Lighting Energy Savings Opportunities in Hotel Guestrooms

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ABSTRACT

A study was conducted by LBNL/DOE in order to better understand the lighting usage and energy consumption patterns in typical hotel guestrooms. This involved a multi-phase research, development, and demonstration program. This program started with the identification and characterization of common lighting technologies in hotel guestrooms and ended in the measurement and monitoring of existing and newly developed technologies at a hotel test site. Emphasis was placed on determining where lighting energy was being used by guests and identifying the savings potentials that energy efficient technologies could present. Data from this study indicates that compact fluorescent lamps (CFLs) and occupancy sensors offer significant energy savings potential in hotel guestrooms.

Project Objective

The objective of this research project was to gather information on how lighting is used in typical hotel guestrooms and determine the subsequent energy implications this information suggests. Specific questions that were addressed include:

- How much energy is used in lighting a guestroom?
- Where is the lighting being used the most?
- What potential savings do CFLs offer?
- What potential savings do occupancy sensors offer?
- Are there trends in room occupancy that affect the energy use patterns?

By answering these questions we can identify the most appropriate energy efficient lighting technologies and approaches in order to assist the lighting and hospitality industries in developing and implementing these solutions.

Technology Background

Many hotels employ energy efficient lighting technologies to reduce operating and maintenance costs (Deng and Burnett 1996). CFLs are becoming the standard in hotels while occupancy sensors have seen limited application. CFLs generally cost $10-$20 each, but usually pay for themselves because they use only one-quarter of the energy and last ten times as long as comparable incandescent lamps. Likewise, the wall-mount type occupancy sensors used in this study have been shown to have very favorable paybacks within two to five years depending upon occupancy, connected load, and added cost. The added cost typically for these devices is $25-$50. (Audin et al. 1997; Rea, 2000)

Research Plan

Ten similar guestrooms on the same wing and floor of the hotel were used for the study. Data loggers were placed on all fixtures in each room in order to record the guests lighting usage patterns (Stoltz and Burnruss, 1995). The data loggers were installed for three months in order to gather nearly 1000 "user-days" from these ten rooms. The rooms were both single and double occupancy and had the following lighting fixtures: an entryway downlight, a bathroom light, one or two bed-end table lamps (depending on room type), a table lamp on the desk, and a floor lamp. (See Figures 1 and 2)

Three of the ten rooms were used as a "baseline" and included all incandescent light sources. The seven remaining rooms were retrofitted with a wide variety of energy efficient lighting technologies including novel prototype CFL fixtures and lighting controls developed by LBNL and our industry partners.

Many of the table lamps were "dedicated fixtures," which were optimized specifically for CFLs based on photometric research done at LBNL (Siminovitch and Mills 1995; Page, Praul and Siminovitch 1997). With the exception of several rooms in which CFL torchieres (uplights) were used in place of the floor lamps, all fixture styles remained consistent, regardless of the source technology used inside them (Page and Siminovitch 1997).

Specially designed and prototyped lighting controls were installed on several of the bathrooms. These controls, which were jointly design by LBNL and Wattstopper, Inc., were wall-pack occupancy sensors that included an additional "night light" feature (see Figure 3). The occupancy sensor was set on an extra-long one-hour timeout so that it would not turn the light off if a guest was in the shower or bath for an extended period and was not detected by the occupancy sensor. The special "night light" feature enabled the bathroom light to be operated at a 10% light output. This was designed as an energy efficient option for people who may want a low-level night light in their bathroom during the night. The light would stay in the "night light" mode for ten hours or until the on/off switch was pressed again.

