Final Report - LED Retrofit

MCHE 4660 Project Final Report

Group 6

University of Georgia Engineering

MCHE 4660

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Background

In 2019, energy consumption by the residential sector and commercial sector was about 21 quadrillion Btus and is equal to 28% of total U.S. end-use energy consumption in 2019 (EIA, 2020). This is a significant portion of energy use and the ability to decrease a building's energy cost will not only benefit the occupants financially but also reduce the carbon emissions across the US.

Lighting energy constitutes a large portion of a building's total energy. While more recent buildings on the UGA campus have better designs such as allowing more sunlight to illuminate the building rather than depending on artificial lighting or using light-emitting diodes (LEDs) for lighting, older campus buildings are still using incandescents. The Lamar Dodd school of Art building we toured had a natural sunlight effect as part of the building design; however, most of the older buildings on UGA's campus do not have this feature. Many of the buildings on the campus are quite old and were not built during a period where LED technology was in widespread use.

With the LED Retrofit program, UGA facility management division (FMD) is progressively and actively replacing the existing lighting fixtures or bulbs with high efficiency LED replacements. We were tasked with assisting FMD with this retrofit project. We are also going to identify which buildings need the new lamps. We will provide the scope of work and number of fixtures that require retrofitment; however, the labor will be performed by the FMD. For our project, we were asked to select three buildings that need the retrofit. We chose Marine Science, Hardman Hall and the Ecology Building.

LEDs are extremely energy efficient as they use 75% less energy and last 25 times longer than incandescent lighting (US Dept of Energy, 2020). That means that LEDs don't have to be replaced as much, reducing costs in labor and materials. UGA hopes to spend a higher upfront cost to replace older lighting fixtures with LEDs while saving more in the long run. There is also reduced electricity costs coming from Georgia Power with their lighting rebate program. The LED retrofit program will allow UGA to save energy as well as saving the environment through burning less fossil fuels for electricity consumption.

The United States Department of Energy reports that LED bulbs possess good thermal management. Meaning that they dissipate heat very well using heat sink technology. This increases the life of the bulb thus reducing equipment and maintenance cost. LED bulbs and fixtures can reduce energy costs by around half in most cases. (U.S. Dept. of Energy Reports, 2020). UGA should expect lower lighting costs overall and decreased maintenance frequency after the retrofit occurs.

Current Examples

There are multiple examples of LED retrofits across the country and around the world. The University of Chicago replaced the incandescent lamps around campus with 800 LED replacement lamps (UChicago, 2020). This allowed electricity consumption to be reduced by approximately 75%. The LED lamps will last 2.5 times longer and reduce costs by 35% compared to the existing metal halide lamp. All of these benefits will only take approximately 3.9 years for payback (UChicago, 2020).

The University of Ottawa also undertook the LED retrofit project by replacing 90,000 T8 fluorescent lamps with T8 LEDs (UOttawa, 2020). This project is expected to reduce energy use by 40%, save 6,000,000 kilowatt hours a year and save $748,000 a year for the university (UOttawa,2020).

Stakeholders

University of Georgia

With the LED retrofit program, UGA will be able to reduce energy consumption of lighting in older buildings across campus. LEDs last longer and don't require frequent replacement as incandescents do, which allows for reduced costs. Electricity costs will go down and Georgia Power will provide rebates due to UGA's installation of LEDs.

General Public, Students, Staff

Potentially, this could reduce students fees. Students and teachers will be able to experience a cleaner UGA campus. This will reduce operating and maintenance costs for UGA and the savings could be transmitted to countless students. Fossil fuel consumption could go down and reduce the CO2 emissions leading to a better environment for the people to live in.

Methods

Each building is toured in order to document the fixture size and the quantities of each fixture. While the buildings are being toured, if we notice any energy-efficiency practices that can be implemented or improved on, they are noted down. These fixtures are photographed and cross-referenced with electrical drawings to ensure accuracy. We recorded the lamps and calculated which LED replacements could be used in place of the existing lamps. The lamp costs were summed and the annual savings were calculated. A return on investment has been calculated over time for each building in Microsoft Excel. These will be plotted in a line graph and compared to a line graph of fluorescent fixtures for data visualization and easier understanding.

