No-cost/Low-cost Ideas to Reduce Energy Use in Office Buildings

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ABSTRACT

This article presents actual examples of energy savings achieved in office buildings occupied by federal government agencies (e.g., DOD, EPA, US Postal Service) and other entities. This has been done using no-cost and low-cost concepts of emergency electricity load reduction programs such as energy "coasting," reduced nighttime baseload electricity use, smart morning HVAC system startup, and bi-level lighting. Before and after comparisons highlight the reductions achieved.

Examples are provided for buildings owned by Beacon Capital Partners or managed by Jones Lang LaSalle. Beacon Capital Partners owns and operates commercial office buildings throughout the US and Europe. Jones Lang LaSalle is a global real estate firm whose services include sustainable building management.

INTRODUCTION

Owners, managers, and occupiers of commercial real estate are embracing the concept of reducing energy use to improve their financial performance and protect the environment.

An entire industry has developed to provide assistance in the increasingly complex and growing field of sustainability—with the greatest focus on improving energy efficiency. Professional designations indicate the level of success in achieving reductions in energy based

on a particular program. The federal government's ENERGY STAR® program, the U.S. Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED®), and the Green Building Initiative's (GBI) Green Globes online tool for green building certification are well-known and accepted standards within this new industry.

PROBLEM STATEMENT

Many properties are hesitant to pursue the energy-reducing programs recommended by these organizations in light of the current economic climate and depressed real estate values. Owners tend to assume that meaningful energy savings require significant capital investment in new equipment, such as replacing aging chillers and package air conditioning units with energy efficient ones, relamping entire buildings, and upgrading HVAC control systems to conserve energy. Some may even believe that only new construction can effectively create green buildings.

Is it possible to be fiscally conservative and environmentally friendly at the same time? The answer is *yes*. A number of no-cost/low-cost changes to building HVAC operations and lighting systems can significantly reduce energy consumption with no impact on tenant comfort.

PROPOSED SOLUTIONS

Beacon Capital Partners and Jones Lang LaSalle have successfully implemented energy reduction strategies at numerous office properties, with little or no capital investment.

Beacon owns and operates large commercial office buildings throughout the US and Europe and has implemented a special no-cost energy savings program at its properties. Jones Lang LaSalle, a global real estate firm whose services include sustainable building management, was named a 2010 ENERGY STAR® Partner in recognition of firm-wide efforts to reduce energy consumption at the properties it manages.

This article presents actual examples of energy savings achieved at buildings owned by Beacon or managed by Jones Lang LaSalle. Five

specific low-cost/no-cost strategies are presented, including before and after comparisons in energy use:

- Emergency electricity load reduction programs, aka demand response
- Energy coasting
- Reducing nighttime baseload electricity use
- Smart morning HVAC system startup
- Bi-level lighting.

DISCUSSION

To effectively reduce electricity use, it is important to monitor and analyze real time electricity consumption. Monitoring electricity use provides key insights into the building's operations. It allows a better understanding of how building operating procedures impact electricity use during key periods such as:

- peak electric demand
- late afternoon cooling load
- nighttime base electric load, and
- morning startup HVAC electric load

Demand Response

Demand response (DR) programs exist in many areas throughout the US, including the PJM (Pennsylvania Jersey Maryland), New England, New York, and California power pools. Demand response programs provide economic incentives for commercial buildings to voluntarily reduce electricity use during peak load "events," which typically occur a few times a year for a few hours—usually during hot weather when air conditioning requirements surge. The property earns rebate checks, both for being on standby as well as for reducing non-essential electricity use. The unused electricity made available by participating properties provides electricity capacity for other users, thereby reducing the need for a local utility to take more adverse actions such as reducing voltage on the power grid or implementing rolling brownouts or blackouts. Long-term, demand response programs can help to offset the need to build additional power plants.

Beacon has 45 properties in DR programs; each property has its own specific load reduction plan. The properties have a wide range of HVAC systems and controls, and electricity-using equipment, but the DR program works at every single property. On average, Beacon has reduced electricity load by 150 kW/100,000 sq.ft., with a high of 300 kW/100,000 sq.ft. To reduce electricity load, the properties turn off selective lighting, park some elevator cabs, raise temperature setpoints a few degrees, etc. One demand response program, launched by Jones Lang LaSalle in 2010 with 12 properties, will generate $108,000 per year in revenue.

Figure 1 shows the areas of potential load reduction. The applicability of each load reduction option is considered for the circumstances of each building, with a decision being made on a building-specific load reduction plan.

