RESIDENCE LIFE RETROFITS

Author: Luis Genis

5.1 Background

California schools are currently in a significant statewide project to upgrade mechanical and electrical systems thanks to funding from Proposition 39: California Clean Energy Jobs Act. Approximately $550 million annually is available for appropriation by the Legislature for eligible projects to improve energy efficiency and to expand clean energy generation in schools.[1] Unfortunately due to the status and identification of Chapman University as a private institute, it does not qualify for any money granted under proposition 39. In order to implement a retrofit project and improve on energy inefficiencies a different method will be investigated to see if Chapman qualifies for rebates provided through Southern California Edison, Southern California Gas or the STEM grant program.

The challenge presented is identifying long-term solutions and strategies, and finding existing technology that will help Chapman achieve energy savings in the most cost-effective and efficient manner. Many universities in California have tested and demonstrated strategies and technology such as: guide cover lighting and day-lighting retrofits, which have proven to provide not only energy savings, but also lighting quality improvements.

Universities in the United States spent over $6 billion on electricity bills and over 30% of the energy consumption in school buildings are considered inefficient or unnecessary.[1] Lighting accounts for 35% of the energy use in an average university facility. [1]Chapman University is committed to a campus culture that promotes a sustainable future. Through this energy audit, opportunities to reduce lighting energy use will be ranked from the potential electricity savings of each application to the ease of the retrofit process.

5.1.2 Introduction

This chapter of the 2015 Environmental Audit will help identify potential retrofits that will help Chapman University's facility team make the best decisions involving investments in low-maintenance/ long-term electricity savings. Residence Halls are one of the most occupied spaces at Chapman in terms of hours spent by students. Electricity consumption in the residence halls will continue to increase over the years if the culture of incoming freshmen continues to mainatain its current trend. It is important to improve the current energy inefficiencies in residence life and implement a retrofit package that will not only save electricity consumption now, but provides a long-term solution for the developing Chapman community. A long term- goal of this audit is to help stabilize the electricity consumption even as Chapman University expands its total square footage.

This chapter will provide a detailed walkthrough of the lighting energy audit conducted for all existing residence halls, excluding North and South Morlan, prioritize retrofit applications according to the university's mission statement, identify different technology options and strategies and build a retrofit package that provides:

- Cost-benefit analysis
- Return on investment
- Environmental Impacts: Carbon emissions
- Energy savings

For the Chapman University 2015 Environmental Audit, all residence halls (except for North and South Morlan) will be audited to identify the best opportunities available to reduce the lighting energy load. For example, inefficient residence hall lightings are typically found in areas that currently do not have an operating occupancy control system and/or do not use daylight harvesting strategies to improve lighting quality.

5.1.3 Chapman's history with retrofits in residence halls

Over the past several years, Chapman University's Facility management team has greatly increased the University's sustainability efforts. Chapter 1 and Chapter 4, Building Construction and Energy, respectively, in the 2013 Campus Sustainability Audit, covered retrofit efforts for new building construction and existing buildings on main campus. The audit provides an insight on how energy is used throughout the campus' main buildings. Chapter 2, Residential Buildings, in the 2014 environmental audit, focuses on water use and efficiency. Electricity consumption and efficiencies still proves relevant in the 2014 audit as cooling towers for residence halls were assessed. Past audits neglected residence halls electricity consumption due to lack of sub-metering per building, but facilities have made several attempts and proposals for the conduction of retrofit projects on residence halls, but none have been implemented.

5.2 Types of Retrofits

There are two main ways to save electricity use for lighting: the introduction of more energy efficient lighting fixtures with lower wattage and the reduction of the operating time of the lighting fixture.[1] During the electricity audit conducted in all mentioned residence halls, two opportunities presented itself for long-term electricity savings. First, a simple retrofit package for three of the residence halls that currently operate outmoded T12s and T8s lighting can be implemented along with electronic ballast. Second, all residence hallways light fixtures contain high wattage light fixtures and are continuously on throughout the day. Switching current light fixtures with dimmable energy efficient ones, installation of occupancy sensors and implementing a policy to keep lighting off during peak sunlight hours for residence halls will help Chapman University greatly reduce energy waste.

