

3.1 Introduction

One of the highest expenditures for businesses and universities is energy consumption and in the U.S, universities spend an average of \$1.95 per square foot on electricity and \$0.18 per square foot on natural gas annually. For a typical 50,000 square foot educational building, annual costs can exceed \$100,000, with 35% of the energy used for lighting, and over 50% used for space heating and cooling¹. Although Chapman University is a small university, the university spent close to \$1.9 million on energy in 2013, \$1.4 million of which was spent on electrical energy on main campus. As Chapman's campus and population grow, it is inevitable that the demand for energy will increase significantly. Therefore, it is economically beneficial to identify possible ways to reduce energy consumption at the university.

As previously stated, on average lighting accounts for 35% of a building's energy consumption. This chapter will attempt to analyze and propose possible lighting retrofits for Chapman University's main campus' buildings. Curbing Chapman's energy consumption will not only result in economic benefits, but will also have positive environmental impacts. Energy consumption causes the release of harmful greenhouse gases into the atmosphere, which has tremendous environmental implications. Reducing energy consumption through retrofits will allow Chapman to accomplish its goal of creating an energy efficient and environmentally sustainable campus.

This chapter of the 2015 Chapman University Environmental Audit will focus on utilities and retrofits for three campus buildings: Roosevelt Hall, Smith Hall, and Demille Hall. These buildings have been strategically chosen because of their potential to undergo successful energy-saving retrofits. The purpose of this chapter of the audit is to:

- Identify possible ways to reduce energy consumption at the university through analyzing and proposing possible lighting retrofits for 3 of Chapman University's main campus buildings.
- Calculate and compare current versus potential economic and environmental impact savings.

3.1.1 History at Chapman

In 2012, Chapman installed electrical sub-metering in its main campus buildings, which was a major step toward improving sustainability. Previously, the lack of sub-meters for individual buildings resulted in having one monthly energy bill for all campus buildings,

making it impossible to see how much energy each building was using. This recently installed technology allows for the ability to identify and monitor trends in consumption of individual buildings so that those in charge can make better informed improvements and verify the results of energy efficiency projects. Consult the Energy Efficiency Chapter in the 2015 Environmental Audit for specific examples of sub-metering data for specific buildings. Also in 2012, Chapman installed hot water recirculation pumps in the Residence Halls in order to deliver hot water on demand instead of having the water constantly heated. As a result of this change, the 2013 Environmental Audit reported a possible savings of 2,000 Btu's per year in the Morlan Residence Halls alone.

The original audit completed in 2013 Environmental audit does include an outline on energy consumption at the university. An explanation how energy is used at Chapman, as well as the concept of the tier system and peak hours when using water, natural gas and electricity, is included in the 2013 Audit. The audit made many suggestions for future studies and ways to improve energy consumption at the university. Among these suggestions were identifying possible lighting retrofits in older buildings on campus (i.e. Smith, Roosevelt and DeMille). A survey conducted in the audit found that 84% of staff and faculty, and 86% of students were accepting and somewhat accepting of installing motion-activated light sensors in classrooms and hallways. The possible cost and energy savings from this retrofit and the overwhelming acceptance by the school community validate the necessity of having these retrofits installed. For other information on energy usage, consult chapter 1 of the 2015 audit.

3.2 Case Studies of Lighting Retrofits

Universities across the country have focused much of their attention on finding ways to reduce energy usage through various lighting retrofits. Lighting retrofits can not only reduce energy usage, but will also lower costs attributed to maintenance costs and replacing the lights as frequently. The potential cost savings from such retrofits could go towards paying for other necessary expenditures.

3.2.1 LED Lighting Retrofit at UC Davis

These different studies indicate an overall shift towards the use of more LED lights to replace CFL's. UC Davis found that T8 LED lamps are 10% more efficacious than a typical T8 fluorescent lamp. It was also found that LED fixtures retain 70% of their original lumen output, which is twice the amount of a fluorescent tube¹. Also, because LED's have an average life that is twice that as fluorescents', there is potential savings from installation costs as well as having the ability to use the light for twice as long.

3.2.2 Occupancy Sensor Retrofit at Pepperdine University

In 2013 Pepperdine University worked with Southern California Edison's *Private Schools and Colleges Audit and Retrofit Program* to implement a lighting retrofit on their

Drescher campus. The university installed Lutron occupancy sensors, switches and relay modules in their classrooms and offices. As a result of this lighting retrofit the university's project stakeholders estimate to have reduced energy by 20-30%.

