RETROFIT TECHNOLOGY CASE STUDY

nbi new buildings institute

Exterior view of Santa Ana City Hall office tower. Credit: NBI

Santa Ana City Hall Tower on 20 Civic Center Plaza

Santa Ana City Hall, located in the Santa Ana Civic Center was constructed in 1972 to serve as an annex to the original 1935 City Hall. The eight-story office tower is home to the City's public works, community planning, and building departments as well as the City Manger's office and other administrative services.

Santa Ana is the largest city in Orange County and is located in California climate zone 8 where sunshine and daylight are plentiful. Since zone 8 is farther from the coast and lacks coastal fog coverage, the temperatures in the summer are warmer, and in the winter, cooler. Building efficiency measures to control cooling and heating are necessary in this climate to achieve comfortable temperature standards within buildings.

In June 2017 as part of the Leading in Los Angeles research project, Santa Ana began a three-year process to complete an energy efficiency upgrade to its City Hall. The building was one of two field demonstration sites, the other being California State University Dominguez Hills.

Overview Facts

Location: Santa Ana, California

Size: Building 127,000 sf, Project 88,000 sf

Number of Floors: 8 floors and basement

Construction Type: Existing Building Renovation

Building Type: Office

Construction Year: 1972

ASHRAE Climate Zone: 3B

California Climate Zone: 8

Retrofit Project Team

Owner: City of Santa Ana

Buildings and Facilities Manager: Phil Neff

Window shades: Illuminate and Automate by Rollease Acmeda

Lighting Controls: Daintree

Shade Installer: Lumenomics

Shade Controls: BeMotorized

Lighting System Installer: SBT Alliance

HVAC Retro-Commissioning: Taylor Engineering

BAS Control Sequencing: Siemens

Research Project Snapshot: Leading in Los Angeles (LiLA)

Research Overview

The LiLA research project set out to test the energy savings of a set of technologies known as the Integrated Technologies for Energy-Efficient Retrofits (INTER). The main objective was to identify an integrated retrofit package that results in a 20% reduction of whole-building energy consumption while improving occupant comfort.

The package consists of:

- Advanced lighting and wireless controls
- Automated wireless shading systems—PV-powered in all windows but north facing
- Minor retro-commissioning of heating, ventilation, and air conditioning (HVAC) systems

The four-year project launched in June of 2017. Researchers used both laboratory measurements along with two field demonstrations to test technology application and performance, quantify energy savings, and assess occupant perceptions. The laboratory testing covered a mock-up of three seasons (summer, winter, and spring) at LBNL's FLEXLAB facility. Energy savings from lighting and HVAC were investigated in both the lab and field demonstrations.

In the Santa Ana field site baseline whole-building energy use was collected starting in early 2018 with sub-metering for end uses starting in September 2018.

The lighting retrofit began in June of 2019, and by the end of November 2019, installation and commissioning of the wireless lighting controls was complete. In March 2020, the space was largely vacated due to the COVID-19 pandemic.

Pre-retrofit occupant surveys helped to quantify occupant perception of their mostly computer-based work environments, but COVID-19 shelter-in-place requirements eliminated the opportunity for a post-retrofit survey. Rather, researchers interviewed a few key staff that remained present in the building to gain an understanding of their perceptions of the building and technologies.

This CEC EPIC research results were shared widely with the commercial real estate industry, architects, engineers, interior designers who specify shades and lighting, building owners and managers, and utility program teams. All the project results and case studies are on the **LiLA web page**.

Project Team:

