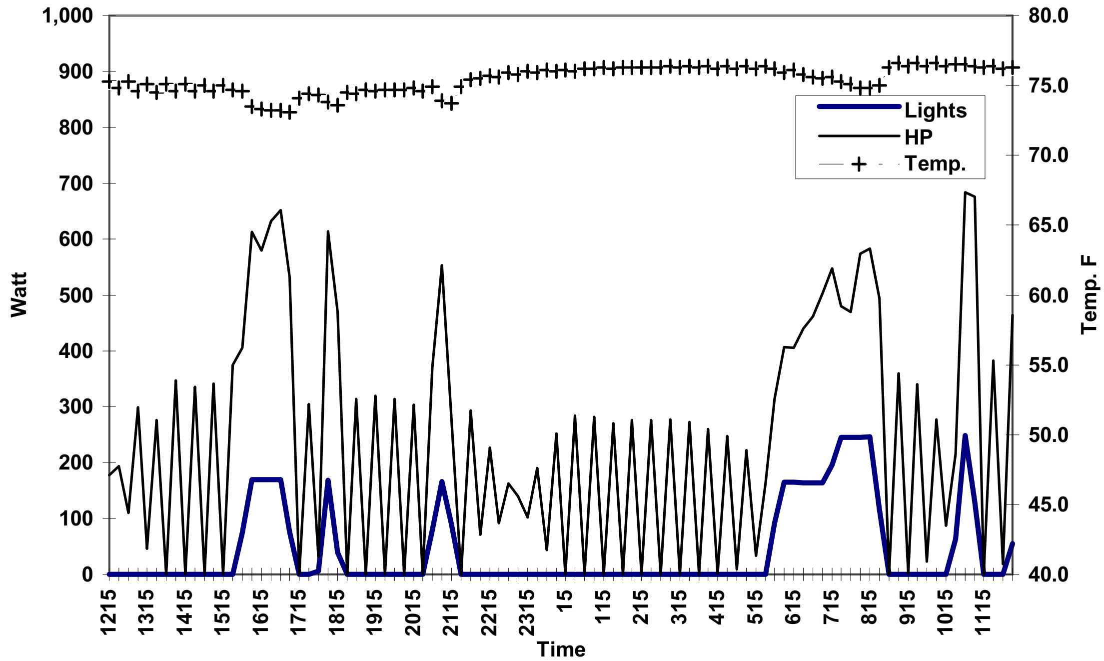

Figure 4 Lighting and Heat Pump Power, and Room Temperature of Room 104 on July 14-15, 1998

Figure 4 shows the load profiles of Room 104 on July 14-15, 1998. The data shows that the room was not occupied between noon and 3:30 p.m. During this period, the heat pump unit was cycling in the cooling mode at low speed. If the energy saving system was not installed, the room would have been over cooled. The unit was drawing about 300 watts, and the room temperature was maintained at about 75°F. Around 3:30 p.m. the guest checked into the room, and turned on two of the three lamps that were controlled by the energy saving system. The lights were drawing about 170 watts. At the same time, the heat pump unit was activated and switched from low speed to high speed, and it was drawing about 650 watts. Once the heat pump unit was running at high speed, the room temperature dropped by about 1°F. Around 5:00 p.m. the guest left the room for about one hour, and returned to the room around 6:00 p.m. He stayed in the room briefly for about 30 minutes, the he left the room around 6:30 p.m. most likely going to dinner. As he left the room with the card key, the lights were turned off and the heat pump unit was returned to the cycling mode. Around 8:30 p.m. the guest returned to the room, and the lights and the heat pump unit were reactivated. At 9:15 p.m. the guest turned off the lights and lowered the heat pump and went to bed. With the heat pump running at low speed, the room temperature drifted up to about 77°F. Around 5:45 a.m., the guest got up and turned on two of the three lamps. At the same time he switched the heat pump to high speed. At 7:20 a.m. the guest turned on the third lamp. Around 8:30a.m. the guest left the room and returned around at 10.30 a.m. Around 11:00 a.m. the guest left the room again for approximately 30 minutes.