It is recommended that if a residence hall currently operates outmoded T8s or T12s fluorescent lamps or any older generation compact fluorescent lamps, they are to be retrofitted with newer T8 LED 18 watts. The installation of the new light fixtures will require the installation of electronic ballasts. With the addition of new electronic ballast, approximately half the power loss that is currently occurring will be prevented.

5.3 Residence Hall Recommendations and Strategies

Using the University of California Davis's: Lighting Retrofit Strategies for California Schools, the same guide will be recommended to this chapter of the audit.

1. Convert T12 and older T8 fluorescent luminaires to higher-efficacy light sources: Recommended lighting fixture to be installed in applicable residence halls: Premium LED T8 Tube Model number: *4RLXT8X018UN*
2. Convert all/any incandescent and CFL down-lights to solid-state or LED technology. Recommended lighting fixture: Dulux D/E 4-Pin SuperSaver, Dulux T/E/IN Amalgam 4-Pin Extended Life SuperSaver and Dimmable Twist Compact Fluorescent Lamps Model Numbers: *CF18DD/E/15W/SS/841/ECO, CF26DT/E/IN/21W/841/XL/SS/ECO and CF14EL/TWIST/827/DIM/BL*
3. Installation of a shading system on windows and skylights to avoid glare and heat gain from direct sunlight penetration. Recommended application: installation of window film to reduce radiant heat gain in residence halls
4. Incorporate electric lighting controls for daylight harvesting in spaces where windows can provide enough daylight to meet required illumination levels
5. Use occupancy-sensing controls in dorm rooms, lounge areas and hallways
6. Integrate appropriate scheduling for all outdoor lighting along with lighting scheduling policy that will help future construction oblige to the same standards

During this phase of the audit it is important to separate the different methods that should be used to help guide the retrofit decision-making process. Strategies one and two are focused on the luminous efficacy of electric light source. Luminous efficacy is a measure of how well a light source produces visible light.

This an important aspect to consider because while the university is looking for ways to find low-cost-or no cost ways to reduce energy expenditures it is also important not to disrupt the learning environment and enhance the comfort of campus buildings.

Strategies three, four and five are ways for Chapman University to harvest daylight to save energy and reduce peak demand. Strategy three improves the amount of daylight that penetrates into rooms, lobby, lounge and common areas. In strategy four, glare and unwanted heat are reduced through the installation of window-shading systems, which will control the amount of daylight admitted into the area. Strategy five, electric lighting controls, maximizes the energy efficiency benefits of daylight harvesting. Strategy six applies for both daylight and electric lighting. Through this recommendation interior surfaces are chosen in order to spread light throughout the room evenly. This method has proven to be one of the most cost-effective modifications a school can make in conjunction with the lighting retrofits. Strategy seven is aimed at dimming or turning off electrical lighting indoor and outdoor spaces based on available daylight.

5.3.2 Current Status: Hallways/ Lobby Areas

Hallways and lobby lighting in the residence halls are on 24 hours per day, 7 days a week. These lights are not necessarily needed every hour of the day as students are often in their dorm rooms or at a main campus building.[1] For these reasons occupancy-based lighting controls, retrofits of the existing light fixtures and daylight harvesting have the greatest potential to yield significant energy savings for the hallways and lobby areas. Current light fixtures in the hallways contain 25-watt compact fluorescent lamps. These lights are on continuously and serve very little to no purpose during sunlight hours. During night hours, lights remain on even when students are not present. Installing occupancy sensors will ensure that lighting is provided only when there is a real need. Occupancy sensors will automatically turn lights on around the area where motion is detected and automatically turn off the lights when unoccupied. Not only will occupancy sensors help Chapman achieve savings in electricity bills and consumption, but the safety of those who use the hallways will also be enhanced. It is important to note that retrofits are recommended not only to save the university money, time and to become efficient in electricity consumption, but to continue providing a safe environment for all students and staff that use the residence halls.

