General Services Administration
Public Buildings Service

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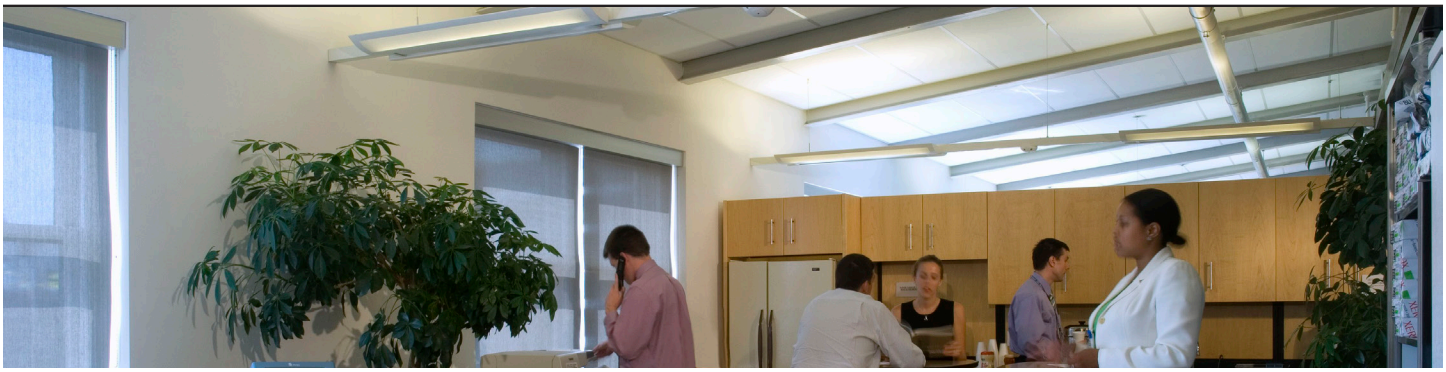
OCCUPANT RESPONSIVE LIGHTING

Responsive Lighting Systems Save Energy

Despite widespread adoption of efficient lamps and ballasts over the past several decades, lighting still accounts for more than a third of the electricity used in U.S. office buildings. With a real estate portfolio of more than 9,600 assets nationwide, most of which include open office space, GSA has an abiding interest in identifying energy-efficient lighting solutions that can help its client agencies conserve energy and reduce costs. Toward that end, GSA's GPG program recently evaluated the performance of occupant responsive lighting technology in five federal buildings. The technology consisted of a workstation-specific (WS) lighting system, dimmable ballasts, occupancy sensors at each WS luminaire, and a Lighting Management Control System (LMCS) that coordinated these components. Seven sites were selected within the five buildings to capture a diverse group of agencies, occupancy patterns, work styles, and site and baseline conditions. Results showed energy savings that ranged from 27% over baseline conditions for spaces illuminated 12 hours a day, five days a week, with regular occupancy patterns, to 63% for a call center illuminated 18 hours a day, 7 days a week. In the call center, payback was less than 7 years.

The GPG program enables GSA to make sound investment decisions in next-generation building technologies based on their real-world performance.

INTRODUCTION



"Not only does this assessment demonstrate that responsive lighting delivers deep energy savings across the board, it also helps GSA understand where deployment of this technology maximizes payback."

Ruth F. Cox
Regional Administrator
Region 9 - Pacific Rim
General Services Administration

What We Did

EXPERTS FOCUSED ASSESSMENT ON THREE CONTROL STRATEGIES

The GSA's GPG program worked with the Department of Energy's Lawrence Berkeley National Laboratory (LBNL) to select demonstration sites and compare the performance of WS lighting systems to the systems in place prior to retrofits. In general, pre-retrofit lighting systems consisted of recessed luminaires that were regularly spaced in open areas or distributed based on layout in private offices. They used neither dimmable ballasts nor photocells, though some did employ zonal occupancy sensors. Retrofit systems, by contrast, were centered over each cubical in the open office and provided both upward-directed (ambient) and downward-directed (task) light; the up-light and down-light components had separate ballasts and could be controlled individually. Although responsive lighting systems can employ a multitude of control strategies, LBNL's evaluation focused on three: institutional tuning and scheduling (where building managers program default light levels and hours of operation within the LMCS); occupancy sensing (which adjusts light levels in response to the presence or absence of occupants); and personal control (where occupants adjust WS light levels to suit their preferences).