Figure 2 shows the actual electricity load prior to and during an emergency demand response event at an office property occupied by

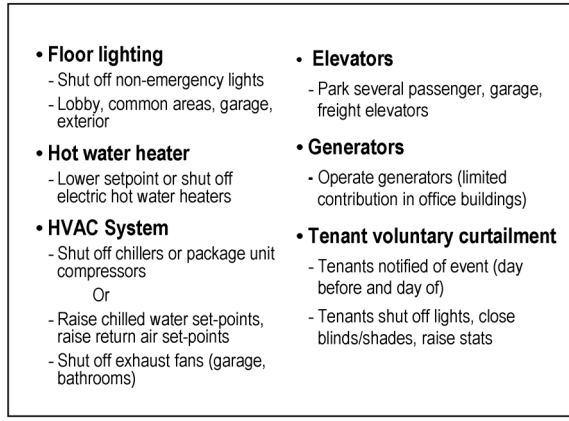

Figure 1. Load Reduction Actions in Office Buildings

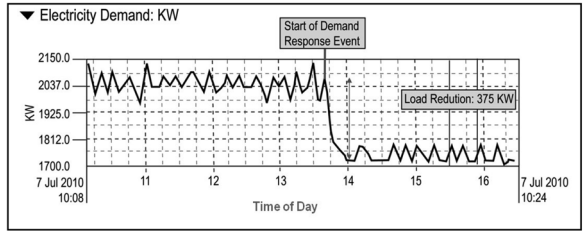

Figure 2. Demand Response Program Event

two Department of Defense agencies. Electric load was reduced from 2,100 kW prior to the start of the event to 1,725 kW after the load reduction plan was implemented. Revenue from this load reduction plan is about $16,000 per year.

Tenants generally cooperate and support the DR program, once they understand the purpose of the program and how it supports Beacon's Electric Emergency Preparedness Program—i.e., what to do in the event of a power outage or blackout. Many tenants voluntarily shut off office lights and close window shades during such an event, which helps to further reduce electricity load. To support active participation, Beacon has instituted a comprehensive communication program with tenants at its buildings so that cooperation is enhanced during demand response events.

The amount of money paid by an independent systems operator (ISO) for electricity load reduction during a demand response event varies significantly. For example, in Manhattan the NY ISO paid $12.90/kW-month for load reduction during emergency conditions in summer 2010, compared to $5.30/kW-month from PJM for Washington DC.

Participation in a DR program requires a real time energy use monitoring service, which includes installation of a simple server and connection of the pulse output from the electric meter(s). This service also provides excellent information on ways to make the building more energy efficient by simple, no-cost operational changes. Beacon uses EnerNOC for this service. Jones Lang LaSalle uses a number of demand response service providers throughout the country, including EnerNOC in the PJM region and metropolitan Chicago.

Energy Coasting

Energy *coasting* is an innovative, no-cost approach to energy management that starts as an experiment and art, then turns into a science. Basically, it means turning off HVAC cooling equipment (chillers, package AC unit compressors—but not supply air fans) prior to the normal weekday shutdown of the HVAC system, without adversely affecting temperatures in the tenant workspace. Coasting is most effective as an energy saver in the non-summer months but still works every day of the year, regardless of the building's HVAC system (e.g., central chiller plant, floor-by-floor package cooling units, ceiling mounted heat pumps).

At first, the operating engineers start coasting 15 minutes prior to the start of after-hours as an experiment to see what happens to their

building. ("After-hours" is the time of day when the HVAC system is shutdown and no air is supplied to the tenant spaces.) At the start of the coasting period, operating engineers take action to reduce the electricity requirements of the cooling system, ranging from shutting off all chillers and cooling towers to raising return air or chilled water setpoints by several degrees.

During the coasting period, the operating engineers record data such as outside air temperature and relative humidity; air handling unit (AHU) supply and return temperature; and chilled water supply and return temperature (if there is chilled water). Typically, this data is initially recorded manually because the building management system (BMS) has not been programmed to trend it. The building management team also uses "hot calls" from tenants to fine tune the process and determine the right mix between coasting and occupant comfort so that coasting does not result in any hot calls.

Over time, the engineers develop a feel for when coasting can begin, based on the weather conditions and knowledge of their building. However, by gathering the above operating data, a simple algorithm can be created to indicate when coasting can be safely started, with the objective of reducing energy use without impacting tenant comfort.

The electricity savings from coasting are significant. Figure 3 shows the decrease in electricity load when energy coasting was initiated at a large commercial office building. For this property, after-hours begins at 8 p.m. (20:00 hours). On May 10, 2010, coasting began at 7 p.m. (19:00 hours), i.e. 60 minutes prior to the start of after-hours, when all HVAC equipment is shut off. Outside air temperature (OAT) was 70°F at the time coasting began. Electricity load was decreased 1,050 kW during this 60-minute period by shutting down chillers, cooling tower fans, and condenser water pumps, but not supply air fans. Chilled water pumps remained on and continued to pump chilled water to the AHUs.

