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Energy Savings Through Lighting Control Settings

BOOSTING MULTIFAMILY ENERGY SAVINGS Through Lighting Control Settings

By reducing the off-delay interval to 30 seconds, a building owner can see energy savings of more than 75%.

by Caren Rubin, PE, Tom Ruscitti, and Ian Shapiro, PE

Occupancy-controlled lighting has become a very common feature in homes and apartments and can offer significant energy savings, but the amount of potential savings is directly related to the off-delay setting—the time that the light stays on after occupancy is no longer detected. Building owners can save money by taking the first step of installing occupancy controls, even with an off-delay of 30 minutes, the maximum setting suggested by the ASHRAE 90.1-2010 lighting standard. For many building spaces, however, significantly greater energy savings can be gained by further reducing the lighting off-delay setting. Figure 1 illustrates how, under identical occupancy conditions, the amount of time that the lights remain on in a vacant space can vary greatly depending on the off-delay setting, especially when people enter and leave the space frequently.

To identify effective energy conservation measures in multifamily housing, the New York State Division of Housing & Community Renewal funded a study to investigate the energy-saving effects of lighting controls given real-life occupancy patterns in multifamily residences. Taitem Engineering, PC, located in Ithaca, New York, conducted the study in 2012. The authors of this article monitored and logged occupancy patterns in three high-rise senior-residence buildings, specifically to track occupancy in corridors and stairways. Energy savings were modeled using the logged data, and simulated using various sensor off-delay time intervals. An analysis of the data suggests that an off-delay setting of 30 minutes can cut electric use by about 25% in corridors and 60% in stairways, compared to a baseline of no occupancy lighting control at all. By reducing the off-delay setting to 30 seconds, however, a building owner can significantly leverage these savings—tripling savings from 25% to almost 75% in corridors and increasing savings from 60% to 78% in stairways. The takeaway is that occupancy controls, at any setting, save energy, and that reducing the off-delay setting to the shortest interval possible can provide significant additional energy savings. This article looks at how off-delay setting strategies can be most effectively applied in different building areas, given typical occupancy patterns.

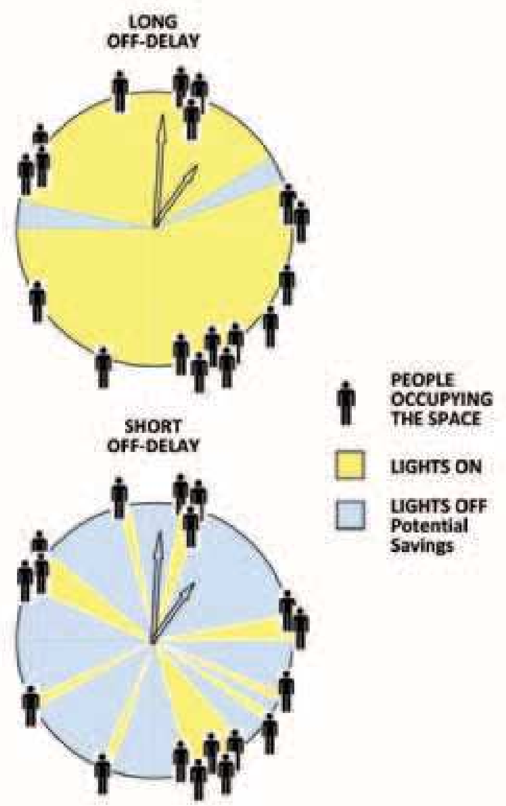

Figure 1. Effect on lighting with varying off-delay settings.

Lighting Reduction Strategies

Lighting reduction in unoccupied spaces is a well-known energy reduction strategy, and energy standards, such as ASHRAE 90.1-2010 ("Energy Standard for Buildings Except Low-Rise Residential Buildings") calls for lighting in most indoor spaces to be reduced or shut off after a period of vacancy. For example, the standard requires that lighting for most indoor spaces be shut off or reduced by at least 50% within 30 minutes after the space becomes unoccupied. The time delay from the end of occupancy until lights are dimmed or shut off by an occupancy sensor control is called the *off-delay time*.