Building Lighting Data

Marine Science

- **Lobby Entrance**
  - 2x4: 3
  - 2x2: 4

○ Quad Bulb: 16

- **1st Floor**
  - 4x4: 48
  - Single Bulb: 2
- **2nd Floor**
  - 2x4: 51
  - 2x2: 16
  - 3x4: 6
- **Exit**
  - 2x4: 4
  - Single Bulb: 2

2x2

2x4

3x4

Single Bulb

Quad Bulb

(All photos above taken by Man Aw, Thomas Dodd, and Anthony Zheng at Marine Science, UGA)

Hardman

- **1st Floor**
  - 2x2: 1
  - 2x4: 10
  - 1x4: 3
- **Stairwell #1 (Front Left)**
  - 2x2: 0
  - 2x4: 0

- 1x4: 2

- **Stairwell #2 (Front Right)**
  - 2x2: 0
  - 2x4: 0
  - 1x4: 2
- **Stairwell #3 (Back)**
  - 2x2: 1
  - 2x4: 0
  - 1x4: 2
- **Second Floor**
  - 2x2: 0
  - 2x4: 11
  - 1x4: 1

2x2 **2x4** **1x4**

(All photos above taken by Man Aw, Thomas Dodd, and Anthony Zheng at Hardman Hall, UGA)

Ecology

- **High Ceiling Office Space**
  - 2x4: 35
  - 3x4: 17
- **Main Floor**
  - 2x2 U-Shaped: 58
  - 2x4:18
  - Single flood bulb: 30
  - 3x4: 23

U-Shaped **3x4** **Single Flood Bulb**

(All photos above taken by Man Aw, Thomas Dodd, and Anthony Zheng at Ecology, UGA)