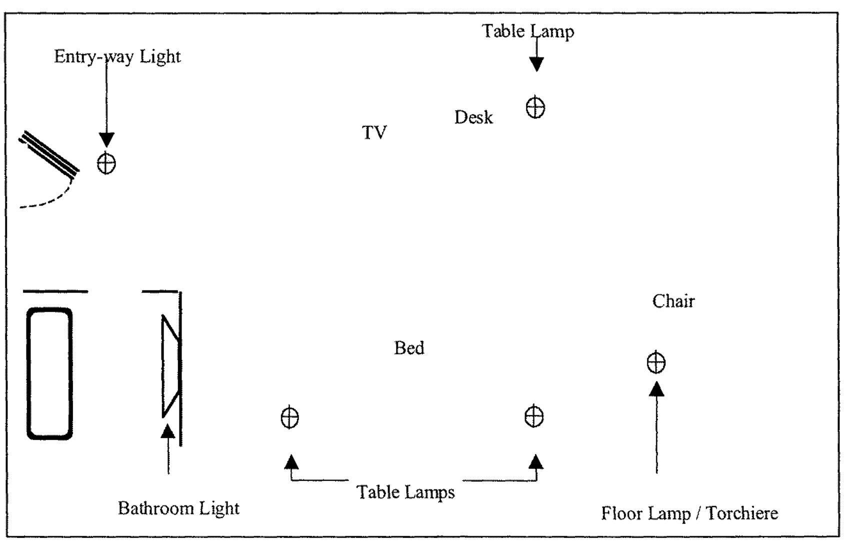

Figure 1. Layout of typical guestroom with fixture types and locations

Figure 2. A typical "single" guestroom with a table lamp on either side of the bed

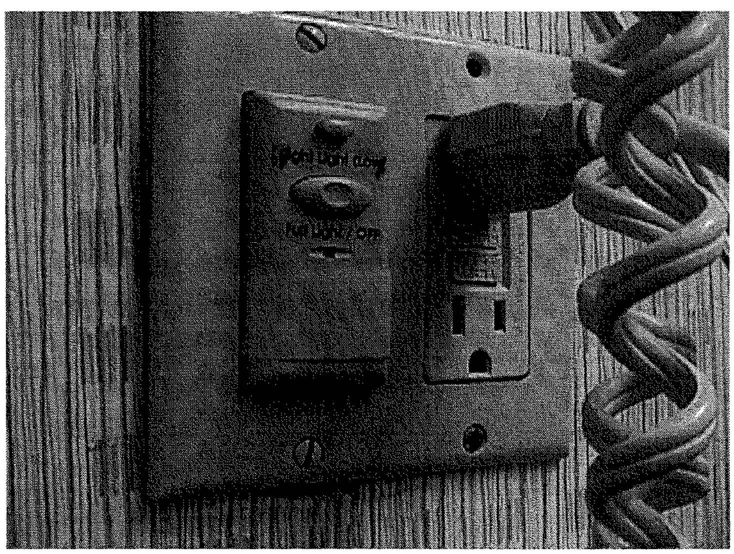

Figure 3. Bathroom controls were co-designed by LBNL and Wattstopper that utilized an occupancy sensor and a low-level "night light" feature

For three months in the summer and fall of 1998, lighting use profile data from the ten guestrooms were collected. All the lighting fixtures in the guestrooms were monitored with small lighting loggers that could record the time at which the light was turned on or off (see Figure 4). The loggers that were used on the entryway lights could also record when they detected occupancy in a room through an integrated occupancy sensor. Occupants were unaware that their usage patterns were being monitored, unless they discovered one of the matchbox-sized loggers. As shown in Figure 4, a brief note indicated these devices were lighting loggers and provided a hotel contact number for the guests who might have questions.