The authors of this study wanted to look at whether additional savings for shorter off-delay times than 30 minutes would be significant, given occupancy patterns experienced by real-world buildings. The study focused on corridors and stairways because these two areas together comprise a significant portion of the common-area energy use in high-rise residential buildings. In a survey of energy audits for 40 high-rise residential buildings, lighting in stairways and corridors comprised 60% of reported common-area electricity use. Despite this high percentage of energy use, only one of the 40 buildings surveyed reported using occupancy sensor controls for stairway and corridor lights, so there is a significant opportunity to capture energy cost savings at relatively low cost by installing lighting controls in many buildings.

The study used actual monitored occupancy patterns to calculate the energy savings achievable by selecting the shortest available off-delay times. A survey of available occupancy sensor lighting controls showed that typical models are available with off-delays ranging from 30 seconds to 30 minutes. The most commonly available off-delay settings are 5, 10, 15, 20, and 30 minutes.

Results of Occupancy Monitoring

To be able to examine the impact of occupancy controls, the authors wanted to identify typical occupancy patterns in actual buildings. Occupancy sensors with data loggers were installed in three high-rise senior-housing buildings for a period of four weeks. In each building, an occupancy sensor and logger were placed in one stairway and one corridor elevator waiting area. The loggers recorded an occupancy event whenever the occupancy sensor was triggered. Table 1 and Table 2 indicate the number of times the logger recorded an occupancy event and show a calculated vacancy rate for corridors and stairways respectively.

Corridor Occupancy Patterns

Differences in the corridor occupancy in each of the buildings may be attributed to various factors, such as apartment density per floor, speed of elevators affecting waiting time, and building-specific resident patterns of movement. However, the overall pattern of more than 97% vacancy in these spaces holds across the three buildings; that is, corridor spaces were only occupied for 3% of the time over the course of a day— leaving those spaces without lighting controls continuously lit.

Stairway Occupancy Patterns

The data reveal that in all three buildings, few people use the stairs over the course of a day, and that overall stairways were

Table 1. Monitored Occupancy Summary for Corridors

	Number of Floors	Apartments per Floor	Number of Occupancies per Day	Average Occupancy per Day in Minutes	Percent Vacant
Building 1	15	12	83.0	30.4	97.9%
Building 2	6	14	92.9	29.8	97.9%
Building 3	5	18	64.5	7.3	99.5%

Table 2. Monitored Occupancy Summary for Stairways

	Number of Floors	Apartments per Floor	Number of Occupancies per Day	Average Occupancy per Day in Minutes	Percent Vacant
Building 1	16	12	14.9	3.0	99.8%
Building 2	6	14	3.1	0.8	99.9%
Building 3	5	18	7.9	1.3	99.9%

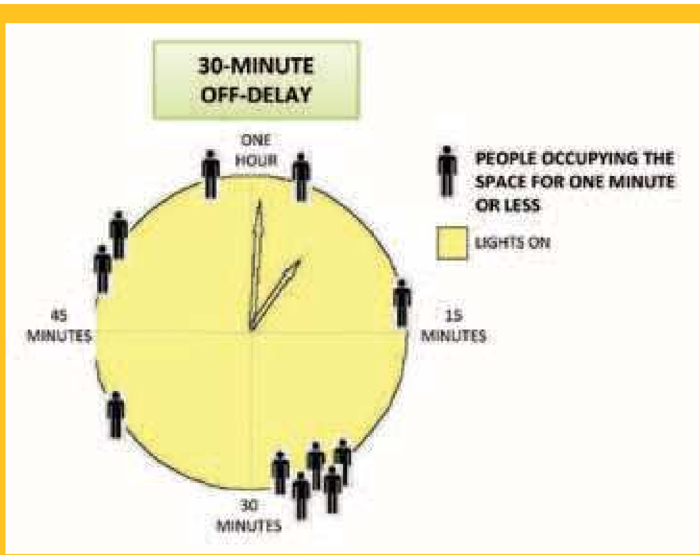

Figure 2. Effect of 30-minute off-delay setting for short-duration occupancies.

occupied for three minutes or less per day. Looking at the data, we speculate that higher occupancy rates in the stairways for any specific building may be heavily influenced, or skewed, by just a few individuals with specific and personal patterns of stairway use. In general, the infrequent use of stairways means that short off-delay settings will not save much more energy than long off-delay settings.