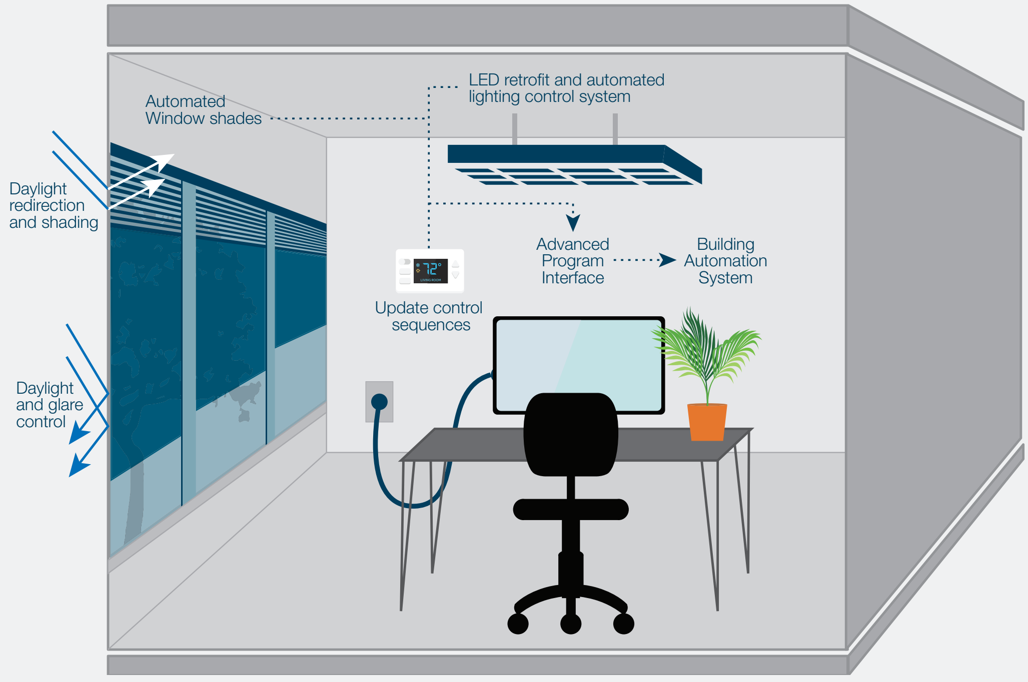
Project Lead: New Buildings Institute (NBI)

Technical Field Demonstration Lead: TRC Companies, Inc.

Lab Test and M&V Lead: Lawrence Berkeley National Laboratory (LBNL)

Manufacturer Partners: Rollease Acmeda, Daintree Wireless Lighting Controls

Project Funders: California Energy Commission's (CEC) Electric Program Investment Charge (EPIC) program and Southern California Edison



Preexisting Building Conditions

Lighting

Santa Ana City Hall has an unusual ceiling grid configuration. Instead of a two-foot by four-foot grid found in typical office buildings, the ceiling in the office tower has an 18-inch by 36-inch grid. Original lighting fixtures were configured in continuous recessed strip lights spaced about six feet apart. The light fixtures had been upgraded from T-12 lamps to four-foot T8 lamps, as was common practice over the past 20 years.

The building's atypical ceiling grid meant some lamps were difficult to access and some were overly bright. Most spaces lacked personal lighting controls. Instead, a typical floor had two manual wall switch control points for all the lighting on the floor, one at each end. The existing automated lighting control system for occupancy and daylight sensing did not function properly due to poor commissioning and failed batteries.

Window Shades

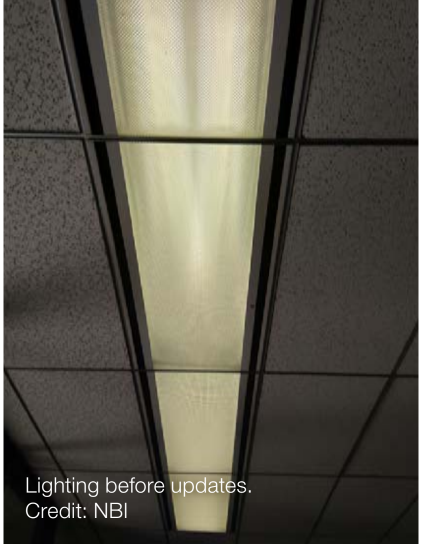
The majority of windows at Santa Ana City Hall face north and south. The floorplan consists primarily of small, shared open office spaces, private offices, and various conference rooms. Before the retrofit, the building was equipped with traditional, manual window blinds. Most commonly, the building had Venetian-style blinds with horizontal slats, which relied on individual occupants to determine whether blinds were open or closed. Other spaces had vertical slat blinds. Staff would position the blinds to avoid glare, and then leave the blinds untouched from then on. This scenario resulted in missed opportunities to allow daylight to fill the space, which is known to improve the work environment and reduce demand for artificial lighting.