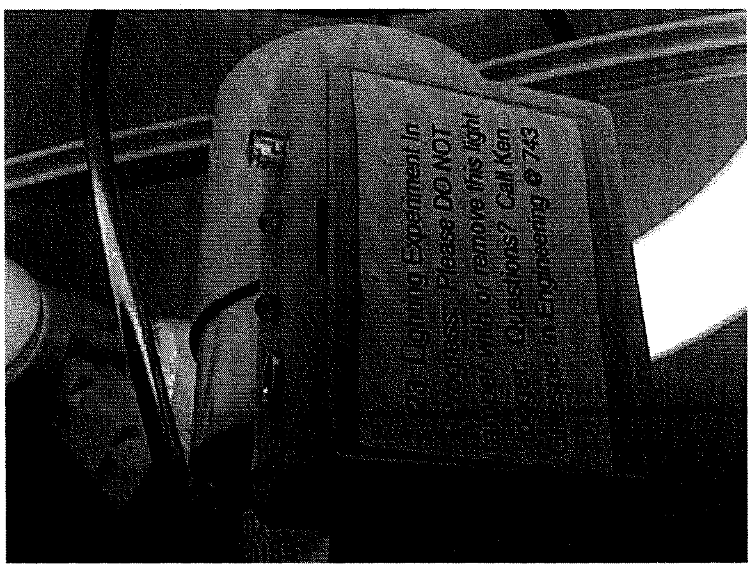

Figure 4. Lighting loggers were connected to all lighting fixtures in the experimental guestroom, including this table lamp

Results

After the experimental test period, the data loggers were retrieved and brought back to LBNL for data reduction. Nearly 20% of the lighting loggers were lost, stolen, or tampered with during the study which left some gaps in the data set. Additionally, the light and occupancy data collected by the entryway lamp loggers failed to generate reliable data as they only recorded for a few weeks due to technical and memory-related problems. While the occupancy data seemed to suggest that guestroom lights were often left on while the rooms were unoccupied, the results were inconclusive. This was basically due to the small sample size and the level of interruption that we experienced in the data stream. As a result, we concentrated our analysis efforts on the more robust information from the site. Entryway data have not been included in Figure 5 or Figure 6.

