College of Engineering

School of Environmental, Civil, Agricultural and Mechanical Engineering

UNIVERSITY OF GEORGIA

LED Retrofit Program for UGA

Physics (1003), Geography/Geology(1002), and Food Science & Technology (1020)

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Methods/Procedure

When deciding on which buildings to examine for the LED retrofit program we considered large instructional buildings based on the number of lights, frequency of use, and ease of access for recording data. Before proceeding with these buildings, the director of the UGA Facilities Management Division, Kevin Kirsche, was consulted about which buildings would be best to examine. The buildings were narrowed further when accounting for the time of construction of the buildings which affects the likelihood of the building still using fluorescent lights. The buildings along Cedar Street and Sanford Drive (Ag Hill) were originally constructed in the late 1950s and early 1960s which makes them well-suited candidates for renovation. Other buildings on the North campus were built earlier, but they are considerably smaller than the Ag Hill buildings and are less likely to be used for research purposes during off-hours like the labs in Ag Hill. Director Kevin Kirsche narrowed down our choices in Ag Hill to the Geography/Geology (1002), Physics (1003), and Food Science & Technology (1020) buildings.

There were two options available with regards to collecting the lighting data in the Ag Hill buildings: physically counting the lights in the buildings or using the UGA plansroom database. In-person counting proved to be the more reliable and efficient option. We focused on large lecture halls and common areas, like hallways and lobby areas, during the data collection, since they have a larger number of lights and will be used the most for any given day. The data was collected on each floor and stairwell then recorded electronically for later reference. Photos were also taken to record and help differentiate the multiple types of light fixtures in each building. Some lights were already replaced with LED bulbs and fixtures; those were recorded for safe measure. We later returned and recorded the bulb type used for each fixture and respective wattages associated with them. All the data collected was added to an Excel sheet, and the pictures of the light fixtures were added to the project folder. Using the UGA Facilities Management Division's plansroom with the as-built drawings and renovations for each building on the Athens campus, we were able to compare and supplement our recorded data with the electrical drawings and electrical records for each building. The online database is not perfect or completely up-to-date, so in the cases where information did not align, the data collected in-person was used.

Once all of the fixtures were counted and confirmed, we completed a full analysis of the data to provide a Return on Investment (ROI) report, a Georgia Power rebate report, and a suggested installment timeline. The ROI includes specific information from each existing fixture and its replacement, like installation time, fixture and ballast cost, lamp replacement cost, various lifespans of the component, the cost of disposal, the maintenance costs, and the rebate among other factors that will contribute to the overall cost and energy savings. An ROI template was provided by Kevin Kirsche and using the collected fixture data as inputs, we were able to create a comprehensive ROI report that summarizes the overall cost and energy savings of the recommended LED fixtures. The Georgia Power rebate includes the necessary information in order to apply for LED fixture rebates to recoup some money spent on the new fixtures. It includes information such as the quantity and location of each existing and new fixture as well as the corresponding manufacturer's spec sheets for the LED replacements, which must be all Energy Star certified. Using this information, a suggested timeline was created that recommends which fixtures should be prioritized to be replaced and when based on the impact replacing them will have and when there is time to do so.

Data

Table 1. Quantity of Existing Fixtures – Physics (1003)

	Light Fixture ID									
	P1	P2	P3	P3.5 (HALF 3)	P4	P5	P7	P8	P9	Exit
Floor 1	20	–	–	–	1	–	–	–	–	4
Floor 2	–	31	–	–	–	–	–	–	–	12
Floor 2 (Main Entrance)	42	–	12	2	–	–	–	–	–	–
Floor 3	1	24	–	–	–	4	–	–	–	13
Floor 3 (Entry Staircase/Room)	11	–	–	–	–	–	–	–	–	–
Floor 4	–	–	–	–	–	–	–	–	4	1
Stairwell Center	8	–	–	–	–	–	–	–	–	–
Stairwell West	6	–	–	–	–	–	–	–	–	–
Stairwell East	4	–	–	–	–	–	–	–	–	–
Auditorium	–	–	–	–	–	–	164	2	–	4
Total:	92	55	12	2	1	4	164	2	4	34