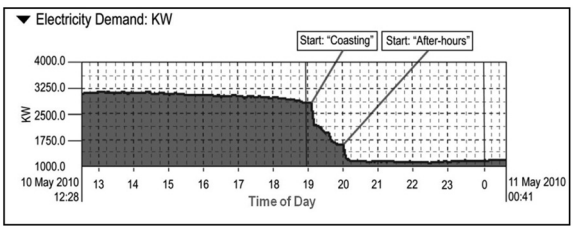

Figure 3. Energy Coasting

By 8 p.m., return air temperatures only rose to 74-75°F throughout the building (still meeting the lease requirement of 76°F) with no increase in tenant hot calls.

On cooler days the load reduction may be less; however, the amount of coasting time tends to be longer. For example, on a hot summer day this property may only be able to coast for 15 minutes but still reduce load by 1,400 kW, whereas, on a cold day, coasting can be started 90+ minutes early, with a load reduction of about 800 kW. At this property, coasting load reduction averages about 1,000 kWh/day, 5 days/wk, 52 wks/yr and saves 260,000 kWh/yr, or $34,000 annually in marginal electricity cost.

Reducing Nighttime Electric Baseload

Another no-cost strategy for energy reduction requires analyzing nighttime baseload electricity use and determining if any equipment or lighting is being unnecessarily left on.

At each Beacon property, a late-night, detailed inspection was conducted to develop a list of all building equipment found operating. The results and subsequent energy savings were both surprising and significant. Engineers found a number of lights left on, as well as various fans, motors, AHUs, package air conditioning units, and other HVAC equipment that did not need to operate after-hours. Many of these properties are not staffed with operating engineers 24/7, which explains why some of this equipment was unknowingly being operated, thus making the implementation of energy reduction procedures more challenging.

At one office building in the metro DC area, occupied by the US Postal Service, we found a faulty lighting control system that failed to turn off half of the lights on seven floors, resulting in a total of 77,000 sq.ft. of lights unnecessarily consuming 425,000 kWh of electricity annually at a cost of $36,000. At another property in Washington, DC, several small-package air conditioning units were found operating after-hours, including one for a health club that served tenants and closed at 8 p.m. Shutting off this equipment only reduced electric load by 73 kW; however, this load reduction is now being achieved 11 hours per night, five days per week and all day Saturdays and Sundays, for 52 weeks per year. Total annual savings is 390,000 kWh/yr, or $43,000.

Lighting poses the greatest challenge to energy conservation, with lights being left on after the cleaning crews leave. Every building has a policy where the cleaning crew is required to shut off lights, but seldom

is there any formal verification or validation that this is occurring. It is very common to find 5-10% of the non-emergency lights left on in an office building. Establishing a special "lights off" program saves thousands of dollars per year at no cost.

All Beacon properties are required to have a lights off program. Some use security guards to inspect for lights left on by the cleaning staff, with checks performed several times per month. Other properties use the engineering staff to do the inspections early in the morning. Many take exterior photographs to help identify and correct problems. Figure 4 shows a Beacon high-rise office building prior to institution of the lights off program. Now, nearly 80% of these lights are being turned off.

Smart Morning Start-up

An additional technique for conserving energy is to focus on the time and methods used to start-up the building's HVAC equipment each weekday morning. Many building engineers will tell you they have *optimum start* software to startup the HVAC that takes into account building and outside weather conditions.

However, Beacon evaluated start-up at many of its properties and found that most were far from achieving an optimum start, and in fact,

Figure 4. Nighttime Lighting Prior to Lights Off Program

many had a very inefficient start-up process that appeared to be independent of weather or building conditions.

In many cases, the HVAC systems were programmed such that they started up many hours earlier than needed. For example, return air temperatures were at desired levels within 60-75 minutes of start-up, yet the HVAC systems were being started 3-5 hours prior to the start of business hours for no apparent reason other than "that is how the BMS is programmed." Also, very frequently the start-up sequence was the same every day and did not take into consideration outside weather conditions. For example, outside air was not used to initially cool the building on cool mornings with low humidity, nor, on hot and humid mornings, was interior air circulated with no outside air intake.

Nearly all of the operating engineers at these properties were unaware of this situation because they never previously had real time electricity use information. They also were not on site 24/7 and typically reported to work at 5-6 a.m. In fact, in a number of instances, the engineers found equipment operating that was programmed in the BMS to be shut off, but shutoff had never been field verified.