Electricity consumption for lighting was only calculated for the following residence halls: Pralle-Sodaro Hall, Sandhu Residence Center and Glass Hall. Davis Apartments were exempt due to low counts of hallway light fixtures. In order to determine the total electricity consumption, the total number of lights in each of the mentioned residence halls needed to be accounted for. Each of the hallways had the same type of light fixture CFL 2pin at 25 watts and were left on for the same period of time 24 hours. The total number of light fixtures were only accounted for the hallways in the first floor and assumed to be the same for the rest of the hallways in the building. The total light fixture for hallways: 935 lights. The total electricity consumption for lighting in the hallways alone is 196,344 kWh/ year or $21,597 per year (note that for this chapter uses a blended rate of $.11 to calculate the total amount paid. Refer to Chapter 1 of Jenny Bowen's Energy Efficiency audit), which is equivalent to 139 metric tons of CO_2. Refer to appendix for details on how to calculate kWh/year, amount paid per year and metric tons of CO_2.

5.3.3 Current Status: Dorm Rooms

Dorm rooms play a significant role on how much electricity Chapman University uses per year. According to the 2015 Student Survey data, students spend approximately 8-12 hours per day in their dorm rooms. Each residence room is equipped with a mixture of lighting fixtures (T12, T8, CFL spiral, 4 pin and/or 2 pin), different wattage ranging from 25-28 watts and total number of light fixtures per room. Due to time restrictions and lack of access to all dorm rooms, Resident Advisor (RA) rooms were evaluated and it was assumed that the rest of the rooms in the building were equivalent.

Total electricity consumption in kWh for residence halls is based off energy bills provided by Southern California Edison (SCE) for the year 2014. In order to calculate the electricity consumption for lighting, each residence hall would need to be analyzed individually. Student survey indicated that an average Chapman student spends typically 8-12 hours per day in their room. The median was taken from this 8-12 hour range and throughout the rest of the calculations for electricity in the rooms 10 hours was assumed.

Electricity consumption for lighting was calculated for all but two residence halls: North and South Morlan. South Morlan is a special case in where retrofits could have been made and implemented quickly due to the current status it holds. South Morlan has been approved to receive major remolding, but because insufficient energy consumption data was unavailable, it was exempt from the audit. Each residence hall has different types of lighting fixtures therefore each building had to be calculated independently on the type of light fixture and wattage. Table 1 shows the total count of lighting fixtures and type per residence building, hallway and dorm room.

Table 1: *Provides the total number of light fixtures for each of the dorm rooms including South and North Morlan for future research purposes. This table helps identify which rooms are currently using inefficient/outmoded light fixtures and are future retrofit projects. The number of rooms and floors are provided and are essential in order to calculate the total kWh of each residence hall.*

Residence Halls	Pralle- Sodaro	Sandhu	Davis Apt.	Harris Apt.	North Morlan	South Morlan	Glass Hall	Henley Hall
Number of Rooms	155	149	60	32	96	64	136	155
Number of Floors	4	4	2	2	3	2	4	4
Total Fixtures: Rooms	620	1848	360	128	480	192	544	465
Total Fixture: Hallways	203	264	40	X	X	X	212	256
Total Light Fixtures	823	2112	400	128	480	192	756	721
Total CFL 4 pin: 26 watts	x	1390	x	x	x	64	x	x
Total CFL 2 pin: 25 watts	638	710	120	64	x	x	606	411
otal Standard Spiral: 25 watt	30	x	280	x	96	64	x	310
T12: 27 watts	155	x	x	x	96	x	136	x
T8: 28 watts	x	x	x	64	288	64	14	x
T5	x	4	x	x	x	x	x	x
Decortive Lighting	x	8	x	x	x	x	x	x

Using the information above the total electricity consumption for in room lighting was calculated to be 361,789 kWh per year, or $39,796, which is equivalent to 249 metric tons of CO_2. Pralle-Sodaro Hall and Sandhu Residence Center are two special buildings because it houses an underground parking structure and a dining area respectively. For this audit only residence rooms and hallways were accounted for. The total electricity and lighting consumption for Sandhu Residence Center and Pralle-Sodaro Hall would be greater if lighting fixtures for each building was accounted for. Stairways and basements were also neglected in this audit. Total electricity consumption for each room versus the electricity used specifically for lighting can be seen in Figure 1.

