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Integrated Lighting Approach Saves Energy in Post Office Facilities

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ABSTRACT

The United States Postal Service (USPS) has made numerous efforts to improve the lighting quality and efficiency in their facilities. These efforts have included both traditional retrofits such as the transition to T8 lamps/electronic ballasts and more experimental approaches such as light pipes and sulfur lamps. However, these efforts have focused primarily on their industrial and plant facilities and have had little impact on their small and medium sized facilities, which comprise roughly 90% of their total building stock. These efforts have also neglected the affinity between task and ambient lighting functions.

The objective of this project was to develop and demonstrate an integrated lighting system that saves energy while improving the lighting distribution and quality in small and medium sized USPS facilities. Work included the evolution of a novel task lighting fixture designed explicitly to improve the light distribution within the carrier case letter sorting station. The new task light system was developed to work in combination with a high efficiency, low-glare ambient lighting system mounted on the ceiling. The use of high-performance task lighting allowed the ambient lighting component to be reduced, thereby limiting the amount of glare produced and reducing the amount of energy consumed.

Design Approach

From the outset, the design process balanced the quality of the new lighting system equally with energy savings. By designing a task lighting system that provides proper illumination for all sorting tasks, ambient light levels can be reduced significantly to levels sufficient for general circulation. Thus, the high quality of the new task lighting opens the door for energy savings through the reduction of the ambient light levels. The three main components of this integrated lighting approach can be summarized as follows:

- High-efficiency, high-performance task lighting. The task light includes custom optics, lamps, and ballasts housed in a high efficiency fixture with a fixture efficiency of 80%. This novel fixture is designed explicitly to improve illuminance and light distribution throughout the carrier station and eliminate any of the dark spots and shadows within the letter sorting station.
- Low-glare ambient lighting. The new ambient system includes the installation of new ceiling fixtures, lamps, and ballasts designed to reduce the potential for high angle luminance which produces glare. Ambient light levels are set at 25 to 30 foot-candles to accommodate general circulation functions while limiting the glare inside the letter sorting stations.
- Advanced lighting controls. Each carrier station's task lighting fixture is individually controlled with occupancy sensors designed to turn off the task fixture when the

carrier leaves the post office and turn on the task fixture when the carrier returns. Each individual sensor can be adjusted for sensitivity to optimize performance and energy savings.

Demonstration

The first demonstration of this integrated approach was installed in the Rodeo, CA Post Office. The total lighting load (ambient + task) at the Rodeo site was monitored before installation of the new system to establish a baseline load. The total lighting load was monitored again after installation of the new system to characterize the retrofit load. Analysis of these data indicates a reduction of 71% in the total lighting load. This includes a 72% reduction in the ambient lighting load and a reduction of 65% in the task lighting load. (See Figure 1.)

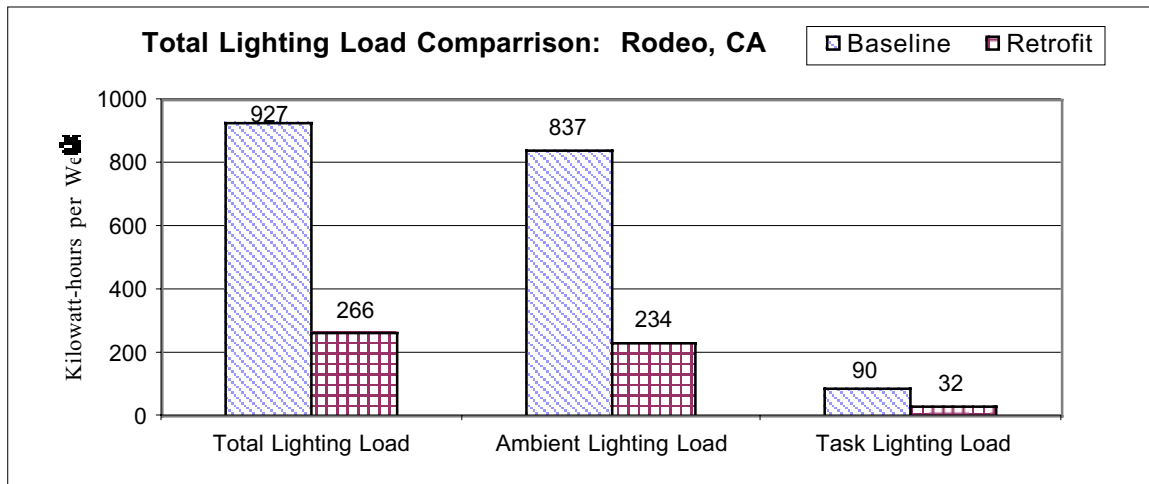


Figure 1. Lighting load comparison

Table 1 lists a comparison of the baseline lighting system and the retrofit lighting system including task lighting, ambient lighting, and control components.