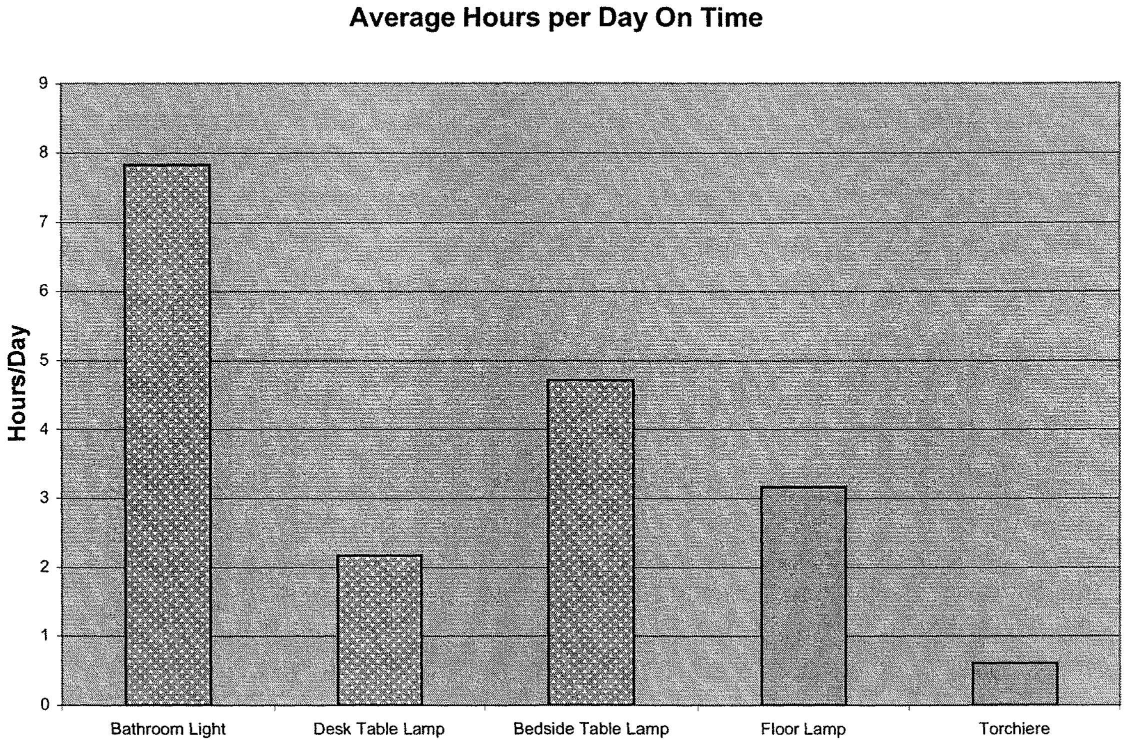

Figure 5. Average hours of operation per day for various fixture types

Figure 5 shows the average use data (or "on-time") for each type of guestroom fixture. This data is based on the average of the ten guestrooms during every occupied day of the study (except for the data from bathroom lights that used the occupancy controllers). This data indicates quite clearly that bathroom lights experience particularly heavy usage at nearly eight hours of operation per day. Since some hotel bathrooms use incandescent vanity fixtures, this can lead to significant energy loads. At this level of daily usage, a bathroom vanity fixture with four 60W bulbs (the fixtures currently used by the Redondo Beach Crown Plaza) consumes over 700 kilowatt-hours a year, or $56 per year (at $0.08/kWh) in each guestroom for bathroom lighting alone. The next most used fixtures were the table lamps on the bed-end tables, which were on for an average of almost five hours per day. With 100W bulbs, this represents nearly 180 kilowatt-hours per year, or $15 per table lamp per year to operate.

Figure 6 looks at the same set of data and shows when, on average, these fixtures are using energy. In general, during the early morning hours (midnight to 5 AM) only a small fraction (less that 15%) of the lights are turned on. Alternatively, all fixture types experience peak usage in the morning (6 AM—10 AM) and in the evenings (after 5 PM). It is interesting to note that some of these fixtures, most notably the high use bathroom and bed fixtures, do not experience a significant "dip" during typically unoccupied daytime periods between 11 AM and 5 PM. These lights are on 20% to 25% of the time during this period. Significant energy savings could potentially be achieved if hotel policy encouraged the cleaning staff to turn all room lights off when they leave.