Comparing the two figures above, the energy usage depends heavily on the guest's behavior. The number of lamps that were turned on were far less than the total number installed in the room. It appears that guests that stay in the motel for only one day usually spend much less time in the room compared to those who stay in the motel for several days.

With the energy saving system, major energy saving can be achieved by cycling the air-conditioning units when the guest leaves the room.

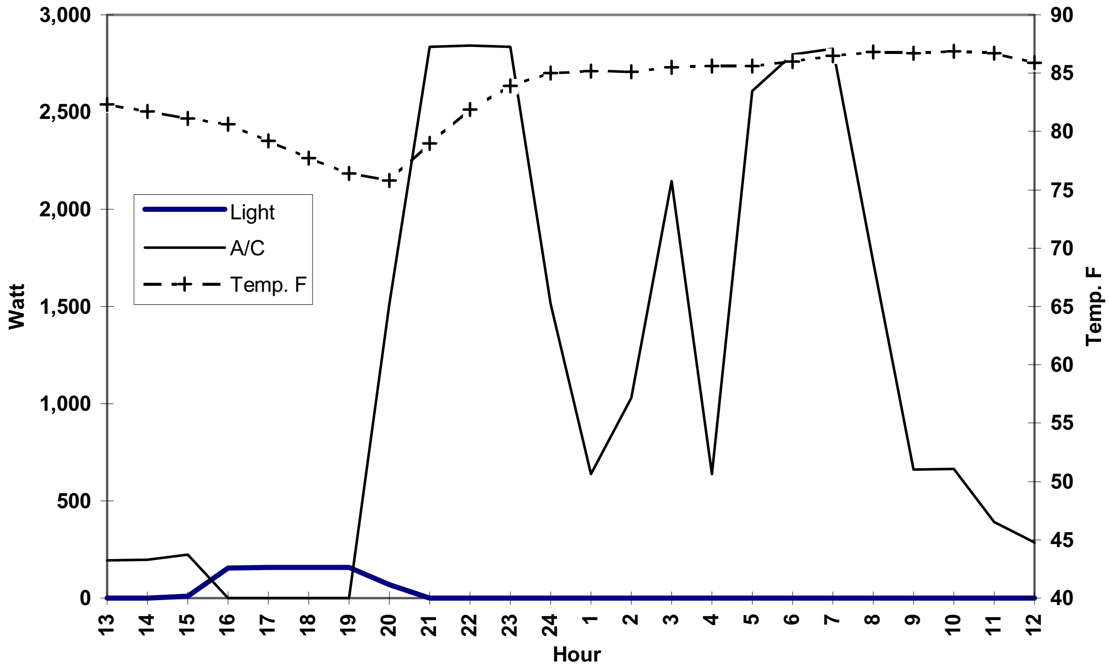

Figure 5. Lighting and Heat-Pump Power, and Room Temperature of Room 106 on January 5-6, 1999

Figure 5 shows the heat pump was in the heating mode in Room 106 on January 5-6, 1999. The guest checked in around 3:50 p.m. The room was at 80°F. He turned on two of the lamps, and turned off the heat pump. At about 7:30 p.m., the room temperature dropped to 75°F. He turned off one of the lamps, and turned on the heat pump to heating mode. Because of the cold outdoor temperature, the electric strip heater came on. It drew 2.8 kW. The room temperature started to rise. Without thermostatic control, by about mid-night, the room temperature reached 85°F. The heat pump turned off the strip heater. By the morning, the room temperature reached 86°F. This shows that the room was over heated.

For the same day, Room 104 was able to maintain the room temperature between 75 and 72°F without turning on the heat pump as shown in Figure 6. This temperature range might be considered comfortable for the guest.