Table 2. Quantity of Existing Fixtures – Geography/Geology (1002)

	Light Fixture ID										
	G1	G2*	G3*	G4	G5	G6	G7	G8*	G9	G10	Exit
Basement	–	–	23	4	4	–	–	–	–	–	8
Floor 1	35	41	–	–	–	–	–	8	–	6	13
Floor 2	70	32	–	76	–	–	–	4	8	–	12
Floor 3	–	34	–	19	–	–	–	2	4	–	11
East Stairwell	–	–	–	–	–	4	1	–	–	–	1
West Stairwell	–	–	–	–	–	6	1	–	–	–	1
Total	105	107	23	99	4	10	2	14	12	6	46

***Fixtures G2, G3, and G8 are already LEDs**

Table 3. Quantity of Existing Fixtures – Food Science & Technology (1020)

	Light Fixture ID																	
	F1	F2	F3	F4 (2 lamp)	F4 (4 lamp)	F4.5	F5	F6	F7*	F8	F9	F10	F11	F12	F13	F14*	Exit*	Exit Triangle*
Floor 1	–	–	–	35	–	1	–	–	–	–	–	–	–	–	–	–	9	–
Breakroom (Floor 1)	–	–	–	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Bathroom (M) (Floor 1)	–	–	–	4	–	–	–	–	–	–	1	–	–	–	–	–	–	–
Bathroom (F) (Floor 1)	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	3	–	–
Floor 2	28	6	2	–	18	–	–	–	–	–	–	–	–	–	–	–	6	–
Bathroom (M) (Floor 2, North)	5	–	–	–	–	–	–	–	–	–	–	1	1	–	–	–	–	–
Bathroom (F) (Floor 2, North)	7	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–
Bathroom (M) (Floor 2, South)	–	–	–	–	2	–	–	–	–	–	–	–	–	2	–	–	–	–
Bathroom (U) (Floor 2)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–
Floor 3	19	–	–	–	18	–	–	–	10	–	–	–	–	–	–	–	4	1
Bathroom (M) (Floor 3)	–	–	–	–	–	–	–	–	5	–	–	1	1	–	–	–	–	–
Bathroom (F) (Floor 3)	–	–	–	–	–	–	–	–	7	–	–	2	–	–	–	–	–	–
Stairwell North East	–	–	–	–	–	–	–	–	–	6	–	–	–	–	–	–	2	–
Stairwell South East	–	–	–	–	–	–	3	1	–	–	–	–	–	–	3	–	1	–
Stairwell West	–	–	–	–	–	–	4	1	–	–	–	–	–	–	–	–	1	–
Total:	59	6	2	45	38	1	7	2	22	6	2	6	2	2	3	4	23	1

***Fixtures F7, F14, and the Exit signs are already LEDs**

Results and Recommendations

Physics (1002)

Upon completion of acquiring the fixture data, a return on investment (ROI) report was created for several fixtures in each building. For Physics, the primary lighting sources were a 2'x4' recessed troffer and a ceiling mounted wraparound. The recessed troffer is used in the hallways on floors 2 and 3, whereas the wraparound fixture is used largely in the entryway on floor 2 and throughout the basement. **Figures 2 and 3** show the net present value (NPV) over a twenty year period of the LED retrofits for the recessed troffer and wraparound fixtures in the physics building.

