In 2009, when one of the world’s largest commercial real estate management companies took over operations of a 200,000 square foot parking garage adjacent to San Francisco’s popular Fisherman’s Wharf tourist destination, a lighting system upgrade was among its top priorities. The parking garage has never had a problem attracting customers, but keeping energy costs in check was an ongoing issue. As a first step, the new management team upgraded the lighting system to high efficiency T5HO fluorescent lamps in enclosed fixtures. With the lights on 24x7 and significant daylight available on the upper levels, a lighting control system was the obvious next step.

The management company determined that traditional wired lighting controls would be cost-prohibitive while providing only limited functionality. Alternatively, the Adura Wireless Lighting Control System delivered a flexible and scalable platform, able to support the facility’s changing needs while providing an attractive financial payback.

Goals

The management company’s criteria for selecting a lighting control retrofit solution required that the energy savings should result in an investment payback in 3 years or less. A primary factor in reaching this goal was controlling rewiring costs – in effect, requiring a wireless solution. After previous experiences with discrete lighting control components that inconvenienced occupants, the management company wanted a system that would enhance safety and occupant comfort. Lastly, the management company sought comprehensive data collection and real-time energy monitoring capability, realizing that continuous operational improvement requires accurate live reporting.

Application

Adura’s Wireless Lighting Control System with flexible control and energy management features increased energy efficiency while providing powerful new management tools. The primary control strategies deployed in this parking garage are daylight harvesting and occupancy detection.

- **Daylight Harvesting**: Adura’s system utilizes photocells that communicate across the garage through the Adura wireless mesh network, controlling lights in the daylit perimeter areas of the upper levels in response to changing daylight levels. Changes to daylight harvesting scenarios can be easily made remotely.

- **Occupancy Detection**: The Adura system responds to the real-time use of the garage. To enhance occupant comfort and security, occupancy sensors are strategically placed and are operated with unique intelligence by the Adura system, such that garage areas are illuminated ahead of pedestrian or vehicle traffic.
This predictive response is a key difference between the networked, intelligent Adura system and conventional approaches with occupancy sensors hardwired to specific fixtures.

- Pairs of wide-view occupancy sensors are placed at the elevator lobbies, stairwells and entrances to all levels, all connecting ramps and at the beginning of all traffic aisles to achieve maximum coverage and granular lighting control.

- Occupancy zones are defined down to the fixture level and aggregated into flexible groupings, responding with intelligence to real-time movement within the garage.

- Occupancy sensor timeouts are remotely programmable and easy to adjust by the facility managers as required.

**Demand Response:** The Adura system enables automatic load shedding in response to utility requests. When the facility will elect to participate in such programs and a utility request is received, the lighting is reduced according to predetermined scenarios. This enables the management to take advantage of attractive Smart Grid incentives, further increasing the total system savings.

**Situational Flexibility:** The Adura system provides facility managers with the ability to adjust and change control strategies, preset schedules and scenes that may be required for special events or demand response days when load shedding is requested by the local utility. For example, individual lights can be instructed to maintain their on or off status regardless of occupancy or daylight.

**Preventative Maintenance & Enhanced Safety:** The Adura solution streamlines lighting system maintenance and reduces security risks by proactively notifying the management team of light fixture failures or vandalism. This greatly enhances occupant safety within the garage and reduces the facility's potential liability while also reducing maintenance costs.

- The Adura system checks for lamp and ballast failure by tracking real-time energy use at the fixture level and monitoring for any variation from the intended power consumption. When such failure is detected, an alert is generated with location-specific details. The management personnel is then informed that maintenance is required, greatly reducing the average time until repairs are completed.

- Safety within the garage is improved by the system’s enhanced occupancy detection working in tandem with the garage’s video surveillance system. When occupancy sensors are triggered, an occupancy alert is created. The security team can correlate the alert with their surveillance of garage patrons driving, parking or walking within the garage. If none of these legitimate activities is in progress, a security officer investigates the level to ensure that there is no unlawful activity.

**Continuous Operational Analysis and Improvement:** The Adura system collects sensor data and energy use and logs it into a powerful database. Analysis and reporting tools allow the garage management to review the facility use patterns in each functional area to deduce operational trends and adjust control strategies for maximum efficiency and effectiveness. For example, database mining allows reporting on usage and occupancy patterns in every section of the garage. Enabled by this information, the garage management can make decisions such as closing off certain areas at specific hours to reduce its operating costs.

**Results**

The Adura Wireless Lighting Control System has exceeded all criteria for this parking garage retrofit. The Adura system is delivering 65% maximum energy savings, 40% total energy savings and is on track to deliver a 24-month payback period.

**About Adura Technologies**

Adura Technologies provides a ZigBee wireless mesh lighting control and energy management system that enables corporate real estate users, facility managers and building owners to implement energy efficiency and load curtailment strategies at a fraction of the cost of traditional control systems. Non-invasive and universally compatible, the Adura system is ideal for retrofit, renovation and new construction projects. The system supports fluorescent, LED, Induction and eHID light sources. Adura’s solution qualifies for up to 14 LEED Credits, Utility Rebates, Federal Tax Credits, and the company is recognized as a 2010 Global Cleantech Top 100 Company. Adura is backed by NGEN Partners, VantagePoint Venture Partners and Claremont Creek Ventures. For more information, please visit www.aduratech.com.
Data Analysis

This section contains in-depth analysis of data collected by Adura’s system to allow a better understanding of how savings and operational benefits are achieved and to assess the value contribution of the system components. The data shown is from a Sunday, the second busiest day of the week for this particular garage located in the heart of San Francisco’s tourist and nighttime center, experiencing daytime as well as significant nighttime activity. Savings are higher for most other days.