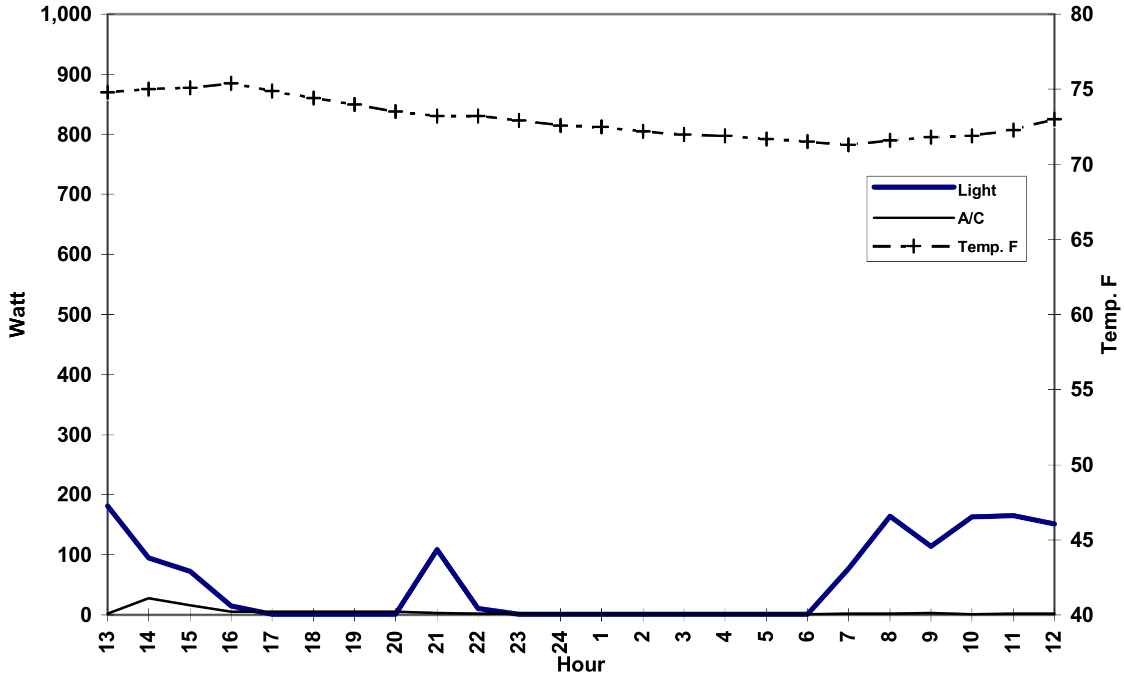

Figure 6. Lighting and Heat-Pump Power and Room Temperature of Room 104 on January 5-6, 1999

Table 2 compares the monthly energy usage between the two rooms. Due to the rewiring on October 9, 1998, the savings for the lights were calculated based on the energy usage between July 14 and September 31. For Room 104, with the energy-saving system, the lighting energy usage in the room was 39.4 kWh compared to 75.5 kWh in Room 106. This is a savings of 36 kWh or 47.9% less than the lighting energy used in Room 106. For space heating and cooling, Room 104 consumed 624 kWh over the six month monitoring period compared to 962 kWh in Room 106. This is a savings of 368 kWh or 43.6% less than the space heating and cooling energy used in Room 106. Comparing the combined energy usage for the two rooms, Room 104 with the energy-saving system used 43.9% less energy than Room 106 without the Energy Saving System.

Table 2. Monthly Summary of Electric Usage and Savings between Room 104 and 106

	ROOM 106[1]		ROOM 104[2]		SAVINGS		SAVINGS		
MONTH	LIGHTS, KWH	HP, KWH	LIGHTS, KWH	HP, KWH	LIGHTS, KWH	HP, KWH	LIGHTS, %	HP, %	LIGHTS & HP
JUL[3]	12.22	157.15	8.23	112.29	3.99	44.86	32.65%	28.54%	28.84%
AUG	41.36	267.79	17.48	178.05	23.88	89.75	57.74%	33.51%	36.76%
SEP	21.94	175.13	13.66	153.38	8.28	21.75	37.74%	12.42%	15.24%
OCT	26.32	136.66	N/A	90.79	N/A	45.87	N/A	33.56%	33.56%
NOV	17.58	69.63	N/A	31.69	N/A	37.93	N/A	54.48%	54.48%
DEC	25.10	156.00	N/A	27.70	N/A	128.30	N/A	82.24%	82.24%
JAN	11.50	145.40	N/A	30.30	N/A	115.10	N/A	79.16%	79.16%
TOTAL[4]	156.03	1107.76	39.37	624.20	36.15	483.56	47.87%	43.65%	43.92%

NOTES:
1. ROOM 106 WITHOUT ENERGY SAVING SYSTEM.
2. ROOM 104 WITH ENERGY SAVING SYSTEM.
3. DATA COLLECTION STARTED ON JULY 14.
4. TOTAL SAVINGS FOR LIGHTS ARE BASED ON JULY, AUGUST AND SEPTEMBER ONLY.