Table 1. System comparison of baseline versus retrofit systems

Technology	Baseline	Retrofit
Ambient Lighting (lamp and ballast)	Eight-foot, T12 linear fluorescent lamps with core magnetic ballasts.	Four-foot, T8 linear fluorescent lamps with electronic dimming ballast.
Ambient Lighting (luminaires)	Eight-foot tandem wraps (pendant mount, 2 lamps per luminaire)	Eight-foot tandem wraps (surface mount, 4 lamps per luminaire) (1:1 swap)
Ambient Controls	Limited use of timers and manual scheduling.	Increased use of timers and scheduling functions.
Task Lighting	T12 linear fluorescent lamps with core magnetic ballasts. 50 watts per fixture	Twin-tube compact fluorescent lamps with electronic ballasts. 50 watts per fixture (1:1 swap)
Task Controls	None	Occupancy sensors integrated into each carrier station.

Task Lighting

The baseline task lighting fixture employs a 40-W T12 lamp and a core magnetic ballast for a total system power of 50-W. These fixtures provided inadequate illuminance in the carrier station delivering an average level of 25 fc on the task plane. Of even greater concern is the range of 10 to 50 fc throughout the carrier station. High degrees of modulation in illuminance levels lead to eyestrain and fatigue.

These fixtures were replaced by custom designed prototypes that utilized new optics and components, and integrated an occupancy control unit. The total system power of these prototypes is also 50-W. While no energy savings are achieved from the replacement of the baseline task fixture (except from the occupancy sensor), the superior distribution and illuminance levels from the custom prototype allowed for a major reduction of the ambient lighting component.

The custom prototype fixture offers an efficient optical package that utilizes a highly reflective (90%) diffuse aluminum reflector insert in conjunction with 80% reflective flat white paint on the interior surface to reduce reflected glare while maintaining maximum light output. Deep-welled fixture bodies are fixed in an angular spread from the center axis of the carrier station to mitigate glare while providing even distribution across the task plane. This deep-welled design also creates a high degree of cut-off, reducing high-angle glare, and directs the majority of the light onto the task plane (see Figure 2).



Figure 2. Carrier case letter-sorting station with custom prototype task fixture

The custom fixture uses two 36-W twin-tube compact fluorescent lamps, which are under-driven for a total system power of 50-W. This lamp source provides superior color rendition with an increase in lamp efficacy and life. The electronic ballast upgrades the control mechanism to the leading edge of ballast technology with an advanced end-of-life shut-off function for added safety.

The new task lighting system provides evenly distributed illuminance on both the horizontal and vertical task planes. The distribution under the custom task fixture offers significantly less modulation throughout the carrier case with a range of 40 to 55 fc. While the baseline fixture delivers adequate lighting levels on the center face of the sorting station, it delivers inadequate illumination along the left and right wings. (See Figure 3.)