3.3 Current Status of Main Campus Energy Use

3.3.1 Energy Usage on Main Campus

In the 2014 fiscal year, the university consumed 38,568,000 kWh of electricity. Of this total consumption, the three buildings being analyzed in this chapter (Demille Hall, Smith Hall and Roosevelt Hall) consumed 633,367 kWh. The amount of kWh spent on lighting in 2014 in these buildings was 170,572kWh, which accounts for 27% of the total energy used by the three buildings (see [Appendix](#)).

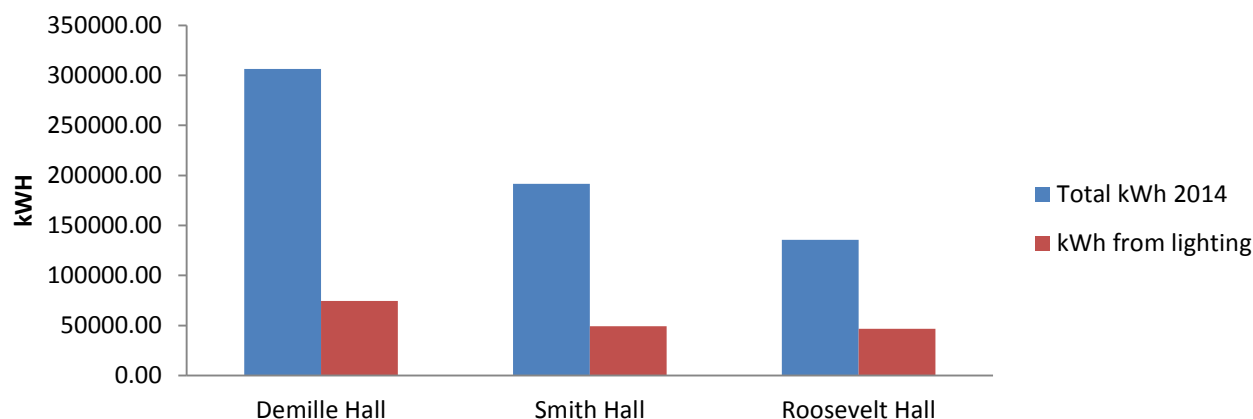


Figure 3.1. Total kWh consumed by each building in 2014 (blue) vs. the kWh used for lighting in each building in 2014 (red).

Between the three buildings being examined, there are a total of 1,234 light fixtures. Of the 1,234 fixtures, 1,197 are T-8's, which are each 28W. Since 97% of the fixtures are T-8, this chapter focuses primarily on these fixtures. In looking specifically at this type of lighting, it was found that (see [Appendix](#)):

- Demille Hall contains 520 of the T-8 fixtures.
- In Smith Hall, there are 355 T-8 fixtures.