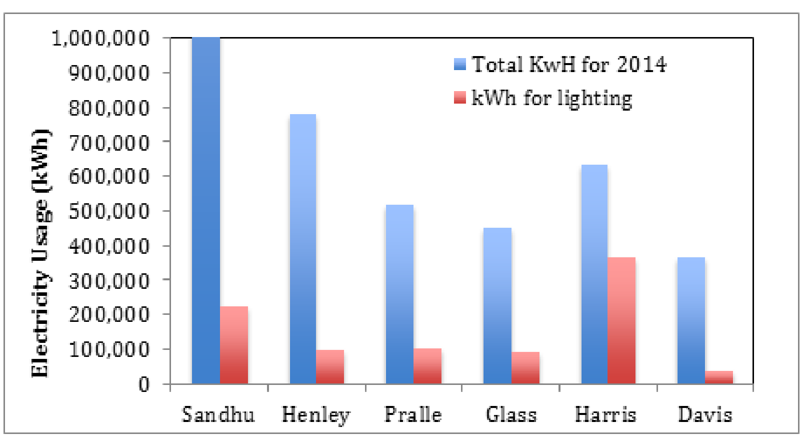

Figure 1: Demonstrates how much electricity consumption per room is used for lighting purposes. In this graph Sandhu total electricity consumption goes beyond 2.8 million kWh. Data for electricity consumption shows that residence halls that are older are using greater energy than newer construction. Sandhu was built in 2009 uses 8% of its total electricity consumption on lighting while Harris Apartments built in 1965 uses about 58%.

5.3.4 Assessment of Pralle-Sodaro Hall

Pralle-Sodaro Hall, built in 1992, is arranged into four floors and two wings. During the energy retrofit audit, Pralle-Sodaro Hall proved to be a prime candidate for lighting retrofit, daylight harvesting strategies and as a learning/development environment for students that are currently living in the residence hall rooms. As the student population continues to grow, so will the number of students housed in this building. Pralle-Sodaro can be utilized as a learning tool for freshman to learn different ways to conserve electricity used for lighting and to incorporate it into their future lifestyle to prepare them for sustainable living. Please refer to Chapter 7, Residence Life Behavior Change, Jacob Lopez's chapter to see how behavior change can affect the environmental sustainability in residence life.

Most residence halls have received very minor upgrades for energy efficiency and Pralle-Sodaro Hall is no exception. Pralle-Sodaro has received very few updates since it was constructed in 1992 and it comes to no surprise that this building continues to run outmoded T12s. The U.S. Department of Energy has mandated the phase-out of T12 fluorescent lamps and magnetic ballasts. As of January 1, 2010 production ended for magnetic ballasts, which are most commonly used with T12s. As of July 14, 2012 the U.S. manufacture or import of T12 lighting fixtures is barred.[1] This serves as a great opportunity for Chapman's facility team to install T8 LED lighting along with electronic ballasts to limit the amount of electricity that goes to waste.

The way Pralle-Sodaro was constructed gives Chapman the opportunity to harvest daylight in order to provide natural light instead of having lights in the lobby on continuously throughout the day. The primary recommendation package for Pralle-Sodaro includes increasing interior surface reflectance by painting the lobby and hallway areas a high reflective white. This will help illuminate areas in the lobby/hallway. Secondly, retrofit all T12s and 2 pin light fixtures to T8 LED and Dulux D/E 4-Pin SuperSaver, respectively. These are simple lighting retrofits from high wattage to low wattage fixtures and not only will electricity be saved, but the new recommend fixtures require low maintenance, have a higher life span and are dimmable. The dimming capability is an important aspect to have because this gives Chapman the opportunity to phase the project from importance. The lighting retrofit can be conducted and after several months of electricity billing savings, dimmers in the dorm rooms can be installed to have a higher savings percentage. Finally, sensor based occupancy/vacancy control system in the lobby area should be installed to control when the lights are on during night hours and to only have lights on when the area is being occupied.

5.4 Recommendations in Action:

Chapman University has made great efforts to become an environmentally sustainable campus. It now has the opportunity to make an initial investment and the end results can prove that Chapman is committed to making a sustainable future a reality today. To calculate projected electricity consumption used for lighting, electricity bills for 2014 were used. Each building and hallway contains different types of fixtures, wattage, and counts. Due to the insignificance of decorative lighting and T5s installed, lighting consumption for these lights were excluded from calculations. For each light fixture that is currently installed a recommendation was made. Recommendations are based on the wattage, required maintenance and life span of the fixture. Table 2 itemizes the light fixtures that are currently installed and the recommended light fixture for that unit.