The Effect of Short-Duration Occupancies

According to the data, 95% of all corridor occupancies were under 60 seconds in duration, and 95% of all stairway occupancies were under 20 seconds. Therefore in the great majority of instances, an off-delay of 30 minutes will result in lights remaining on *far* longer than actually needed. In spaces like corridors and stairways, imagine that the light comes on for typically less than 60 seconds while someone walks by and

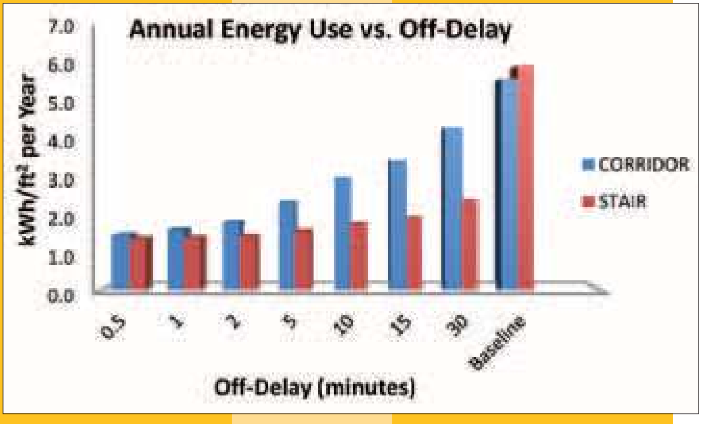

Figure 3. Annual energy use for various off-delays.

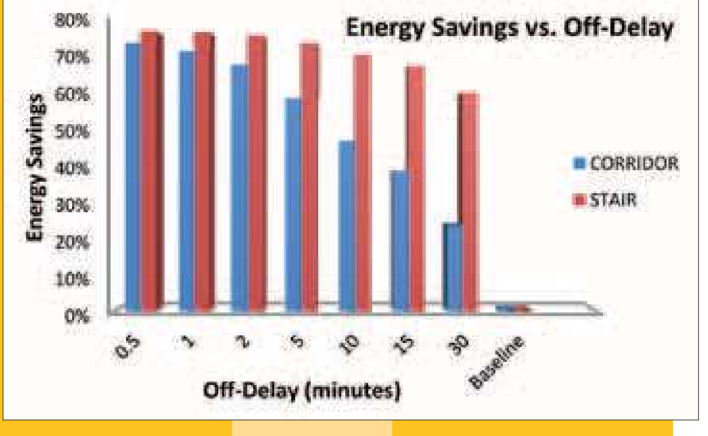

Figure 4. Energy Savings for various off-delays.

then stays on for another 30 minutes, *unnecessarily lighting an entirely empty space*. For busy times of the day, the occupancy sensor is likely to be retriggered before the 30-minute off-delay expires, resulting in almost continuous lighting.

Energy Savings Model Results

As noted above, the Taitem study modeled potential energy savings for various off-delay times using the actual vacancy intervals logged for each building, 24 hours per day over four weeks. The savings were calculated in the following way. For a given off-delay time, each vacant interval throughout the day was compared to the off-delay time. If the off-delay time was shorter than the vacant interval, then potential savings equal to the difference were recorded. If the off-delay time was greater than the vacant interval, no potential savings were recorded.

The calculated energy consumption for the baseline case assumed ASHRAE guidelines for minimum lighting levels in watts per square foot (W/ft^2) for corridors and stairways. Similarly, the energy consumption was calculated for different off-delay scenarios using the same W/ft^2 lighting level assumptions. See Figure 3 for a graphical display of the results.

We then calculated energy savings for each off-delay scenario by subtracting avoided energy consumption during off-periods from the baseline, continuously lit, case. A comparison of the energy savings for different off-delay settings is presented in Figure 4. These comparisons show not only the potential energy savings that result from taking the first step to install occupancy-controlled lighting, but also the *very significant additional savings achievable by selecting the shortest possible off-delay setting.*

It should be noted that we compared the savings of each scenario to a baseline of 24-hour lighting operation because a survey of energy audits showed that the vast majority of high-rise residential buildings are not yet equipped with occupancy lighting controls, and lights in corridors and stairways are continuously lit.