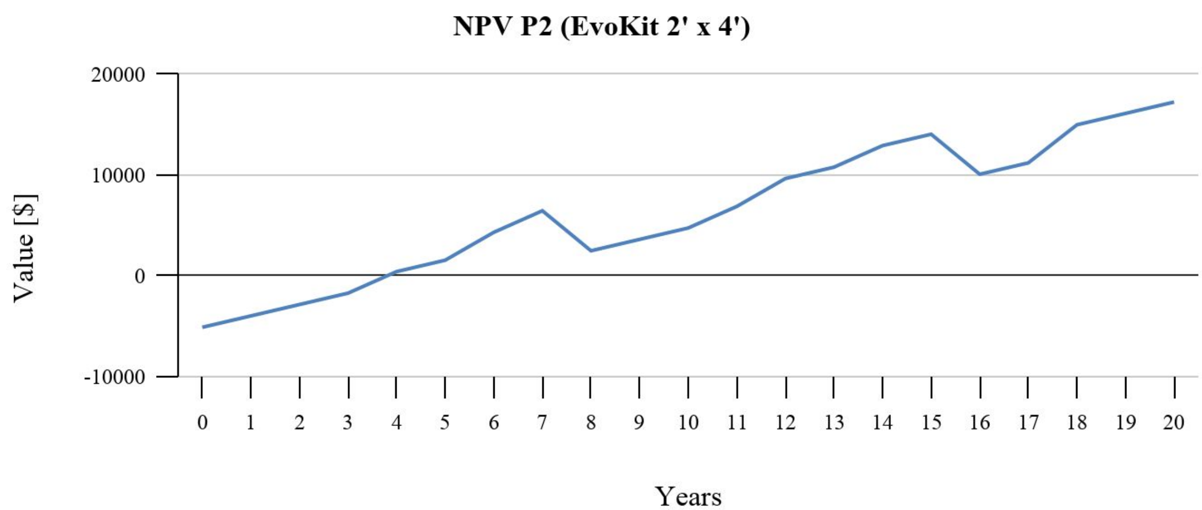

Figure 2. ROI for EvoKit 2' x 4' (Physics)

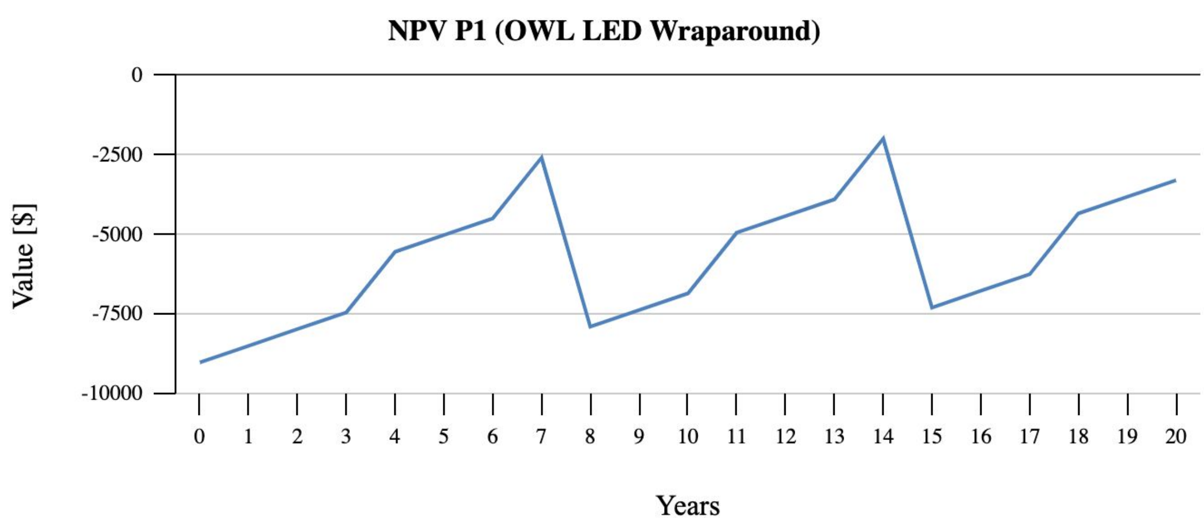

Figure 3. ROI for OWL Wraparound Fixture

The NPV for the fixtures above is calculated using several factors including fixture cost and lifetime, labor cost, and LED cost and lifetime. These were input into the ROI for Physics to produce the NPV charts shown above. The recessed troffer will be replaced with a Philips EvoKit 2' x 4' and within 10 years of installation the NPV will be positive indicating a positive return on investment. The dips on the figure represent the costs associated with replacing the LED fixtures. By year 20, the EvoKit 2'x4' will have saved the university over $15,000. **Figure 3** above does not show a positive NPV for the OWL LED wraparound. This is due to the small wattage difference between the fluorescent and LED fixtures. LED fixtures can produce more light per wattage. In order to improve the NPV, the quantity of LED lights can be reduced by half given the larger light production. **Figure 4** shows the NPV with the reduced LED fixture quantity.