Table 2: Gives the list of recommendation for each light fixture. The recommended light fixtures were chosen because they provide the most electricity saving per year. Also, it gives Chapman an opportunity to install dimmers in the future because the recommended light fixtures are all dimmable.

Current Light Fixture	Recommended Retrofit
2 tube at 25 watts	Duluxe D/E 15 watts
3 tube at 26 watts	Duluxe T/E/IN 21 watts
T12 at 27 watts	LED T8 18 watts
T8 at 28 watts	LED T8 18 watts
Standard Spiral at 27 watts	Dimmable Twist 14 watts

The total electricity consumption for each of the residence halls is first determined in order to calculate the projected lighting consumption. The projected lighting is determined for each type of lighting fixture, hallway and room. The number of hours that a light fixture is on stays the same throughout each calculations the only difference is a change in wattage for each fixture. For a step-by-step explanation on how the projected lighting was calculated refer to the appendix. With recommended light fixtures installed the expected light consumption is displayed in Figure 2.

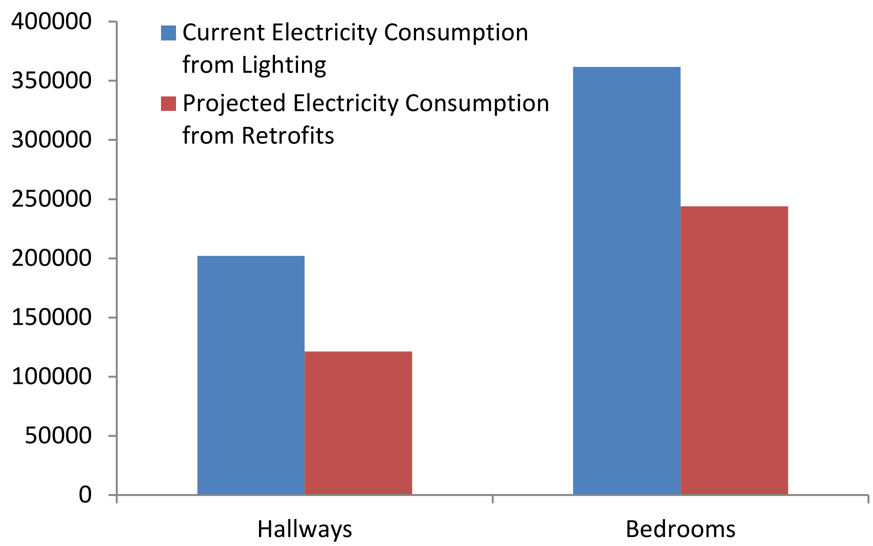

Figure 2: with the recommended light fixtures installed an average of 39% savings in electricity bills and energy consumption is determined. All residence halls see a great reduction in the amount of electricity used for lighting. Davis Apartments and Henley Hall see the greatest reduction in electricity 45% and 42%, respectively.

The average amount of electricity bill and consumption savings is 39%. Simple retrofits have the ability to decrease the amount of electricity used for lighting, which in terms reduces the amount metric tons of CO_2, emitted into the atmosphere. CO_2 emissions for lighting is measured at 636 metric tons and for the project lighting carbon emissions is reduced to 405 metric tons. The amount of saving per year in dollar amount is equivalent to $35,700 dollars.