The physical layout of the garage is displayed below. The Adura system’s live-view shows individual occupancy sensors state (triggered or not) and each light fixture state (on or off).

Occupancy Sensing

The use of occupancy sensors, while widely practiced inside buildings, is not common in garage lighting systems. To understand their contribution, we have leveraged Adura system’s logging of all events on the network in a typical 24-hour period.

- **Occupancy Sensing on Garage Access Ramps:** The garage in this study has 4 internal levels and a roof level. The data shows that the peak traffic times in this garage are 6:00AM to 9:30AM and 11AM to 6:00PM, with steady traffic around dinnertime and a traffic outflow between 12:00AM and 2:00AM (Chart 1). The occupancy sensors also show that while levels A through C are busy throughout the day, levels D and the roof are hardly used during the afternoon and evenings. The resulting energy savings are captured in Chart 2, with significant savings on the roof and floor D in the afternoon and throughout the night.

- **Occupancy Sensing on Garage Parking Sections and Stalls:** The installation included occupancy sensors covering each section of each of the 4 parking levels. Chart 3 displays the number of occupancy sensor triggers per hour for two representative sections, one on floor B and one on floor D. The traffic patterns on the parking levels correlate well to the traffic patterns on ramps as described above. The data shows, as expected, that floor B is both occupied and vacated ahead of floor D. The overall traffic on floor B is, as expected, significantly higher than floor D.

The resulting energy savings are captured in Chart 4. For comparison, we included the energy savings data at the main exit. The chart clearly shows significant savings on floor D for most of the day, while floor B savings are primarily in the evening and night hours.
Daylight Harvesting

The use of photocells to control lights in response to available daylight effect is a difficult task and not common in parking garages, except for trivial areas such as outdoors or rooftops. The Adura system is capable of accurately interpreting photocell data and executing an effective daylight harvesting control strategy. To understand the contribution of daylight harvesting to the total savings, we separated the individual contribution of occupancy sensing and the overriding daylight harvesting control. The resulting impact on energy consumption is analyzed in Chart 5.
Daylight Sensing and Harvesting: The garage has two photocells on the upper levels, which realize the majority of daylight benefit. When the photocell signal exceeds a predetermined threshold, the fixtures configured to its control zone are turned off. The blue line in Chart 5 shows the savings generated by occupancy (OCC) sensors which amounts to 43% for the entire day. With a photocell only, the savings are represented in Chart 5 by the green line and it amounts to 52% for the same 24-hour period. Finally, the combined savings are represented by the gray line and amount to 89% for the day, or an additional 46% savings above and beyond the use of occupancy sensors.

Conclusion: Daylight harvesting is a powerful and effective incremental saving strategy, contributing an additional 40%-60% savings on top of the savings possible with occupancy sensing.

Summary

The Adura Wireless Lighting Control System’s utilization of occupancy sensors and photocells is achieving significant energy savings and providing a very attractive payback. As summarized in Chart 6, the savings realized, while different for each area of the garage, generally range from 20% in the busier zones to 50%-80% everywhere else. Garages which are open 24 hours per day and have a more business hours oriented occupancy pattern (unlike the tourist and nightlife schedule for the garage in this study) should expect even higher savings employing these same strategies.

In addition to providing energy savings, the Adura Wireless Lighting Control System is a powerful data collection and analysis platform, capturing the patterns for each functional area in the facility throughout the day. The reporting tools enable the garage management to make operational decisions to further reduce variable costs through optimizing supervision and/or security labor. Such decisions could include the closure of low use areas in off-peak hours. Mining the Adura System data shows the precise hours and locations where such actions can be taken, leading to opportunities for continuous operational improvement.

The total savings for the site are reported via the Adura system “Dashboard” in Chart 7 below. Based on reported actual energy savings, the projected energy use on an annual basis will drop from 200,954kWh to just under 120,000kWh, a saving of just over 40%. This represents a projected close to $40,000 direct energy related savings, in addition to the rest of the benefits and savings outlined. The current and projected savings are summarized in Table 1 below. The analysis utilizes the actual energy use for November 2010. The projected numbers take into account the impact of additional daylight harvesting during the summer months.

Table 1. Savings summary

<table>
<thead>
<tr>
<th>Energy Use</th>
<th>Before</th>
<th>After</th>
<th>%</th>
<th>$</th>
</tr>
</thead>
<tbody>
<tr>
<td>kWh/Month, Actual Nov. 2010</td>
<td>16,792</td>
<td>10,496</td>
<td>37.5%</td>
<td>$755</td>
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<tr>
<td>kWh/Month, Projected monthly Average</td>
<td>16,792</td>
<td>10,024</td>
<td>40.3%</td>
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<tr>
<td>kWh/Year (projected)</td>
<td>200,954</td>
<td>119,960</td>
<td>40.3%</td>
<td>$9,719</td>
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<tr>
<td>Investment (post rebate)</td>
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<td>$19,500</td>
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<td>2 years projected savings (electricity only)</td>
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<td></td>
<td>$19,439</td>
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<td>4 years projected savings (electricity only)</td>
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<td>Payback Period (years)</td>
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</tbody>
</table>

Chart 6. Savings summary by zone

Chart 7. Adura system’s dashboard