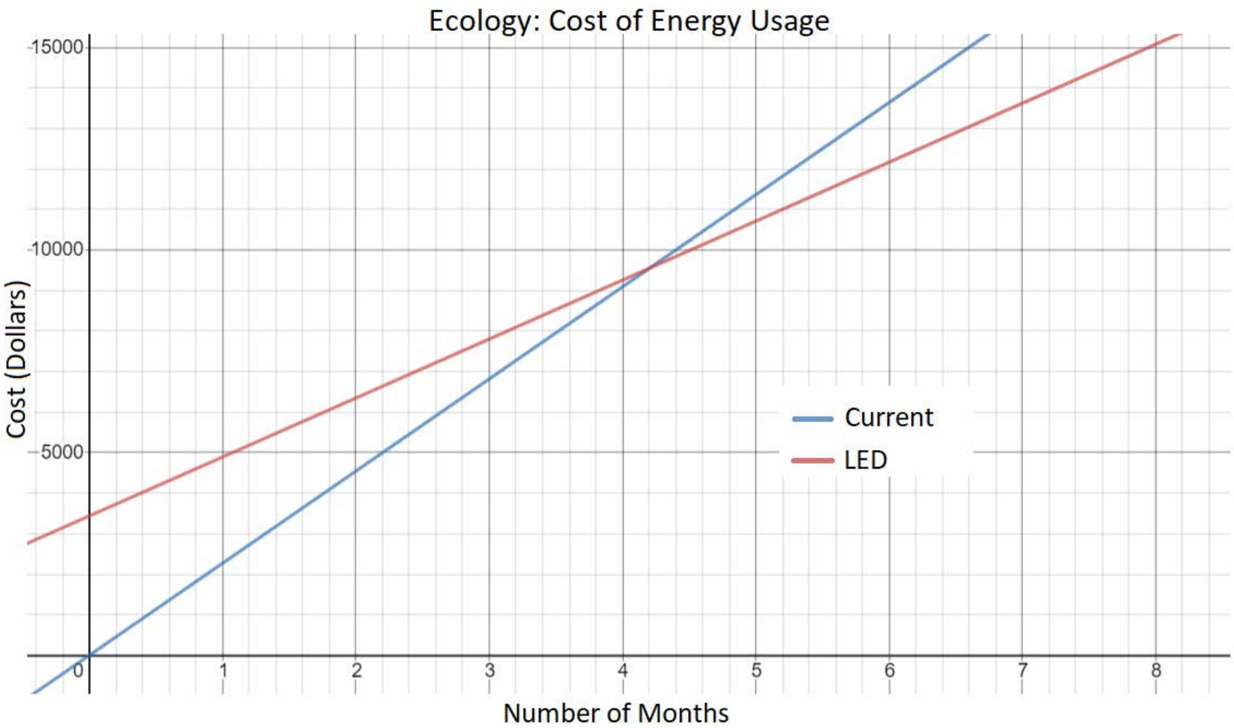
Results

As directed by Tyler Chapman, our main source of contact in the Facilities Management Division (FMD) - Energy Services, we created a tables detailing the quantity of each type of fixture being removed, fixture type (recessed troffer, can light, pendant, etc.), fixture size (2x2, 2x4, etc.), Lamp Type (CFL, T-8, T-12, etc.), number of lamps for each fixture, lamp wattages for each lamp for each fixture type and ballast type (magnetic, electronic, etc). **Tables 1,6, 11** located in the appendix section list those details.

For the Ecology building, the cost of the LED lamps is a total of $3,437.04. The current energy costs for the Ecology building is $27,270.0 while the energy costs with LEDs is $17,451 which means the savings from switching to LED is a total of $9,819. More details can be found in Appendix A.

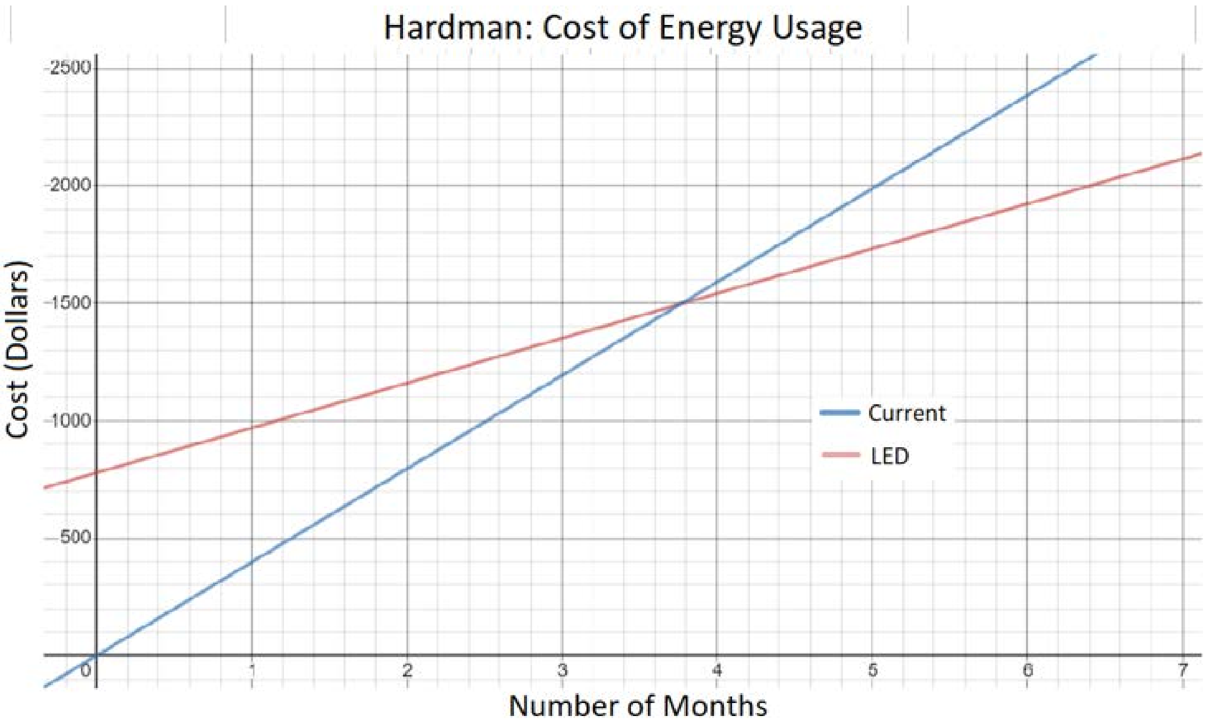
For Hardman Hall, the cost of the LED lamps is a total of $778.10 The current energy costs for Hardman Hall is $4,770 while the energy costs with LEDs is $2,289.60 which means the savings from switching to LED is a total of $2,480.40. More details can be found in Appendix B.