Standby Lighting and Off-Delay Controls

Bilevel occupancy controls are becoming more readily available, allowing the use of various combinations of off-delay times and standby lighting levels during unoccupied periods. One popular bilevel fixture allows a minimum standby lighting level of 5% of full fixture output for each fixture, enough to provide a basic level of safety lighting for the instant before the occupancy-controlled lighting turns on. In order not to overstate potential energy savings, we chose this configuration for our analysis of energy savings, as presented in Figures 3 and 4 discussed above. Specifically, for a standby lighting level of 5% full output (90% reduction), we used a corresponding 78% input wattage reduction that is typical of the nonlinear relationship between input wattage and output when fixtures are dimmed. Other common lighting control scenarios include an occupancy sensor for every other fixture or for two out of three fixtures. Each configuration will result in different energy savings due to off-delay settings.

The Effect of Resident Populations

The resident population for any particular building has its own unique occupancy patterns. For example, a building occupied primarily by professionals will likely have fewer people in the corridors or stairways from 9 am to 5 pm, with peaks between 7 am and 9 am and between 5 pm and 7 pm. Younger professionals may have another peak between 10 pm and 2 am when returning from socializing. Laundry rooms will have occupancy periods of 5–20 minutes at a time, as residents start and finish and fold laundry loads. *Generally, the more people are in the space, intermittently, the more savings can be achieved by reducing the delay time of the lighting controls.* A greater number of short occupancies, as in corridors, results in a modest savings with a 30-minute off-delay, but a large savings will result when a shorter off-delay is set. In stairwells, where there are very few, brief occupancies, the greatest savings are achieved by taking the first step to install occupancy-controlled lighting at any off-delay setting, but additional, modest savings can be achieved when off-delay times are shortened. The contrast between the savings in these two areas can be seen in Figure 4, where a further 15% savings are gained by reducing corridor off-delays from five minutes to 30 seconds, while that same change saves a little less than 3% in stairways. *One trend holds throughout all spaces: regardless of the occupancy pattern, reducing off-delay times will always achieve an additional energy savings.*

The Effect of On-Off Cycling on Fixture Life

The energy savings are clear, but the picture is not complete without considering that fluorescent lighting life will be reduced by many short on-off or dimming cycles. Our investigation into this issue did not reveal any clear predictions for reduced lamp light subjected to cycling. The extent to which fluorescent lighting life is affected by cycles depends greatly on the bulb and ballast types; these data are sometimes provided by the lighting manufacturer, but usually for on-off cycles of three hours or more.

When adding occupancy controls to existing lighting, it is important to replace instant-start electronic ballasts with programmed-start ballasts. Instant-start electronic ballasts start fluorescent lamps in a fraction of a second by providing a voltage that is high enough to start the lamp without preheating the lamp electrodes. While they are energy efficient and fast, these ballasts cause stress on the cold electrodes that results in fewer on-off cycles before lamp failure. Programmed-start ballasts work by first applying, and then maintaining, a precise voltage to heat the lamp electrodes before applying the voltage to ignite the lamp. This minimizes lamp deterioration caused by oxides sputtering off the cold surfaces of the electrodes. Therefore, lamps with programmed-start ballasts may survive up to 5 times as long as lamps equipped with instant-start ballasts. When choosing new fixtures with integrated controls, be sure to choose those with programmed-start ballasts. Most fluorescent lamps, when used for occupancy-controlled applications, will have a recommended burn-in period during which the lamp is continuously lit. Many occupancy sensors will have a built-in feature to accommodate the burn-in period.

As fluorescent fixtures with occupancy controls continue to gain market share, the industry will likely respond with components that are more robust to on-off cycling. For example, most manufacturers already offer extended-life T-8 lamps. Bulb and ballast replacement intervals should be monitored to better understand the trade-off between replacement costs and clear energy savings. With good maintenance and energy records, off-delay times can be adjusted upward if it appears that lighting life is being compromised.

What We've Learned

When lighting controls are being evaluated for a building, our study shows that it pays to choose occupancy controls that allow for off-delay times as short as 30 seconds. For occupancy controls that do not allow such short off-delays, significant savings will be achieved by selecting the shortest allowable off-delay setting. In all common areas, very significant energy savings are realized by using much shorter off-delays than the 30-minute maximum specified in ASHRAE 90.1-2010.