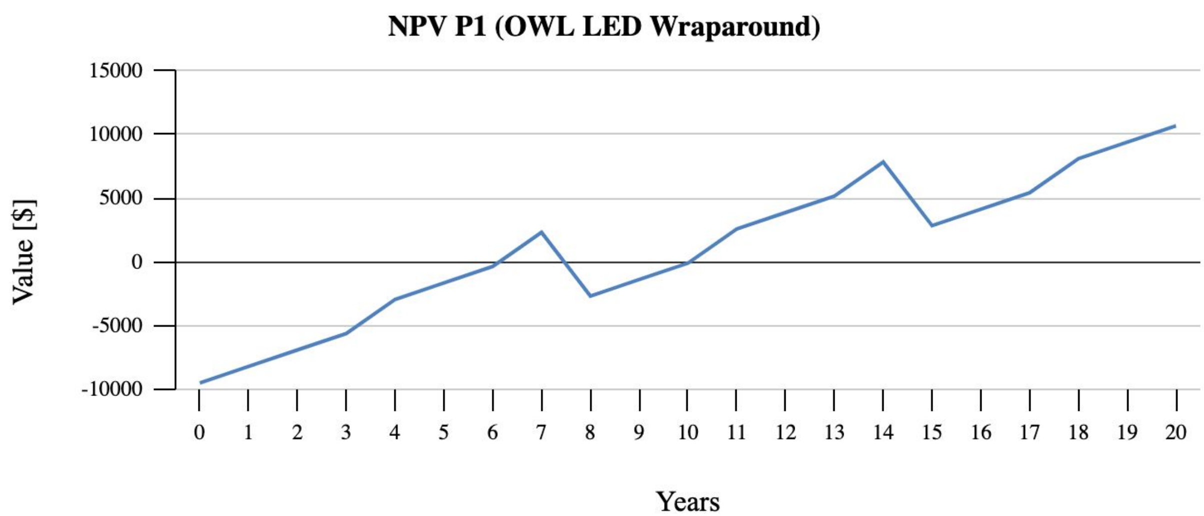

Figure 4. ROI for OWL Wraparound, quantity reduced by half

With this change, the NPV will be positive by year 10. By year twenty, the university will have saved over $10,000 with this change.

For fixtures P3 and P7, the NPV remains negative over a 20 year period. The same change may be applied for P1 in order to reduce the amount of fixtures needed and improve the return on investment. P3.5 has a positive NPV and will save the university $270 over twenty years. P3 may also be replaced with a shorter LED fixture used for P3.5 in order to improve the NPV. The final LED fixture count will be determined by the Operations and Maintenance team who will be installing the LED fixtures. Their expertise and onsite evaluation will ensure that the correct quantity, if reduced, is being installed.

An ROI was completed for each of these fixtures throughout the physics building. These are included in the document *ROI-Physics.xlsx*. The first sheet includes the input data for each fixture type and the following sheets will auto populate based on the first sheet. Several categories including ballast cost and lifetime are estimates given that we were not able to accurately identify the ballast via visual inspection. These numbers may be adjusted accordingly in the first sheet to update the NPV graph on the following sheets. Prior to completion of the LED retrofits, these numbers may be adjusted with accurate numbers of the fixtures to be replaced.

Given the results from the ROI report, the following fixtures in **Table 4** are recommended to be replaced with the corresponding LED fixture.