For Marine Science, the cost of the LED lamps is a total of $3,441.83 The current energy costs for Marine Science is $7,635 while the energy costs with LEDs is $3,429 which means the savings from switching to LED is a total of $4,206. More details can be found in Appendix B.



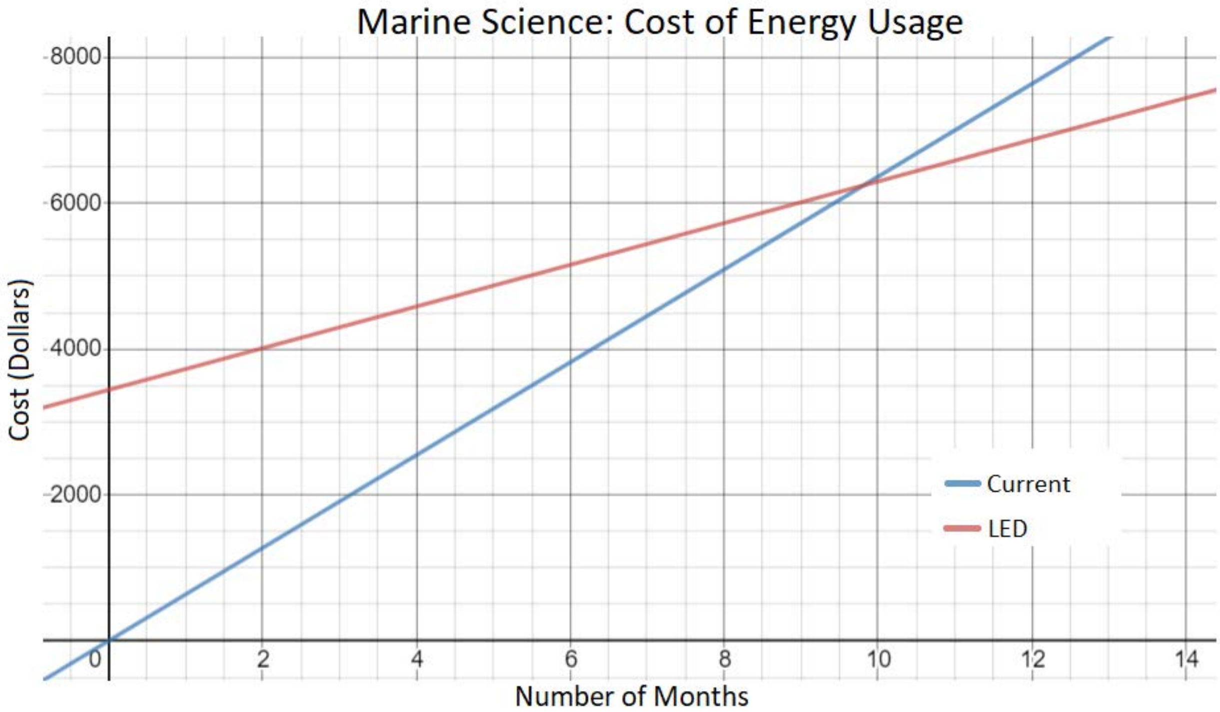
Graph I. Ecology Energy Cost

The initial investment of replacing all lamps with LED lamps would be $3437.04. However, the monthly cost of LED lamps for Ecology is only $1454.25, while the monthly cost of current lamps for Ecology is $2272.50. As demonstrated in Graph I, this indicates that by the fifth month of LED lamp usage instead of fluorescent lamp usage, Ecology would start paying a lower aggregate amount for energy usage.



Graph II. Hardman Energy Cost

The initial investment of replacing all lamps with LED lamps would be $778.10. However, the monthly cost of LED lamps for Hardman is only $190.75, while the monthly cost of current lamps for Hardman is $397.50. As demonstrated in Graph I, this indicates that by the fourth month of LED lamp usage instead of fluorescent lamp usage, Hardman would start paying a lower aggregate amount for energy usage.



Graph III. Marine Science Energy Cost

The initial investment of replacing all lamps with LED lamps would be $3441.83. However, the monthly cost of LED lamps for Marine Science is only $285.75, while the monthly cost of current lamps for Marine Science is $636.25. As demonstrated in Graph III, this indicates that by the tenth month of LED lamp usage instead of fluorescent lamp usage, Marine Science would start paying a lower aggregate amount for energy usage.