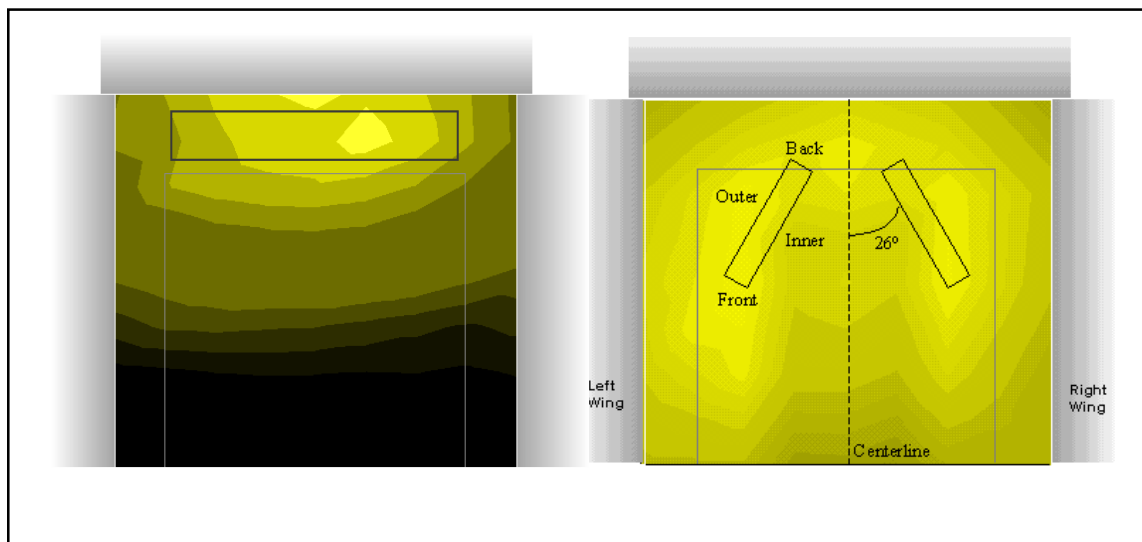


Figure 3. Task plane isofootcandle plots of baseline task fixture (left) and prototype task fixture (right)

Ambient Lighting

The Rodeo post office has 20-foot high ceilings, which is typical of postal facilities. The baseline ambient system utilized eight-foot T12 lamps and magnetic core ballasts. Baseline ambient illuminance in the workroom ranged from 50 to 75 fc at the task-level with an average of 65 fc. Due to physical obstructions from the carrier case stations themselves, this translated into only 15 to 25 fc in the carrier stations. This high level of ambient illuminance provided far more light than necessary for other non-detail-oriented tasks in the workroom, but failed to provide sufficient illuminance in the carrier case stations.

The baseline ambient system was replaced with eight-foot tandem wraparound fixtures with dimming capabilities of 10% to 100%. The dimming capabilities were necessary for maximum control over the ambient conditions for experimentation. These fixtures upgraded the ambient lighting from T12 lamp and magnetic core ballast systems (837 kWhrs/week) to T8 lamp and electronic ballast systems. This upgrade to efficient components resulted directly in a 25% reduction (to 605 kWhrs/week) in the total lighting load. The ambient lighting was then dimmed down to 25 to 30 fc in the areas where the carrier cases are located. In other areas, such as near the clerk cases that have no task fixtures, the baseline illuminance level of 65 fc was maintained. This decrease in the ambient lighting levels resulted in an additional 25% reduction (to 370 kWhrs/week) in the total lighting load. A further reduction to the total lighting load of 15% (to 234 kWhrs/week) was achieved through tighter regulation of the ambient operating schedule (see Figure 4).