HVAC

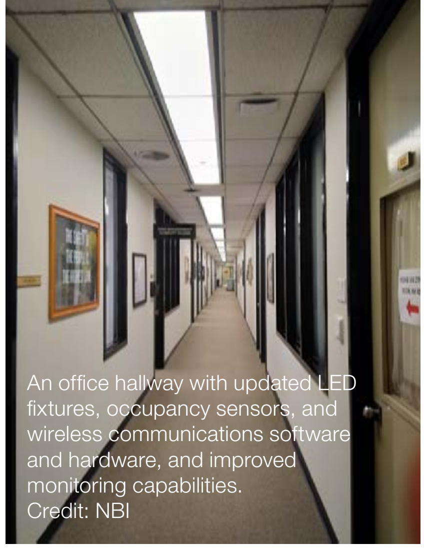
The building HVAC system is comprised of 11 variable air volume dual duct air-handling units (VAV DD AHU). Each floor has its own VAV DD AHU. Cooling is supplied by chilled water from the county's central plant nearby. The City of Santa Ana has a service contract with Siemens to maintain the HVAC system at City Hall. A Siemens building management system (BMS) is used for equipment scheduling, set point management/modifications, and to provide general alerts regarding HVAC equipment status. Additionally, the Siemens system can be used to trend data on both the HVAC and domestic hot water (DHW) equipment.

A private office with an example of horizontal Venetian-style blinds. Credit: TRC Companies, Inc.

An open office space with an example of vertical slat blinds. Credit: TRC Companies, Inc.



Lighting before updates.
Credit: NBI



An office hallway with updated LED fixtures, occupancy sensors, and wireless communications software and hardware, and improved monitoring capabilities.
Credit: NBI

Lighting after retrofit with a close view of the sensor.
Credit: NBI

Retrofit Strategies and Features

Santa Anna City Hall was retrofit with the LiLA integrated measure package explained below, which was selected to reduce energy use while improving occupant comfort.

Lighting and Daylighting

Electric lighting upgrades included LED fixtures, Daintree wireless integrated lighting controls with updated communications software and hardware, and improved monitoring capabilities. The lighting system was redesigned to provide opportunities for more localized lighting control in each space, rather than for the entire floor. For example, conference rooms were allotted their own control zone. Additional lighting control allowed entire zones of lighting to turn off when not in use and dim when adequate daylighting was available. This reduced energy demand for both lighting and cooling. The automated lighting controls were networked into the Siemens BAS, which provided the facility manager detailed information on both energy use and occupancy patterns, by zone.

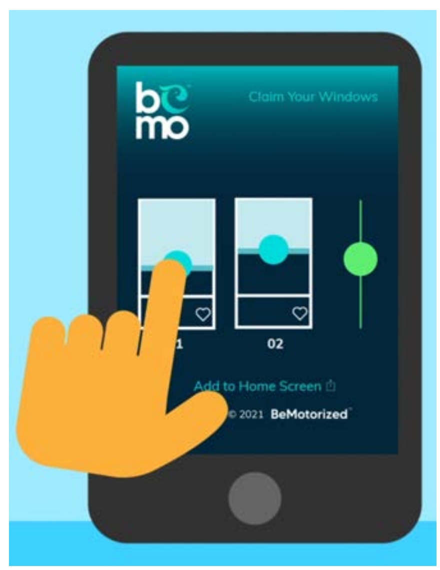
Daylighting shades at the top automatically redirect light deeper into the space while separately-controlled perforated shades allow views to the outside.
Credit: TRC Companies, Inc.

Automated Shading

Santa Ana City Hall was retrofitted with automated window shades designed to optimize visual comfort, thermal comfort, and daylight harvesting for energy savings. The shading system product, called Illuminate, is separated into two distinct parts: an upper blind that directs daylighting and a lower perforated fabric roller shade that provides views when closed and allows occupant control.[1]

The upper 'daylight' portion of the window shade consists of motorized, louvered blinds. Even with the lower shade closed, the upper blinds redirect light into the space based on daylight availability. An interior daylight sensor on the upper shades determines daylight availability. When appropriate, the blinds automatically reposition to direct daylight deeper into the space. When light bounces off the ceiling, it increases brightness in the space, causing adjacent automated overhead electric lights to dim or turn off completely to maintain preset lighting levels. By reducing the need for lighting, less heat is generated, thereby reducing HVAC loads.