For the annual operating hours, there was a rough estimate of 10 hours per day and 5 days a week with 300 days in use. It is difficult to account since we don't have exact numbers from the building and since some of the fixtures had lamps that weren't working or were turned off. There are potentially more energy savings that can be done if each building made use of natural daylight instead of leaving most of the fixtures on even during the day. Some fixtures had a total of 4 lamps which could be reduced to two lamps with higher lumens. The Ecology building is a good example of this since it has large windows that allow light to come in especially in the office space but it has 35 2x4 fixtures about 15-20 ft above the office cubicles. If those fixtures could be reduced and instead use small wattage lamps clamped onto the cubicles, the energy costs would decrease.

Summary

We have learned a great deal of information on the technical information that surrounds lighting energy usage. All of our key project deadlines on our timeline were met. Our work has finished before each of our projected datse. Remaining in close contact with Kevin Kirsche and communicating with other stakeholders in the project has been a key initiative. Old fixtures have been tallied, and energy usage data has been collected to present to FMD to suggest implementation of LED updates. We can submit the information to FMD for approval as one of our closing steps and allow the lighting retrofit to be executed. We hope that this effort will benefit UGA and the students and faculty who use it. We learned that not all fixtures in the campus buildings are alike and some have been replaced with newer models over the years. We had to account for this by tracking the number of lamps per fixture and lamp details, then performing our calculations based on the data. We also learned that LED lamps can significantly reduce the overall operating cost of a building. The wattage rating for LED lamps allows equivalent illumination to incandescent lamps and LED lamps produce less heat. This translates to less energy lost to heat.

For the future, an automatic LED dimming system integrated with the building and the surrounding environment could decrease energy costs even further and increase building efficiency. If it could automatically adjust the lighting and color temperature by detecting incoming light similar to Apple's Night Shift, it could potentially improve user experience while being energy efficient. Upcoming technologies and LEDs will push for a brighter and greener future.

Appendix A

QTY	Fixture Type	Size	Lamp Type	Number of Lamps	Watts per Lamp	Ballast Type
58	troffer	2 x 2 U-bent	F40CW	2	40	electric
53	troffer	2x4	F40CW/U	2	40	electric
40	troffer	2x4	F40CW	3	40	electric
30	Recessed Can	--	150 R/FL	1	150	electric

Table 1. Ecology Lighting Data - Halls and Main Use Areas

Lamp Cost - Ecology				
Type	Length	QTY - Total	Cost	Totals
T-8 LED/U	24"	116	$12.84	$1,489.44
T-8 LED	48"	226	$7.35	$1,661.10
LED Flood	N/A	30	$9.55	$286.50
				$3,437.04

Table 2. LED Lamp Cost Ecology

Current Usage Ecology	
Wattage	40
Annual Operating Hours	15000
kWh per year	600
kWh rate of $.10	$60.00
Fixtures	342
Wattage	150
Annual Operating Hours	15000
kWh per year	2250
kWh rate of $.10	$225.00
Fixtures	30

Energy Cost	**$27,270.00**

Table 3. Current Light Usage Ecology and Energy Cost

LED Usage Ecology	
Wattage	32
Annual Operating Hours	15000
kWh per year	480
kWh rate of $.10	$48.00
Fixtures	342
Wattage	23
Annual Operating Hours	15000
kWh per year	345
kWh rate of $.10	$34.50
Fixtures	30
Energy Cost	**$17,451.00**

Table 4. LED Usage Ecology and Energy Cost

Savings	
Existing	$27,270.00
LED	$17,451.00
Savings	**$9,819.00**

Table 5. Energy Cost Savings Ecology

Appendix B

QTY	Fixture Type	Size	Lamp Type	Number of Lamps	Watts per Lamp	Ballast Type
2	troffer	2x2	T8	1	32	electric
21	troffer	2x4	T8	4	32	electric

10	troffer	1x4	T8	2	32	electric

Table 6. Hardman Hall Lighting Data - Halls and Main Use Areas

Lamp Cost - Hardman				
Type	Length	QTY - Total	Cost	Totals
T-8 LED	48"	104	$7.35	$764.40
T-8 LED	24"	2	$6.85	$13.70
				$778.10