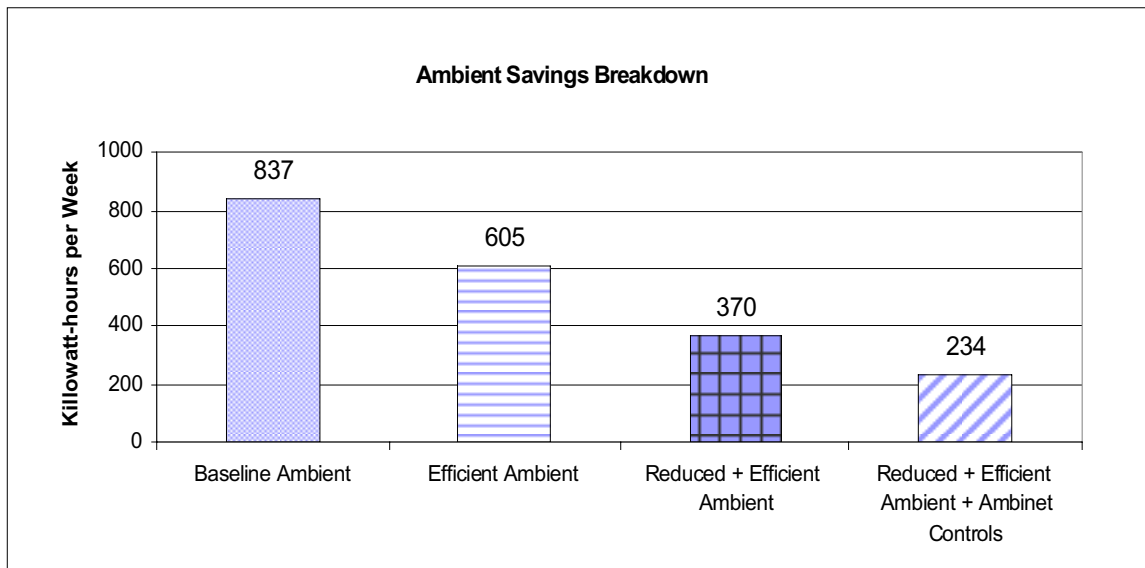


Figure 4. Ambient savings breakdown

Lighting Controls

Each of the custom prototype task fixtures was outfitted with an occupancy control unit. This occupancy controller operates on passive infrared technology and has been strategically placed in the sorting station to avoid any mis-triggers from individuals walking past the sorting station but not into it.

The daily hours of operation for the baseline task lights were monitored and recorded. From the analysis of these data, three distinct usage patterns emerged: individuals who regularly turned their lights off at the end of the morning when their sorting duties were complete, individuals who turned their lights off at the end of the workday, and individuals who left their lights on all of the time. The daily hours of operation were then monitored and recorded for the custom prototyped task fixtures. These results were compared with the baseline data to calculate the energy savings gained from the use of occupancy controls. (See Figure 5.)

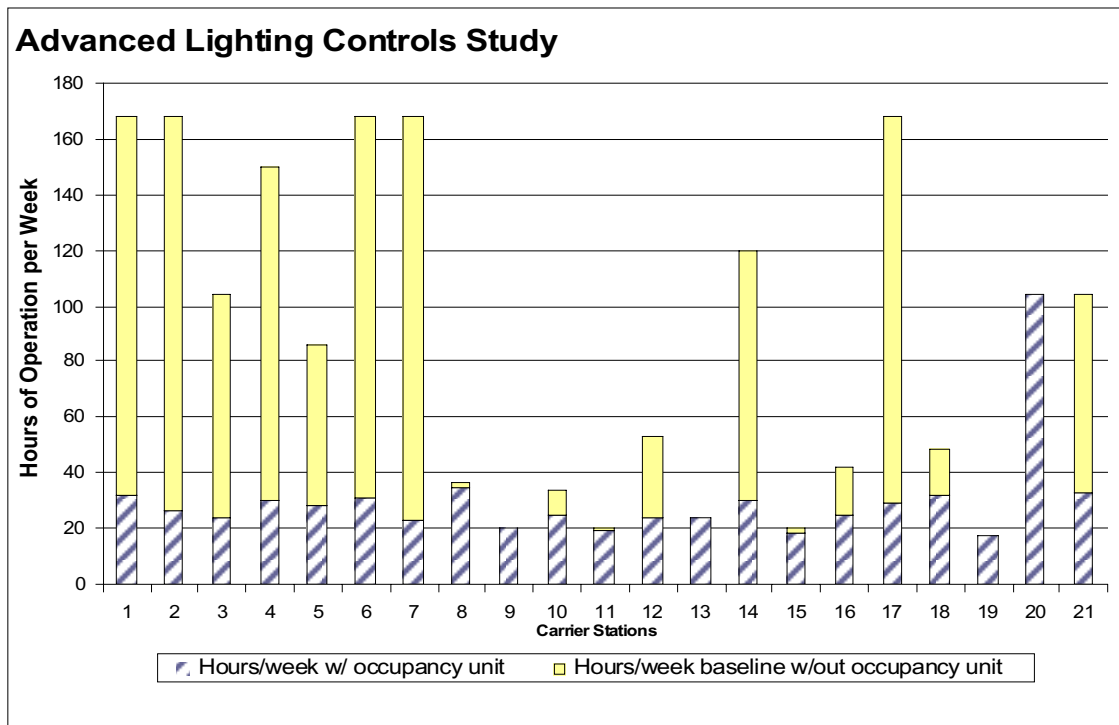


Figure 5. Advanced lighting controls study

Each column represents the recorded hours of task light operation for one week in each carrier case station without an occupancy sensor. The lower level shows recorded hours of task light operation per week in each carrier case station with an occupancy sensor. The upper portion of each bar represents the energy savings. (*Note: Station #20 remained the baseline task fixture and was not equipped with an occupancy sensor.)