The upper blind and lower roller shade were designed to operate independent of one another. An integrated PV panel charges the batteries within the shade motor for all window shades except for the north-facing



Occupants can control individual or groups of shades in their space via smartphone app or web browser. Credit: The Energy Coalition

1 A 3% fabric perforation was selected to allow for views to the outside without compromising the thermal and glare benefits of the shade in the closed position.

ones, eliminating the need for wiring. The motor size was based on the size of the window. Lower roller shades control options included:

- Wall-mounted controller switches
- Remote smartphone application
- API software to enable control through a Siemens BAS
- Internal daylight sensor

Occupant Control

Building occupants can override the automated shading system using a smartphone app or browser website, which allows them to adjust the shade positioning as needed. Additionally, physical buttons mounted at desks and in common areas allow building occupants to quickly adjust blinds to one of four positions—fully closed, fully open, and two intermediate steps between the two. However, the shades reset at the end of each day to provide optimum performance for glare reduction and daylight harvesting based on time of year.

Heating, Ventilation, and Air Conditioning (HVAC)

The project implemented minor retro-commissioning through controls adjustments to ensure HVAC systems function as efficiently as possible and to improve coordination with the other installed technologies. Retro-commissioning measures included:

- Programming adjustments for scheduling and controls
- Tuning of temperature set points and nighttime setbacks
- Programming updates for the existing BAS based on ASHRAE Guideline 36 standards for sequences of operation

Results

Research on the LiLA integrated measures in the laboratory and at Santa Ana City Hall demonstrated significant energy savings and multiple other benefits.

Energy Savings

SANTA ANA MEASURED RESULTS

Researchers collected data on the lighting and energy consumption before and after the Santa Ana City Hall retrofit project. Results show a significant lighting energy savings of 42% after the retrofit was completed in November 2019 during full occupancy. Researchers measured whole-building energy savings of 15%, and HVAC energy savings at 6%.

LABORATORY SAVINGS

Findings from research in the FLEXLAB at LBNL show that in all seasons, the energy impact of the installed technologies at the FLEXLAB was significant. For example, compared to a typical existing office building with T8 lamps, lighting energy savings ranged from 62% in winter to 76% in summer. Increased savings during the summer months is a direct result of additional daylight entering the space and offsetting electric lighting consumption.

Even compared to a new construction office built to the California Title 24 energy standard the savings were compelling, ranging from 50% in winter to 62% in summer. LBNL researchers also found that in warm seasons (summer) for existing buildings the HVAC cooling load was reduced by 36%, and by 28% in the fall. Not surprisingly, HVAC savings from a Title 24 baseline were less, in

2,422
lighting fixtures upgraded to LEDs and networked controls

481
windows have new shades

HVAC light retro-commissioning:

Programming adjustments

ASHRAE 36 sequence of operations

At-a-Glance Measured Energy Savings from Santa Ana:

Category	Percent Savings
Site energy*	15%
Site electricity	19%
Lighting	42%
HVAC*	6%

*Does not include savings in the campus central district steam, due to erroneous post-retrofit data. These figures represent electricity and chilled water savings only. The project team estimates that with steam savings the site energy savings most likely meets the 20% target.

the range of 15-19% of cooling load. HVAC savings were driven by the reduced heating demand from the lower-wattage electric light upgrade. Also, in the lab daylight glare was carefully measured and determined to be adequately controlled for all test scenarios during all seasons.

At-a-Glance Energy Savings from the Lighting and Shade Retrofit Package in the LBNL FLEXLAB[2]

Baseline Comparison	Savings Type	Season		
		Summer	Fall	Winter
Existing Building T8 lamps, 1.0 W/sf, no dimming; manual blinds	Lighting Energy	76%	73%	62%
	Cooling Load	36%	28%	n/a
Title 24 Building T5 (0.69 W/sf); stepped dimming; manual blinds	Lighting Energy	62%	57%	50%
	Cooling Load	19%	15%	26%

Additional Benefits

The integrated set of measures offer many advantages for owners, occupants, and operators.

Owners. The set of energy efficiency measures installed at Santa Ana City Hall are an effective way to modernize a building while offering amenities such as localized controls. Owners also benefit from cost savings resulting from reduced energy use. And, because LED lamps last 2-3 times longer than older T8 or T12 lamps, less staff time is required to switch out lamps. For leased spaces, having attractive, controllable interior features and system upgrades helps command higher prices and appeals to today's employers.

Occupants. Of the staff remaining in the building during the post-retrofit period, several expressed the positive impacts the new LED lighting and advanced controls had on their work environments. Occupants appreciate the ability to fine-tune their lighting as well as control glare while also experiencing consistent views to the outside.