There are 322 fixtures are in Roosevelt Hall

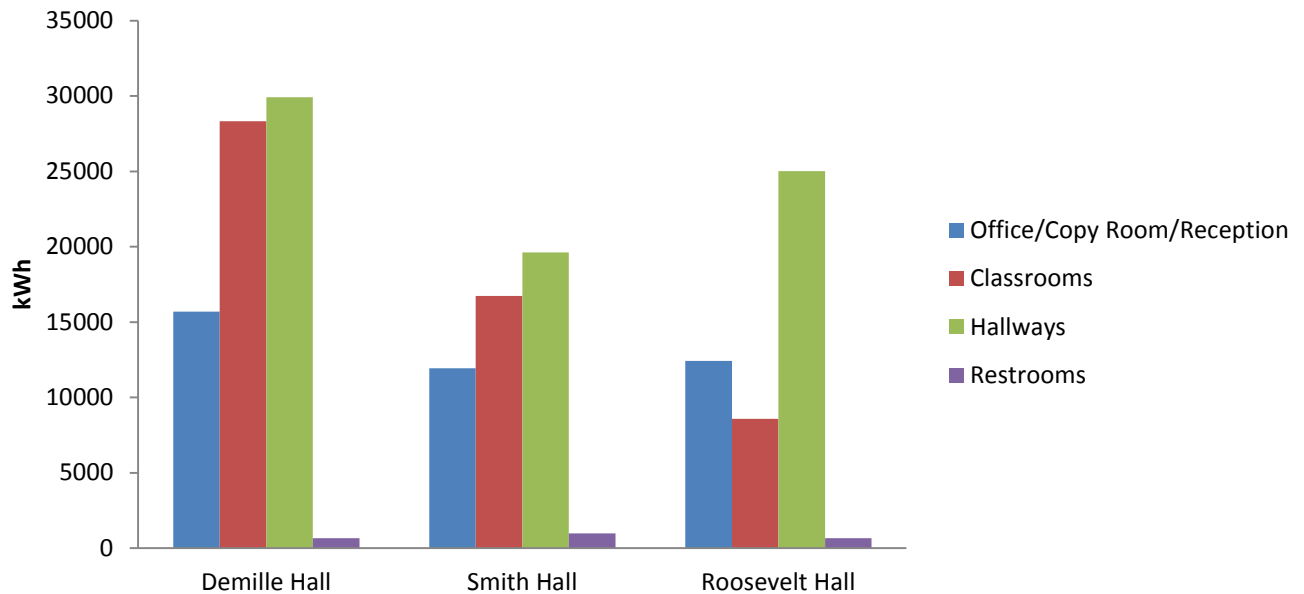


Figure 3.2. Total 2014 kWh in each building separated by type of room.

3.3.2 Energy Costs

The Energy Efficiency Chapter of the 2015 Environmental Audit found that in 2013, the university spent an average of \$0.1735 per kWh in the summer months (Oct-May). For 2014, it was calculated that the university spent an average of \$0.1902 per kWh in the summer and \$0.1064 per kWh in the winter months. Using these rates it was calculated that in 2014 (see [Appendix](#)):

The university spent \$87,158 on energy for Demille, Smith, and Roosevelt Hall.

- Lighting contributed to \$23,500 of the \$87,158 spent on electricity.

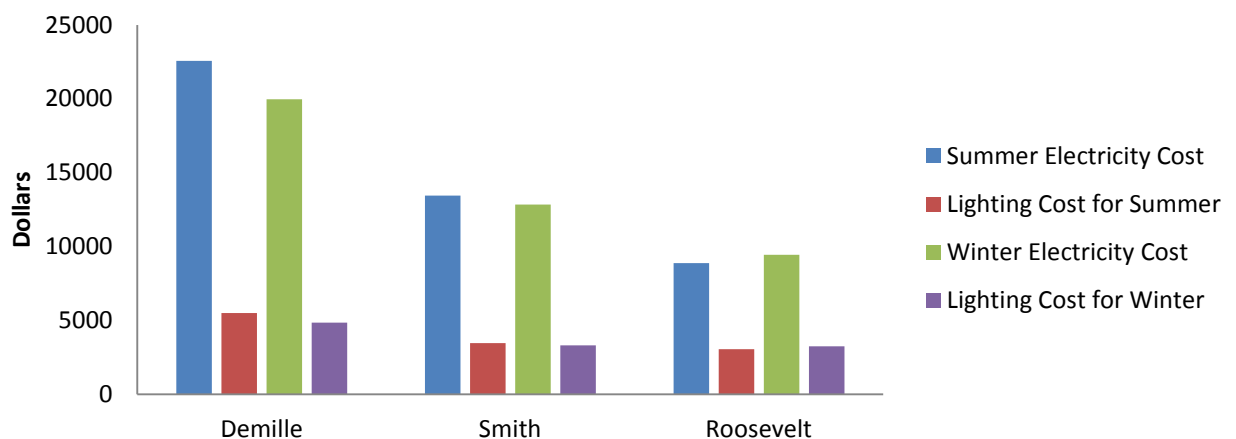


Figure 3.3. Summer and winter costs of electricity in 2014 vs. the summer and winter costs of electricity used for lighting in 2014 for the 3 buildings.

The 2014 blended rate cost for energy is \$0.11 per kWh. Using this rate it was calculated that in 2014 (see [Appendix](#)):

- The university spent \$69,670 on energy for the three buildings.
- Of the \$69,670, close to \$18,763 was spent on lighting alone.