The integration of an occupancy control system in each of the stations accounted for a reduction of 65% of the original task lighting load (from 90 to 32 kWhrs/week) or a

6% reduction of the total lighting load. Because the task load is small relative to the ambient load, this dramatic reduction from the occupancy sensor did not have a large effect on the overall lighting savings.

Conclusion

The installation of the new integrated system in the Rodeo, CA Post Office resulted in a 71% reduction in the total lighting load. These savings can be broken down into the following components:

- Efficient ambient savings: the upgrading of the ambient lighting system to more efficient technologies accounted for a reduction in lighting energy consumption of 25%.
- Reduced ambient savings: reduction of the ambient lighting levels accounted for a reduction in lighting energy consumption of 25%,
- Ambient control savings: a more stringent ambient lighting schedule offered an additional 15% reduction in total lighting energy consumption.
- Task control savings: the addition of occupancy controls to the task fixtures offered an additional 6% reduction in the total lighting energy consumption

While the new task lighting offers no direct energy savings, it is the enhanced performance of this fixture that allows the reduction in ambient light levels. (See Figure 6.)

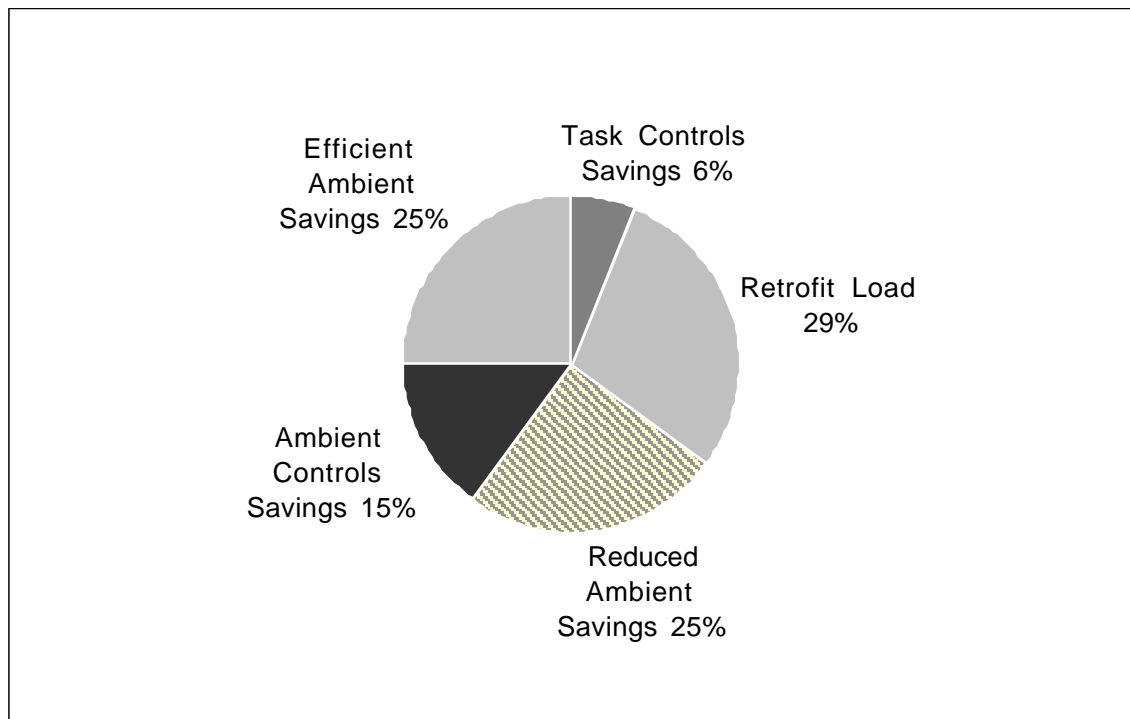


Figure 6: Energy savings breakdown

This demonstration has shown that achieving both energy savings and improved lighting quality is feasible. This unique integrated lighting approach can be applied to nearly 35,000 postal facilities nationwide with estimated energy savings of 50% in the lighting

energy consumption for each facility. The ambient lighting can be modified during a regularly scheduled upgrade, or the existing ambient system could be de-lamped to achieve savings from the reduced ambient portion of the concept without the cost of installing a new ambient system. However, for maximum energy savings, the integrated approach will provide the best results.

This integrated lighting approach is not limited to postal applications. These design principles can be incorporated into industrial facilities of all types, specifically those where individual workstations comprise a significant portion of the industry.

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