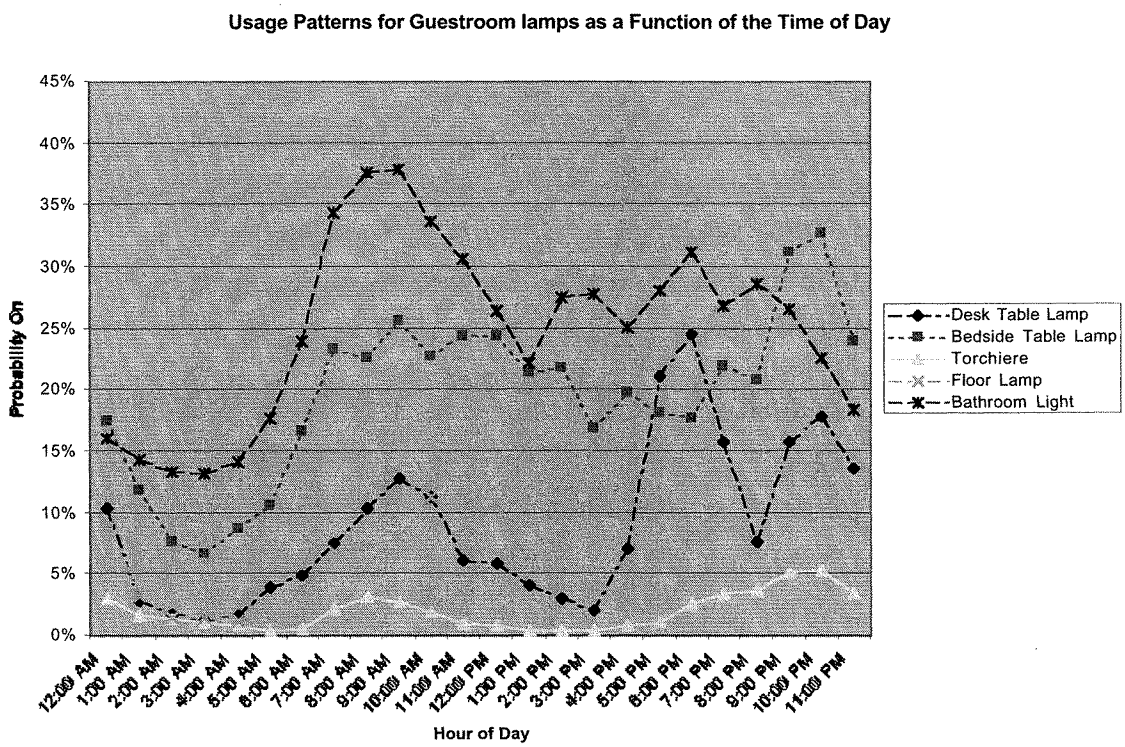

Figure 6. The percentage of lamps on at any given hour for each lamp type. For example, at 10 AM, 38% of all bathroom lights are on

The bathroom fixtures present a significant opportunity for the use of an occupancy sensor because the room is separated from the general guest room area and thus will not be falsely triggered by movement there. Additionally, the long burning hours of the bathroom luminaire make this area particularly suitable for these energy saving sensors. Figures 7 and 8 present the use patterns in this area and can help identify the energy savings potential that occupancy sensors offer in these bathrooms. Figure 7 shows how long these lights are generally left on during each use. This chart shows "twin peaks," one around 1-2 minutes and another around 16-32 minutes, implying that occupants are generally using the bathroom either relatively briefly or for longer time periods, such as for bathing. Rarely is the light turned on and then off in less than 30 seconds or left on longer than two hours at a time.

Figure 8 looks at the same set of data as Figure 7, but plots the percent of the total energy used during each of the use durations. This plot is significantly shifted to the right, or towards the longer duration on cycles, indicating that most of the energy is consumed during long periods of operation. In fact the bathroom lights are left on for periods longer than two hours only 10% of the time, but these longer burning periods account for over 75% of this fixtures energy consumption. This statistic leads to a very strong case for an occupancy sensor. If the two-hour and greater cycles were eliminated by an occupancy sensor, significant energy savings could be achieved in a manner that would largely be transparent to the hotel guest.

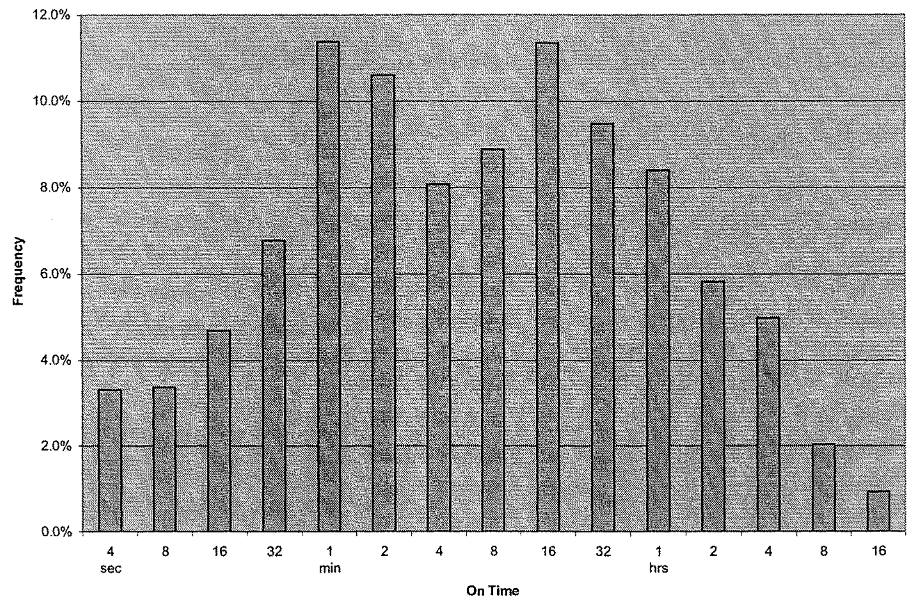

Figure 7. Guest bathroom lights were rarely left on for more than 2 hours per use