What We Measured

EVALUATION TRACKED CRITICAL METRICS

Circuits supplying power to lighting fixtures were metered during both pre- and post-retrofit periods at each site. Power data was converted to lighting power density (LPD), which was converted in turn to energy use intensity (EUI), the unit of measurement used to describe building energy use. Finally, EUIs were calculated for each site based on an assumed typical distribution of 251 weekdays, 104 weekend days, and 10 holidays per year. Pre-retrofit and post-retrofit annual EUIs were then compared to determine energy savings at each site. Greenhouse gas (GHG) emissions were also summarized. Desktop illuminance levels were taken in open office workspaces, and an assessment of the economic benefits resulting from this project was performed. Last, occupant surveys were administered before and after the lighting retrofit at each site.

FINDINGS

SIGNIFICANT ENERGY SAVINGS Through the use of advanced lighting controls, retrofits generally achieved energy savings of around 1 kWh/sf/yr, resulting in calculated annual savings by site ranging from 27% to 63%. The large variations in energy savings were attributable mostly to the way space was used. Spaces where the tenant required illumination for long workdays and/or workweeks, with variable levels of workstation occupancy during those hours, showed the greatest savings. Spaces where the tenant required illumination for a 12-hour workday, five days a week, and whose employees were at their desks most of the day, showed the lowest level of savings.

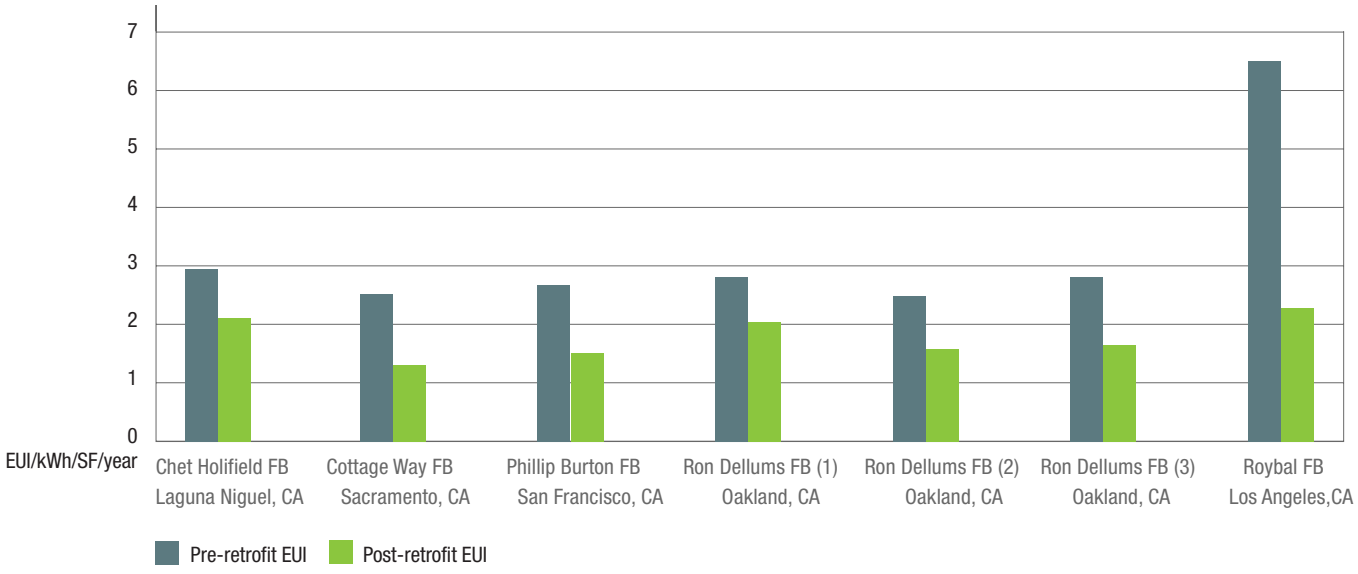
LOW SIMPLE PAYBACK FOR SITES WITH LONG HOURS, VARIABLE OCCUPANCY Simple payback for one of the sites, a call center at the Roybal Federal Building, was calculated to be less than 7 years. While no other site showed comparable payback, a key finding of this study is that, as a result of GSA's ongoing efforts to save energy, baseline efficiency in the 7 selected sites was already relatively high, compared to norms in commercial building office space. Therefore, while additional energy savings that contribute to achieving GSA's mandated goals were realized in all spaces, these savings did not in all cases deliver payback comparable to Roybal's. Finally, it should also be noted that WS lighting is an emerging technology, and costs are expected to decline with increased market penetration, which would reduce simple payback under all circumstances.