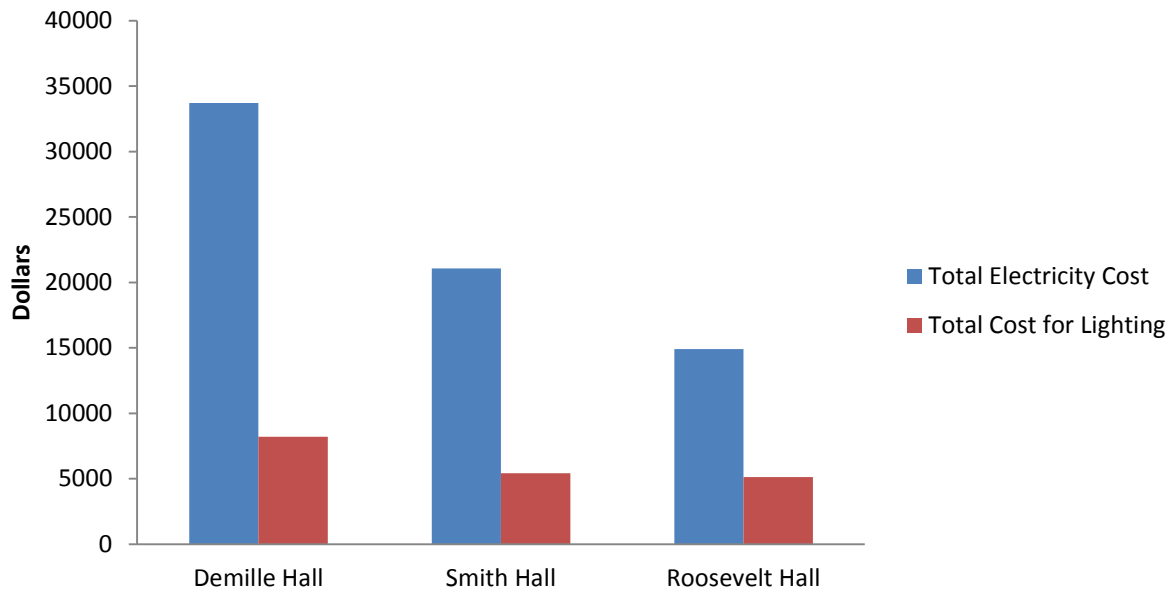


Figure 3.4. Calculated total electricity cost for each building in 2014 (red) vs. total cost of electricity for lighting in

3.3.3 Environmental Impact:

The EPA calculated that one kWh of electricity used is equivalent to the emission of 6.89551×10^{-4} metric tons of CO₂. Using this conversion, it was calculated that (see

[Appendix](#)):

- The total CO₂ emission for the three buildings in 2014 was 436 metric tons CO₂. This is equivalent to the emissions from 49,144 gallons of gasoline.
- From lighting alone, the equivalent amount of CO₂ emissions was 118 metric tons CO₂, which translates to 13,235 gallons of gasoline.

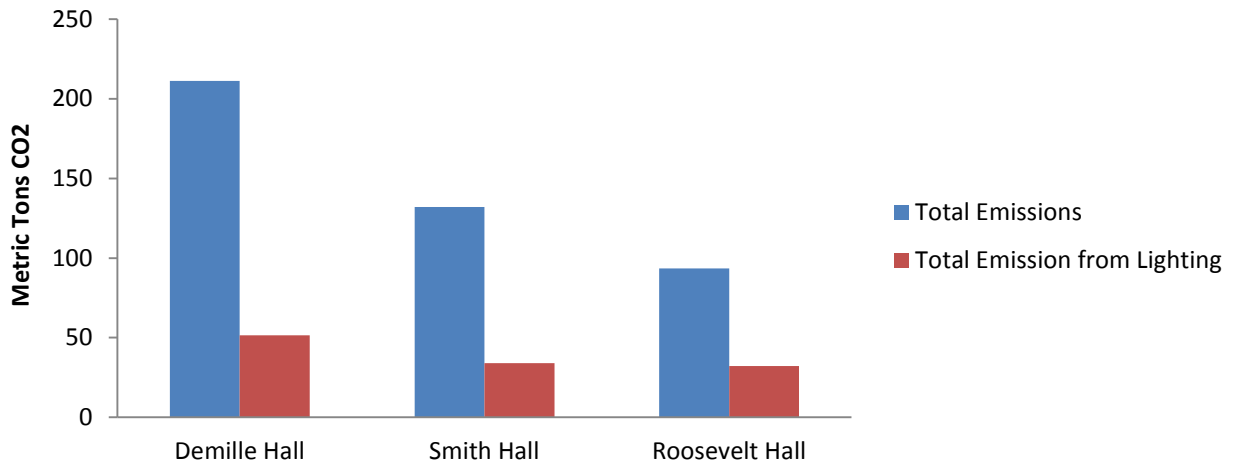


Figure 3.5. Total emissions from lighting in 2014 (red) vs. total emissions from the 3 buildings in 2014. Measured in metric tons of CO₂.