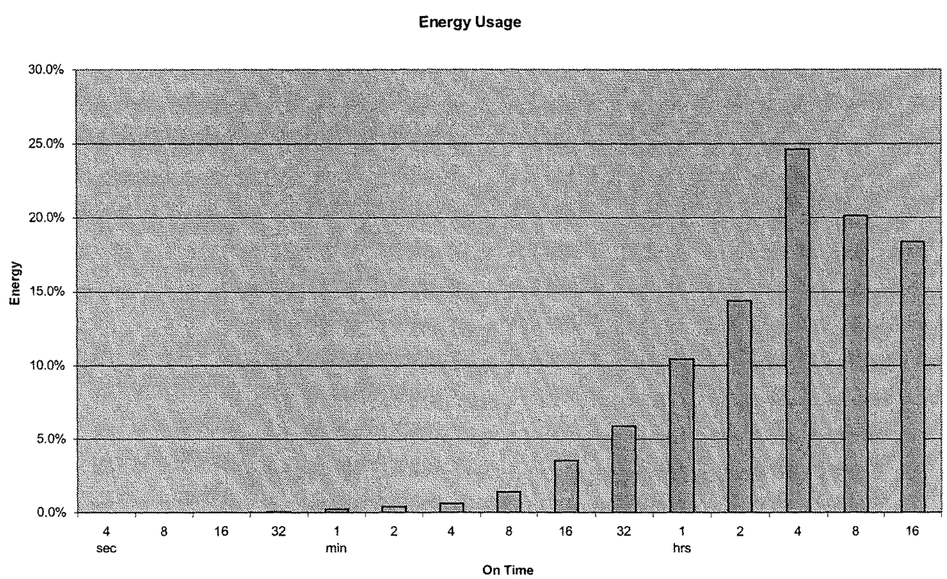

Figure 8. Most of the bathroom fixtures' energy was consumed when the light was left on for 2 hours or longer

Conclusion

A significant finding in this study is the relative usage and energy impact of the bathroom lighting. While many bathroom fixtures are already fluorescent, significant energy savings could be achieved through the integration of occupancy sensors in bathrooms due to the substantial burn hours of these fixtures. Because of their high wattage, incandescent bathroom fixtures offer extraordinary energy savings for occupancy sensors at nearly $40 per fixture per year. But even fluorescent bathroom fixtures could save nearly $10 a year with the addition on an occupancy sensor. Integration of a bathroom lighting controller/occupancy sensor can present energy savings that rival those achieved by retrofitting all table and floor lamps with CFLs, but a much lower initial investment. Assuming that 90% of the 15 million U.S. hotel rooms already have fluorescent bathroom fixtures, an additional 3 billion kilowatt-hours annually can be saved with occupancy sensors that simply eliminate the "on periods" greater than two hours.

In most cases a simple payback of less than two years can be achieved by replacing incandescent lamps with CFLs in table and floor lamps. Many hotels have recognized the energy saving potential of CFLs and mandated their use in all of their facilities. But as many as half of the 15 million hotel rooms in the U.S. still use incandescent lamps in the table and floor lamps. If these remaining portable fixtures were relamped with CFLs, the annual energy savings would be 3-5 billion kilowatt-hours.

Additional research should be conducted on a larger scale and in hotel environments different from Redondo Beach in order to verify these findings. Also, it is critical to obtain user survey information in order to determine the acceptance of these energy savings technologies by the hotel guests. Hotel managers are understandably very reluctant to accept new technologies that they perceive will sacrifice the quality of the guestroom environment—even if the new technology promises to save them money. While more information needs to be gathered, it appears that there are significant energy savings opportunities in hotel guestroom lighting.

Acknowledgments

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