Table 7. LED Lamp Cost Hardman

Current Usage Hardman	
Wattage	32
Annual Operating Hours	15000
kWh per year	450
kWh rate of $.10	$45.00
Fixtures	106
Energy Cost	**$4,770.00**

Table 8. Current Light Usage Hardman and Energy Cost

LED Usage Hardman	
Wattage	16
Annual Operating Hours	13500
kWh per year	216
kWh rate of $.10	$21.60
Fixtures	106
Energy Cost	**$2,289.60**

Table 9. LED Usage Hardman and Energy Cost

Savings	
Existing	$4,770.00
LED	$2,289.60
Savings	**$2,480.40**

Table 10. Energy Cost Savings Hardman

Appendix C

QTY	Fixture Type	Size	Lamp Type	Number of Lamps	Watts per Lamp	Ballast Type
108	troffer	2x4	T-8	3	32	electric
20	troffer	2x2	T-8	2	32	electric
4	pendant	2x2	T-8	4	32	electric
4	Can	--	CFL	1	30	None
9	troffer	2x4	T-5	3	32	electric

Table 11. Marine Science Lighting Data - Halls and Main Use Areas

Lamp Cost - Marine Sci				
Type	Length	QTY - Total	Cost	Totals
T-8 LED	24"	40	$6.85	$274.00
T-8 LED	48"	388	$7.35	$2,851.80
T-5 LED	48"	27	$10.29	$277.83
LED Flood	N/A	4	$9.55	$38.20
				$3,441.83

Table 12. LED Lamp Cost Marine Science

Current Usage Marine Sci	
Wattage	32
Annual Operating Hours	15000
kWh per year	450
kWh rate of $.10	$45.00
Fixtures	153
Wattage	150
Annual Operating Hours	15000
kWh per year	1875
kWh rate of $.10	$187.50

Fixtures	4
Energy Cost	**$7,635.00**

Table 13. Current Light Usage Marine Science and Energy Cost

LED Usage Marine Sci	
Wattage	16
Annual Operating Hours	13500
kWh per year	216
kWh rate of $.10	$21.60
Fixtures	153
Wattage	23
Annual Operating Hours	13500
kWh per year	310.5
kWh rate of $.10	$31.05
Fixtures	4
Energy Cost	**$3,429.00**

Table 14. LED Usage Marine Science and Energy Cost

Savings	
Existing	$7,635.00
LED	$3,429.00
Savings	**$4,206.00**

Table 15. Energy Cost Savings Marine Science

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Contributions

Thomas Todd

I have been in contact with Kevin Kirsche and Peggy to coordinate the building tours and access to the electrical drawings. I have also toured the marine science building with Man Wah to record the light fixtures. I have coordinated the buildings with the other groups and Kevin. I have also helped write the project updates and the reports. For the final report, I helping write the background, the appendices and the summary. I calculated all of the lighting metrics for the marine science building and made the costs analysis for the operation.

For the lighting details, I communicated with Tyler Alsen and also researched the costs of installing new LED lamps in each of the buildings. I also presented all of the final presentation in class for our group, group #6.

Man Wah Aw

For this project, I have toured the Marine Science and Ecology building with Thomas Dodd to count the fixtures located in the buildings. I compiled the images and data that I took from both buildings into a google doc. I have written about two pages for the group study project and edited the document to improve it. I also wrote two and a half pages for the project update 2.

I looked over the Ecology electrical blueprint to generate all the tables in Appendix A. I wrote most of the results section except for the parts covered by Anthony with the graphs. I made the powerpoint for the final presentation by adding in our data and wrote the script for it. I added in the Appendix sections of the final report. I wrote the last paragraph for the summary.

Anthony Zheng

I created the meeting agenda for the Zoom meeting with Kevin Kirsche on 10/16/2020 and took notes on the meeting. I researched case studies for the group study paper on model predictive control and discussed the future of model predictive control. I toured Hardman Hall to conduct research on the lighting fixtures located in the buildings. I generated Table 6, Table 7, Table 8, Table 9, and Table 10 for Appendix B. I generated Graph I, Graph II, and Graph III to indicate energy cost over time for the three buildings. I wrote the methods and part of the results section for the final report.