3.4 Chapman University Sustainability Survey

As part of the 2015 Audit, a campus-wide survey was conducted with faculty, staff, and students. The student survey had a sample size of 430 students and yielded the following results:

- Over 74% of the student population either somewhat or strongly support the installation of light dimmers in the classrooms, while only 6.7% of students who took the survey were either somewhat or strongly opposed.
- Similarly, 76% of students somewhat or strongly support installing occupancy sensors in classrooms, and only 5.6% is somewhat or strongly opposed to the idea.
- Close to 74% of students were somewhat or strongly in support or occupancy sensors in restrooms. Only 11% were somewhat or strongly opposed to this idea.
- Students are overall in support of installing motion activated lighting in the hallways and common areas, with 68% of students somewhat or strongly in support and 15.3% who strongly or somewhat oppose.

In addition to the student survey, a survey conducted with 282 staff and faculty participants had some of the same questions and yielded similar results:

- Close to 72% of faculty and staff somewhat or strongly support installing dimmers in classrooms, while only 7% are somewhat or strongly opposed.
- Almost 79% are somewhat or strongly in favor of installing occupancy sensors in classrooms, and only 5% are somewhat or strongly opposed.
- When asked their thoughts on installing light dimmers in their offices, 65% of faculty and staff were somewhat or strongly in support and only 14% were somewhat or strongly opposed.

- Almost 70% of faculty and staff somewhat or strongly support installing occupancy sensors in their offices, while only 13% are somewhat or strongly opposed.
- Around 55% of faculty and staff responded to turning off the lights often or very often when leaving a classroom.

The results from both surveys indicate that the campus community is interested in pursuing various practices such as installing occupancy sensors and/or dimmers in offices, classrooms, hallways, and restrooms. Whatever the reasoning for the interest in these retrofits, the overwhelming support received means there is much energy and cost saving potential in performing similar retrofits.

3.5 Concluding Assessment

3.5.1 Areas of Progress

Chapman has taken many steps towards making its campus more sustainable and energy efficient. The installation of sub-metering in individual campus buildings, hot water recirculation systems in the residence halls, Big Belly Solar trash cans, and water-bottle refill stations are all noteworthy steps that the university has taken in recent years. Having a yearly sustainability audit enforces the university's commitment to building an environmentally sustainable community.

3.5.2 Areas in which to improve

It is true that in recent years the university has increased its sustainability efforts. However, there is still a large margin of possible energy savings that can be achieved. There are many locations on campus which contain occupancy sensors, yet their presence is unevenly distributed throughout campus. Increasing the number of occupancy sensors can result in tremendous cost and energy saving potential.

3.5.3 Existing gaps in knowledge

There were a few assumptions made in order to generate the projections in this chapter. The following are the assumptions which were made:

- Classroom lights are kept on for 14 hours per day.
- Office lights kept on for 8 hours per day.
- Restroom lights kept on for 8 hours per day.
- Hallway lights kept on for 24 hours per day.

Since it was difficult to obtain access to certain rooms such as storage and electrical rooms, these not been included in the data and their consumption is not factored into the projections. Also, due to the inability to access 10 of the offices in Demille Hall, the assumption was made that these rooms have the same number of fixtures as the rooms of similar size in the building. It was assumed that in Smith and Roosevelt Hall, each buildings' offices have the same number of lights because the floorplans are the same.

When these buildings are retrofitted, it would be beneficial to create a building floorplan that includes specific lighting details for each room. This would include the type of fixture, any lighting options the room has (dimmers, occupancy sensors, etc). Since fixtures are constantly being replaced in various rooms, the lack of such information makes it nearly impossible to know exactly what is in the building. There should be a policy implemented which requires facilities to document this information each time they perform a lighting retrofit in a room. Having this data a few years from now will also allow facilities to see what buildings have outdated lighting, as well as areas with high energy-saving potential.

3.6 Recommendations

Examples of the lighting retrofits that will be analyzed for the three chosen buildings include replacing existing fixtures with newer and more energy-efficient fixtures, as well as installing occupancy and/or daylight sensors. Figuring out how much energy is used and where it is used will indicate which types of rooms use the most energy, which could have further indications that may be helpful in finding ways to reduce energy.