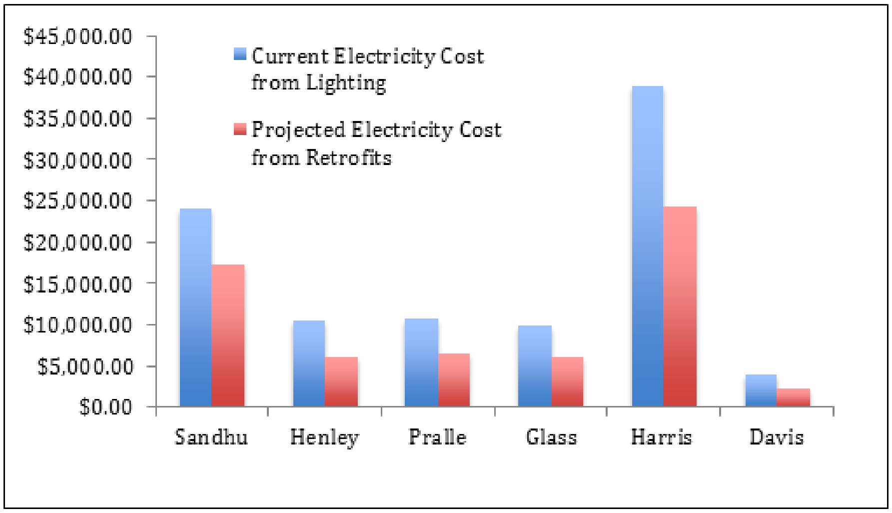

Figure 3: Indicates the amount of money saved if the recommended retrofits are installed. The projected annual bills were calculated using the blended rate of $.10636. This is an overestimate as the blended rate chosen is for summer months. Each building had an average saving of about $6,000 except for Harris. Harris, using 2014 data, had a reduction of $14,000.

Lighting retrofits for residence halls have the potential to be simple and efficient. Chapman University paid a total of $98,000 for lighting alone in 2014. If the recommended lighting fixtures are to be installed it's projected that Chapman would pay a total of $112,000 for lighting. The University will be in line to save approximately $64,000 every year for lighting retrofits. This does not include additional money that can be saved by installing occupancy sensors in hallways.

5.4.1 Return on Investment (ROI) for Lighting Fixtures

Besides calculating environmental impacts (metric tons of CO_2 emitted) and the projected electricity cost from retrofits, it is important to consider the return on investments. This will help Chapman University prioritize which building should be considered for a pilot program. Return on Investment will be calculated as a whole to maximize profit. This is done because light fixtures are sold at a lower cost if they are purchased in bulk orders.

In order to determine ROI, the first step is to learn the amount of money saved for each building. See appendix for details on how ROI is calculated. The initial investment is calculated to be $46,645. It has been established that if the recommended retrofits are installed, Chapman will have an annual savings of approximately $64,000. ROI is calculated at 37%. The initial savings for the first year will ultimately pay for the retrofit project in all the residence halls and future savings will be profits for the university.

5.5 Concluding Assessments

Chapman has taken initiatives in making residence halls more energy efficient and sustainable. The installation of sub-metering helps identify residence halls that are inefficient electricity consumers. Through environmental audits conducted by the graduating class, Chapman University gets an insight of the small inefficiencies that go unnoticed.

In this years audit, North and South Morlan had insufficient data for energy consumption. One week's worth of electricity bills were compiled but the assumption was too extreme to include in this audit. Dimmers and occupancy sensors are great strategies to decrease the amount of electricity used throughout the day, but unfortunately time restraints made it difficult to calculate the amount of energy saving per residence hall, room and hallways.

In order to get calculations for current and projected electricity consumption a few assumptions were made.

- Student survey suggested that rooms are occupied 8-12 hours per day. For calculations 10 hours was used.
- Resident Advisors rooms were used as models for the entire building
- Hallway lights were only counted for the first floor of each building and assumed to be the same for each floor
- Blended rate for summer ($.19024) was used to calculated total amount paid for 2014 and projected cost for electricity and lighting

5.6 Future Areas of Research

Some future areas of research can include:

- Full audit on both south and north Morlan. Since South Morlan has been approved to receive major upgrades, it should be assessed on how efficient it will be
- Stairways, underground parking structure and Sandhu dining Hall should be audited
- Potential areas to install dimmers and occupancy sensor should be research to determine the total electricity consumption of the residence hall

5.7 Contacts

Mackenzie Crigger, Energy Conservation and Sustainability Manager, Chapman University Facilities Management (crigger@chapman.edu, 714-997-7370)

5.8 References

Chapman University 2013 Environmental Audit

Chapman University 2014 Environmental Audit

University of California Davis: Lighting retrofits for California Schools

US National Grid

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Lutron Lighting

elightbulb

ELEDlights