SATISFIED OCCUPANTS Surveys demonstrated that occupants were generally more satisfied with the retrofitted lighting systems. They provided better quality light and less glare, occupants observed.

RATIONALE FOR TARGETED DEPLOYMENT Offices with 3-tube 2x4 troffer light fixtures, operating days that are 14 hours or longer, utility costs of $0.11/kWh or greater, and an occupancy pattern that is variable, offer the best potential for energy savings at a low simple payback and therefore a strong argument for targeted deployment. Future cost reductions could justify wider deployment within GSA's portfolio.

Annual Energy Savings by Site

Energy savings ranged from 27% to 63%



CONCLUSIONS

These Findings are based on the report, "Responsive Lighting Solutions," which is available from the GPG program website, www.gsa.gov/gpg

For more information, contact GSA's GPG program gpg@gsa.gov

What We Concluded

SPACES WITH LONG OPERATING HOURS AND VARYING OCCUPANCY PATTERNS BENEFIT MOST

The workstation-specific (WS) lighting systems evaluated in this study delivered deep energy savings, comparable if not superior light levels, and increased occupant satisfaction. They were found to be most cost effective in spaces with long operating hours and varying occupancy patterns, such as the call center cited above. Greater implementation of personal controls, which would allow occupants to set and adjust light levels in real time within boundaries set by building policy, would result in still better performance.

Lessons Learned

TRANSPARENCY AND TRAINING COULD IMPROVE PERFORMANCE

This demonstration study revealed a variety of lessons for responsive lighting control retrofits. They include the following:

THOROUGH COMMISSIONING IS ESSENTIAL For the most part, formal and well-documented commissioning did not occur in the study areas. This impeded performance and in some cases resulted in extended work to address occupant complaints and correct performance issues. Thorough commissioning that is both transparent and well-documented is essential to providing lighting systems that match owner intent, operate effectively, and can be maintained over time.

CONTROL INTERFACE MUST BE INTUITIVE The control system studied here presented some challenges for post-commissioning operation and a steep learning curve for system operators. Advanced lighting control systems should be intuitive to operate, with well-designed user interfaces and useful data presentation. Related, appropriate training should be provided to operators in order to counter the steep learning curve and maintain investment in the commissioning process.

PERSONAL CONTROLS CAN IMPROVE PERFORMANCE Because of GSA security restrictions and a lack of understanding on the part of occupants about how to request changes in light level settings, personal control was implemented infrequently during this study. This should be remedied. Direct and easily accessible control over workspace light levels allow occupants to obtain the full benefits of the WS lighting system, which could result in increased energy savings, increased satisfaction, and improved performance.