Table 4. Replacement Light Fixtures – Physics (1003)

Label	Quantity	Fixture Type	LED Fixture
P1	46	4' x 10" Wraparound	OWL LED Wraparound
P2	55	2' x 4' Recessed Troffer	EvoKit LED Retrofit 2' x 4'
~~**P3**~~	~~12~~	~~Strip Light~~	~~4' FluxStream EZ LED Strip~~
P3.5	8	(Half) Strip Light	2' FluxStream LED Strip
P4	1	Singular Bulb	Philips LED 60w Equivalent
P5	4	CFL Canned	Alset 8"-10" LED Frosted Downlight
~~**P7**~~	~~164~~	~~Strip Light (Auditorium)~~	~~4' FluxStream EZ LED Strip~~
P8	2	Specialty (View Image)	
P9	4	2' x 2'	EvoKit LED Retrofit 2' x 2'
Exit Signs	34		Rotating Edge Lit Exit Sign

As shown in the NPV charts above, fixture P2 should be replaced with the EvoKit LED 2’ x 4’. Given the negative NPV if replaced with the same quantity of LED fixtures, it is recommended that fixture P1 be replaced by the OWL LED Wraparound with half of the quantity of the fluorescent fixtures denoted in **Table 4**. In the entryway on Floor 2, P3 fixtures may be replaced with eight 2’ FluxStream LEDs which will provide a similar quality of light with a significant reduction of energy usage. P4, P5, and P9, if replaced with LED fixtures, will reduce the energy consumption dramatically and are recommended to be replaced. The lights in the main auditorium should not be replaced due to their current energy efficient performance. It is possible for these to be replaced with half of the quantity of LED fixtures, but that will depend on the lighting needs of the auditorium and should be accounted for by the installation team. If the recommended changes above are completed, the university will save over $30,000 by year twenty.

Geography/Geology (1002)

After collecting data in the Geography/Geology building common areas, a total of eleven different light fixtures were found. Three of these fixtures (G2, G3, & G4) were already retrofitted with LED bulbs and therefore were not included in the ROI. In order to make the retrofit process more efficient only fixtures with a substantial quantity (# ≥ 10) were included in the ROI. The main fixtures observed in the building were the Compact Fluorescent Light (CFL) single bulb pendant and the Recessed Troffer 2' x 4'. The CFL fixtures (G1) are only located at the main entrance on the first floor and the back entrance on the second floor. The Recessed Troffers (G4) are located in the lecture halls on the second and third floors.

The single bulb CFL pendant has no ballast cost and is relatively cheap at $1.50. The fixtures in this instance don't have to be replaced, so only the bulbs need to be replaced. After all of the fixtures at the entrances have LEDs installed, the savings for the university will increase rapidly. **Figure 5** shows that after just two years the lights will be profitable, and after 20 years the total profit will be $13,204.