3.6.1 Low Cost/effort:

- Decrease time that lights are left on during mornings and nights before class and work hours.
 - Some buildings are not open 24/7, so reducing the daily operating time can save energy and money.
 - Shutting off hallway lights for 12 hours a day instead of leaving them continuously illuminated would result in a savings of over 37,000kWh per year, which is a 22% energy reduction in lighting in the three buildings. This would result in an annual savings of over \$5,000 per year, and there would be no initial cost involved.

3.6.2 Medium Cost/effort:

- Implement more initiatives to raise awareness of sustainable practices
 - Educating individuals on important practices such as shutting off lights when leaving rooms can yield effective energy saving results.
- Creating and implementing a policy establishing standard sustainable lighting retrofits.
 - By having a list of suitable energy efficient retrofit options for the different fixture types in the buildings on campus, maintenance and facilities will be able to use this information when replacing or purchasing replacements for existing fixtures.

3.6.3 High Cost/effort:

- Replace existing 28W fluorescent T8 fixtures with 18W LED T8 fixtures from ELEDLights¹. Consult *Figure 3.5-3.7* for specific energy and cost saving details(see [Appendix](#)).
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 - Doing so would result in 35.7% energy reduction, which is a savings of 61,000kWh per year and a savings of over \$8,380 from the 3 buildings alone (Demille, Smith and Roosevelt Halls).
 - This is equivalent to a reduction of 42 metric tons of CO₂ and the emissions from over 4,700 gallons of gasoline.
 - To purchase 1,197, fixtures at \$13 per fixture, the initial investment would be \$15,561. The simple payback for this purchase would be 1.86 years using the 2014 average summer and winter rates and would be 2.3 years using the 2014 blended rate.
 - Because these LED fixtures have a lifetime that is twice that of the traditional fixture, there would be immediate savings from using one lamp for twice as long.

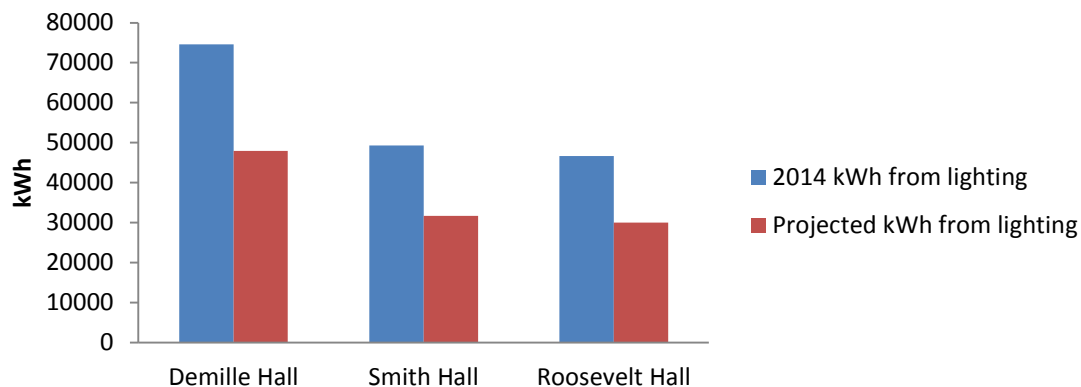


Figure 3.6. Total 2014 kWh from lighting vs. projected kWh from lighting after retrofits.