Operators. With the automated lighting controls and shading system networked into the building's BAS, the facility manager now has access to detailed information about energy use and occupancy patterns, by zone. Benefits experienced by occupants may lead to fewer complaints, which is an important benefit to facility managers.

Costs

Construction & Design Costs

Typical cost for this type of integrated system retrofit, including the localized lighting controls, automated shades, and minor HVAC retro-commissioning is estimated to be approximately $14 per square foot. The wireless lighting control system is estimated to be about $7.47 per square foot. Square footage of window area is a more typical figure, but this research project

2 The lab setting measured light savings in the zone affected by the daylighting and thus are higher than the whole building lighting savings at the demonstration sites which include lights further from windows.

Benefits of Automated Lighting and Shading Systems

Owners
Modernized building
Reduced operating costs
Higher tenant satisfaction

Occupants
Personalized control
Thermal comfort
Elimination of glare
Maintained views

Operators
Centralized data and control
Reduced maintenance of lamp change outs
Reduced comfort complaints

Typical Cost per Square Foot	
Lighting and Controls	$7.47
Shades equipment	$3.24
Shades installation	$1.38
Shades controls	$0.95
Wiring	$0.33
Shades Total	$5.88
HVAC Retro-Commissioning	$0.65
TOTAL	**$14.01**

Note: These costs are illustrative and not reflective of costs for this project.

had extensive variables. So the estimates are for the building area—at $5.88 per square foot. (Note, these costs are illustrative and not reflective of costs for this project).

Conclusion

An integrated package of LED lighting with wireless daylighting and occupancy sensors, automated shading systems, and minor retro-commissioning of HVAC systems, led to significant energy reductions and improved occupant environments at Santa Ana City Hall. The project upgrades achieved whole-building energy savings by incorporating integrated modern best technologies and practices coupled with specific strategies to achieve additional benefits.

Smaller lighting zones with controls and PV powered battery-operated shading devices took advantage of wireless systems and allow lighting to be tuned based on occupant preferences and available daylight. The reduced demand for lighting contributed to energy savings for both lighting and HVAC systems. The immediate feedback from occupants about the upgrades has been positive.

The measures investigated in the LiLA research project demonstrate numerous opportunities for achieving significant energy savings through building upgrades. In California, the retrofit market is massive with existing commercial office building stock representing 22% of the total state's commercial floor space and 27% of the commercial energy consumption—more than any other sector. With widespread adoption, the measure packages studied in the LiLA research project have the potential to help owners save and make money, occupants be more comfortable, and society meet goals for carbon reductions associated with energy generation.

Keys to Success in Integrated Building Upgrades

- **Focus on occupant improvements.** Identify needs that are not currently being met by the building.
- **Convene and engage stakeholders early.** Include the IT department, facilities managers and other building management staff, and key occupants. Communicate the benefits of the new systems to create buy-in from occupants.
- **Maximize savings by packaging measures.** Combining HVAC retro-commissioning, lighting upgrades, advanced lighting controls, automated shading, and other advanced technology solutions saves costs and time.
- **Engage a single entity to lead the project.** Finding one company to provide turnkey design, installation, commissioning, and long-term support for maintaining systems reduces costs, hassle, and time.

> "Since we installed the new window shades and lighting, the building has been much more comfortable, our bills are lower, and we've reduced the need for maintenance. The updates have really improved everyone's work environment."
>
> Christy Kindig, Projects Manager, Public Works Agency at City of Santa Ana

New Buildings Institute (NBI) developed this case study.

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EPIC invests in scientific and technological research to accelerate the transformation of the electricity sector to meet the state's energy and climate goals.

SCE funding for research on these technologies is aligned with their Going [carbon] Neutral Pathway 2019 goals and steps.

Program Information

Southern California Edison's **Energy Express and Customized Solution Programs** offers incentives.

Other California utilities also have programs for upgrading to advanced technologies. Check your local utility web site.

NBI Program Information

info@newbuildings.org

Read More: **Leading in LA**

New Buildings Institute (NBI) is a nonprofit organization driving better energy performance in buildings. We work collaboratively with industry market players—governments, utilities, energy efficiency advocates and building professionals—to promote advanced design practices, innovative technologies, public policies and programs that improve energy efficiency and reduce carbon emissions. We also develop and offer guidance and tools to support the design and construction of energy efficient buildings. Learn more at **newbuildings.org**