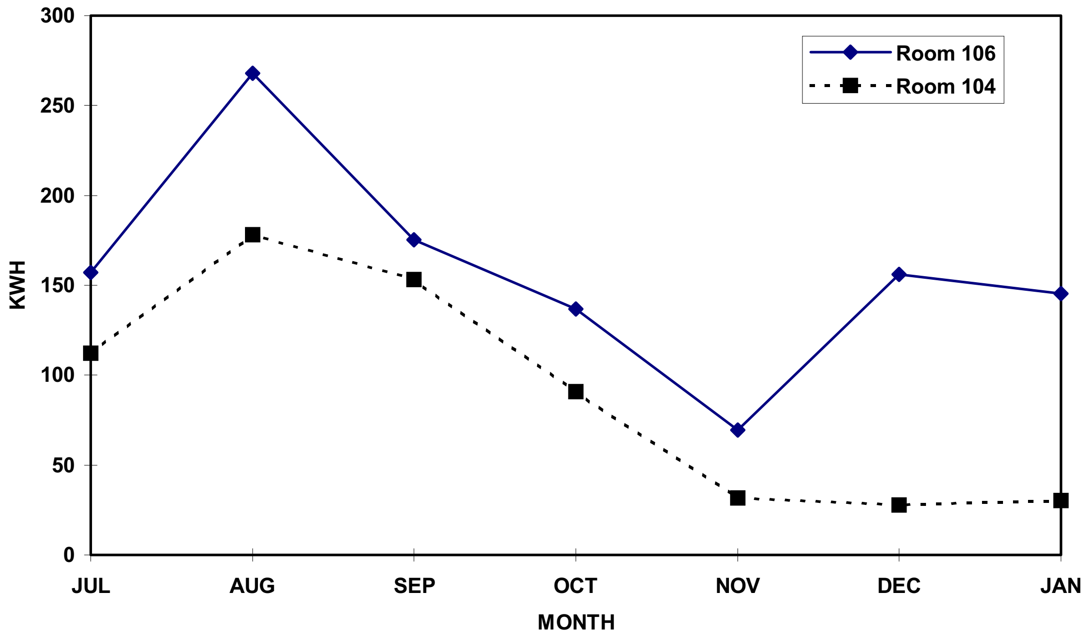

Figure 7. Comparison of Monthly Heat Pump Energy Usage Between Room 106 and Room 104

Figure 7 compares the monthly heat pump energy usage between the two rooms. Note that there was more energy saved in the mid-summer and mid-winter periods than other times of the year. This was expected because the demand for cooling and heating was at its greatest at these times of year. During the fall season, the weather was milder, and the demand for heating or cooling was less. As a result, the savings were also less.

Conclusions

The data showed that the energy usage in a guest room depends heavily on the behavior of the guests. Some guests turned on more light than the others did, and the number of lamps turned on was far less than the total number in the room. Some guests preferred cooler temperatures, and guests who only stayed for one day usually spent much less time in the room compared to those who stayed for several days.

The energy used by lights in hotel and motel rooms accounts for approximately 12% of the total energy usage. When the guests leave the room, they usually leave the lights on and the HVAC system running. Unitary air conditioning and heat pump units with manual control cannot maintain constant room temperature, and tend to over-cool the room in the summer and over-heat the room in the winter. By using an energy-saving system, a hotel/motel owner could save as much as 44% of electricity and reduce operating costs significantly. Most of the savings occurred during the mid summer and mid winter when the heating and cooling demands were the greatest. The savings would be less if the HVAC system was controlled by a thermostat which would eliminate the over heating and over cooling problems.

References

Lockyer, John. 1998, “Thermostat Plus, Temperature on the Move,” Popular Home Automation, November 1998.

Okko, Chris. 1998,Personal communication, Newport Beach, California, U.S. Import Export of America, Inc.