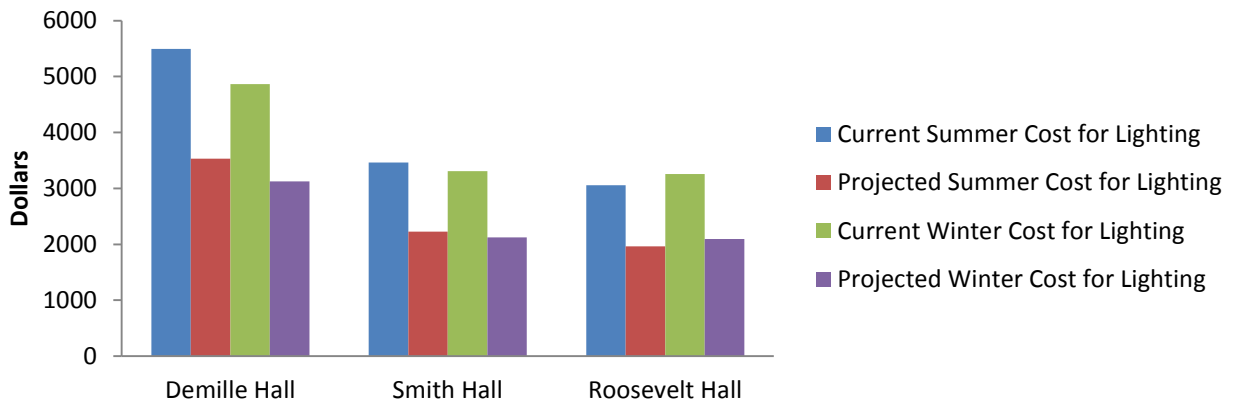


Figure 3.7. Total 2014 winter and summer energy costs vs. total 2014 summer and winter lighting costs per building. Calculated using avg. summer cost of \$0.19024/kWh and winter cost of \$0.10636/kWh.

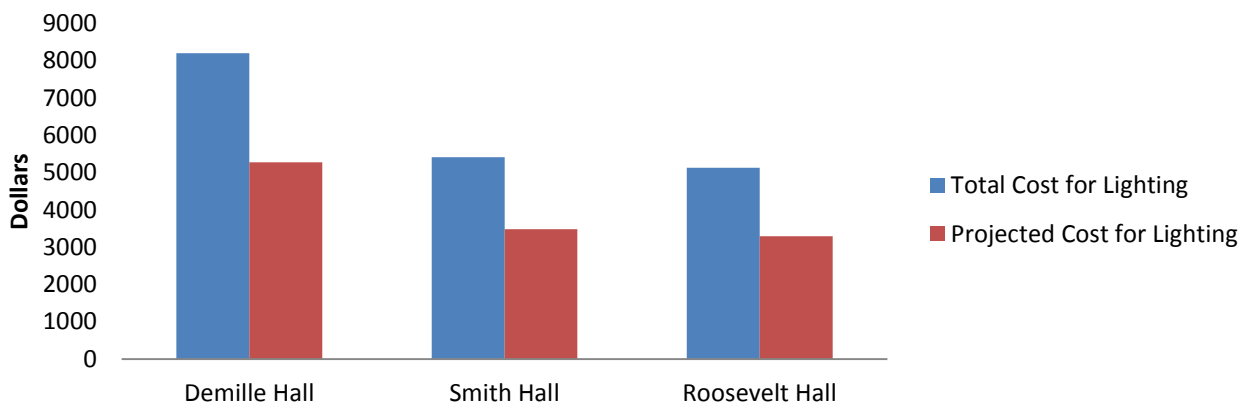


Figure 3.8. Total 2014 Energy Cost vs. Cost of Lighting in each building. Calculated using a blended rate.

3.6.4 Future Areas of Research:

Some future areas of research to be explored in succeeding audits may include the following:

- Return to Demille, Smith and Roosevelt Halls and identify potential locations for occupancy sensors and/or dimmers.
 - Although this chapter addressed basic cost savings in regards to the installation of these retrofits, future audits could identify specific types of rooms, such as hallways, that are eligible for retrofitting.
- Identifying similar 28W T8 fixtures that can be retrofitted with new LED fixtures and perform a cost benefit analysis and environmental impact savings.

- Assessing possible lighting retrofits for Marion Knotts Studio.
 - Marion Knott Studios is one of the highest consumers of energy of all the buildings on campus, having used 2,189,434 kWh in 2014. Since this accounts for 5.7% of the total kWh of energy used by all the campus buildings combined, particular attention should be paid to this building. In the entrance alone, there are six 500W halogen quartz lights that are on all the time and consume an estimated 26,280 kWh/year and cost \$1820/year to light (assuming the lights are on 24 hours a day, 7 days a week). This is just for six lights, that don't even need to be turned on most of the day because there is an abundance of natural daylight.
- On average, 50% of electricity is spent on HVAC heating and cooling, which highlights immense possible savings. Consult chapter 6 of the 2015 audit for details on HVAC retro-commissioning projects in residence halls.

3.7 Contacts

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7. Cheryl Stack, Administrative Assistant, Hashinger Science Center (cstack@chapman.edu, 714-628-2862).

3.8 References

1. Chapman University 2013 Environmental Audit
2. Chapman University 2014 Environmental Audit
3. US National grid
4. Pepperdine University
5. UC Davis
6. Lutron Lighting
7. Eledlights