Not surprisingly, the savings achieved with different occupancy control settings depend on occupancy patterns. In corridors with mostly short-term occupancies, approximately 24% savings are achieved by first introducing occupancy controls with a 30-minute off-delay. During periods of the day when more people move through the space, it is likely that someone will trigger the occupancy sensor before the 30-minute off-delay interval passes, meaning that the lighting will be continually triggered, and the space continuously lit. This is why very significant savings can be achieved by selecting the shortest off-delays. Setting a 30-second off-delay can provide a total energy savings of approximately 74% over no controls at all.

One caveat to short off-delays: The occupancy data suggest that off-delays of less than one minute should be avoided in an elevator waiting area to prevent unwanted light reduction while an occupant is standing quietly waiting for the elevator. Some lighting controls allow sensitivity adjustments to address this problem. The possibility of unwanted light reduction in other corridor areas or in stairways is very small, since occupants will pass through these areas very quickly.

For very low-occupancy areas like stairways, the greatest energy savings (nearly 70%) come from the first step of installing occupancy controls, even with a 30-minute off-delay time. The vacancy periods are so long that the occupancy sensor will almost always turn off the lights before the next occupancy. Additional savings of about 10% can be achieved by selecting an occupancy control that allows off-delays as short as 30 seconds, bringing the total savings up to almost 80% compared to 24-hour lit operation.

General Recommendations

For saving light energy in the common areas of multifamily-buildings, we recommend the following.

- In all areas, an occupancy sensor with a 30-minute off-delay will result in some savings. *However, much greater energy savings can be achieved with shorter delay settings.*
- In corridors and stairways, use bilevel lighting with standby lighting during vacancies set to 5% of the fixture output, unless site-specific safety conditions require stronger lighting.
- In corridors, set the off-delay to a maximum of 15 minutes, preferably less; off-delays of 1, or even 5, minutes will greatly increase savings. *Reduce the off-delay to 30 seconds to maximize energy savings.*

- In stairways, set the off-delay to a maximum of 15 minutes. Set to shorter off-delays for even greater energy savings.
- At elevator waiting areas, set the off-delay to 1 or 2 minutes to maximize energy savings while reducing the possibility of false shutoffs when residents are waiting.
- In low-rise buildings that do not have elevators, treat stairways the same as corridors for off-delay settings and projected savings.
- Use only programmed-start ballasts for all lighting controlled by occupancy sensors (dimming, bilevel, and full-shutoff applications).
- Consider monitoring ballast and lamp life when using off-delays shorter than 5 minutes. Multistory buildings provide a perfect setting to make controlled comparisons and adjust off-delays to fit your site conditions. Consider setting hallway controls on two floors at a 5-minute off-delay, or less, while the others are set at 30 seconds. Then compare lighting replacement costs over a two-year period. Balance the replacement costs against your energy savings to find the right strategy for your buildings.

When considering lighting controls based on occupancy sensors, keep these two points in mind. Installing any level of occupancy sensor control will yield savings—especially in infrequently used areas such as stairways and corridors. And reducing the off-delay settings to turn the lights off (or dim them) in the shortest possible time can yield substantial additional energy savings—especially where people come and go frequently.

Caren Rubin, PE, LEED AP, *has worked for over 22 years in the areas of HVAC mechanical design, construction, energy, and energy analysis. She is currently a mechanical engineer for LaBella Associates, PC.* **Tom Ruscitti** *provides test engineering, statistical analysis, and test design consulting for research, engineering, and material development related to energy systems.* **Ian Shapiro, PE, LEED AP,** *is president and founder of Taitem Engineering, Ithaca, New York. Taitem specializes in mechanical, electrical, and structural design; LEED consulting; commissioning; energy studies; and energy research.*

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>> learn more

Caren Rubin, Tom Ruscitti, and Ian Shapiro. Taitem TechTip: *Boosting Energy Savings through Lighting Occupancy Control Settings in Multifamily Buildings*, Ithaca, New York: Taitem, 2012. To obtain a copy of this report, contact Taitem Engineering, 110 South Albany St., Ithaca, New York 14850. Tel: (607)277-1118; Web: www.taitem.com.