Figure 5 shows a building HVAC start-up beginning at 1:00-2:30 a.m. (a prior practice), with the nearly peak electricity use for the day occurring at 5:30 a.m., well before any building occupancy by the tenants. The engineers found that the BMS was sequentially turning on one

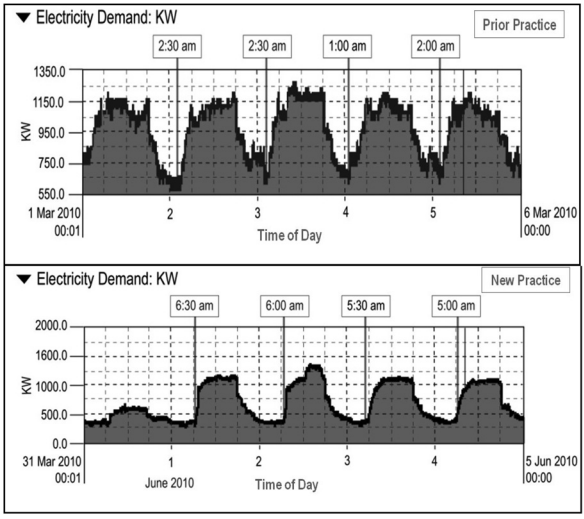

Figure 5. Smart Morning HVAC Start-up

piece of HVAC equipment at a time over a several-hour period. Now the building is starting up at 5:00-6:30 a.m., with good space temperatures being achieved by 7 a.m., the start of business hours.

The start-up changes have resulted in annual energy savings at this 280,000-sq.ft. office property of $40,000. Avoiding earlier than necessary HVAC start-up time was the biggest cost saver. Now Beacon is focusing on smart start-up that takes weather conditions and forecast into consideration.

Bi-level Lighting

Low-cost, energy efficient capital investment options available to building owners and managers include a bi-level lighting fixture that Jones Lang LaSalle has successfully implemented in a pilot property in Northern California, which is also being rolled out to its other properties in the area.

Traditional stairwell lighting operates continuously at full power, unnecessarily consuming electricity in areas where use is occasional. Bi-level lighting fixtures can significantly reduce electric consumption by maintaining low light levels when an area is unoccupied, down to as low as 10% of normal output. Motion detectors in the fixture restore brightness when occupancy is detected. The result is energy savings of up to 70-80% for each fixture replaced.

Jones Lang LaSalle evaluated a "proof of concept" test in stairwells in a San Francisco office building based on 32 bi-level fixtures. The Lamar Occu-Smart® fixture was selected because it satisfied the San Francisco Department of Building Inspection (DBI) requirement that the lamp return to full brightness should the occupancy sensor fail. The proof of concept projects an annual energy reduction of 74.7%, resulting in a payback of approximately 2.0 years (after rebates). Figure 6 shows the energy reduction and percentage of projected energy savings produced by groups of fixtures included in the study.

Plans to roll out this program to 14 properties managed by Jones Lang LaSalle in Northern California, including many smaller properties, could result in annual energy savings of 230,000 kWh, a decrease of 58%, or about $34,000.

Savings will vary by property based on lighting levels required and the actual amount of light reduction allowed by code. Rebates and incentives are often available from local utilities; in the pilot stairwell example an incentive from the San Francisco Department of the Envi-

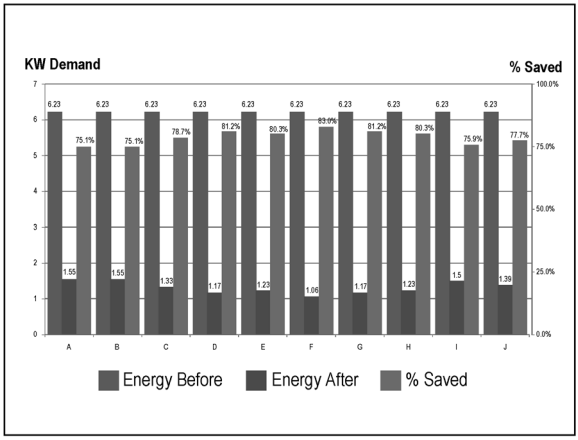

Figure 6. Projected Savings through Bi-level Lighting in a San Francisco Office Building

ronment reduced the initial cost of the fixture by 41%. In addition to stairwells, these fixtures are also recommended for installation in hallways, parking structures, and bathrooms.

CONCLUSION

Commercial property plays a critical role in energy conservation, given its collective impact on the environment. The current emphasis on sustainability demands that building owners, managers, and occupants aggressively pursue green strategies in their daily operation. Today's economy precludes some properties from instituting fully sustainable operations; however, not all approaches require significant capital investment. The strategies discussed above identified five approaches to significant energy reduction at virtually little or no cost—demand response, energy coasting, reducing baseload electricity use, smart morning start-up, and bi-level lighting.

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