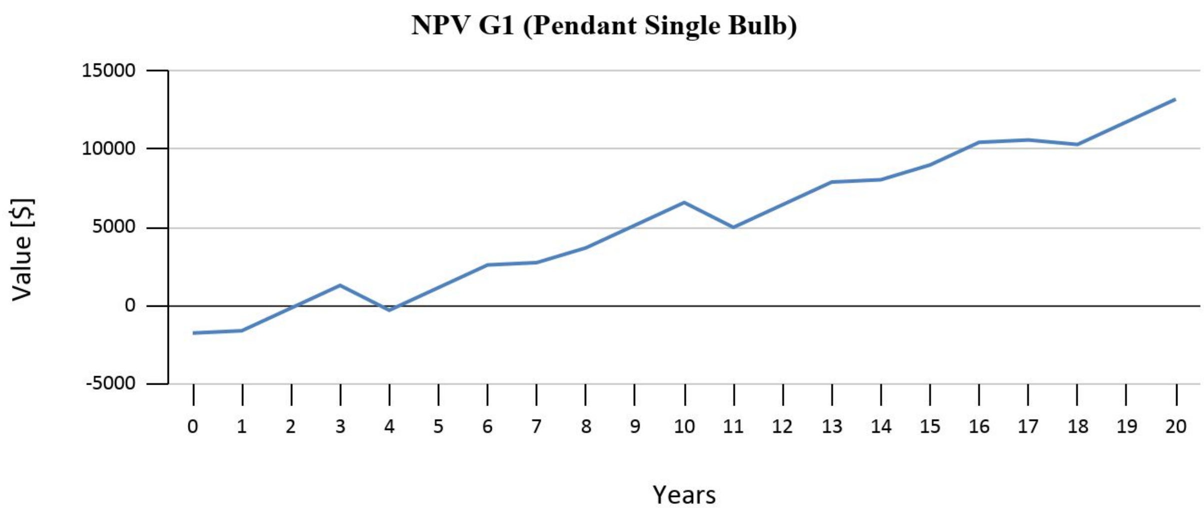

Figure 5. ROI for LED Single Bulb

Due to the easy replacement and large quantity of these fixtures, G1 should be the top priority for the retrofit project in Geology. Although adding several LED fixtures is preferable, the decorative ceiling at the entrances limits the retrofit of G1 to only bulbs. In order for larger LED fixtures to be installed, some construction work would be needed to change the ceiling structure of the Geology building. Another high priority light fixture for the retrofit is the recessed troffers.

The recessed troffers in the lecture halls make up a large amount of the Geology's buildings lights. These 99 lights should be replaced with EvoKit 2' x 4' LED fixtures because UGA can receive a profit on energy savings after just 5 years as shown in **Figure 6**.

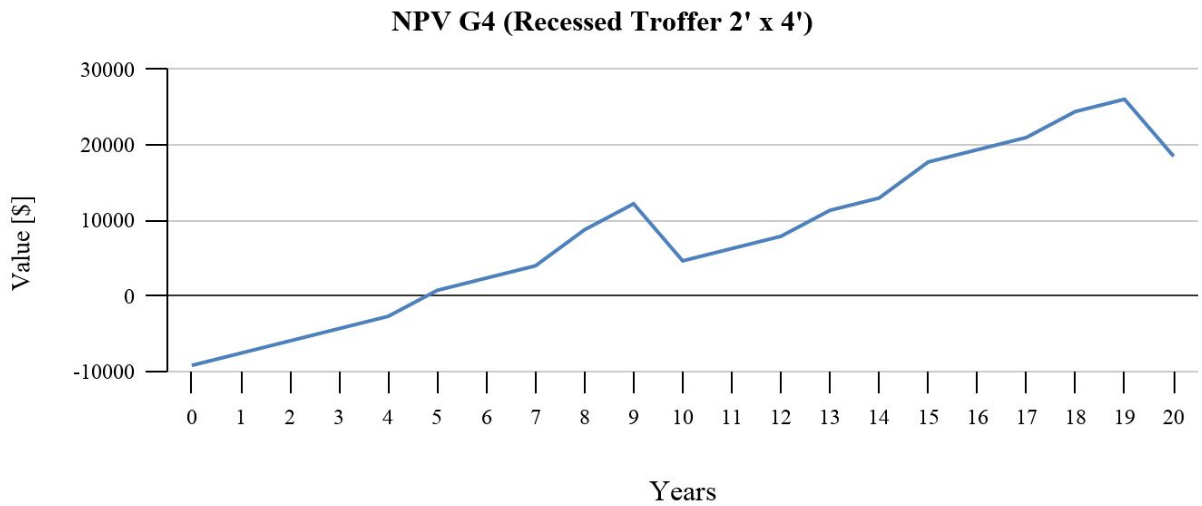

Figure 6. ROI for EvoKit 2’ x 4’

The cost to replace these fixtures ($106.30) is higher than that of the individual CFL bulbs ($5.00), but the energy savings still make this change profitable. Every 9 years the university can expect a $10,000 replacement cost for the fixtures, but during the next 9 year period, that cost will be recovered in monthly electricity bills.

There are only 10 fixtures that fall under G6 , so the change in value illustrated in **Figure 7** is not as drastic as the two previous fixtures in the geology building.

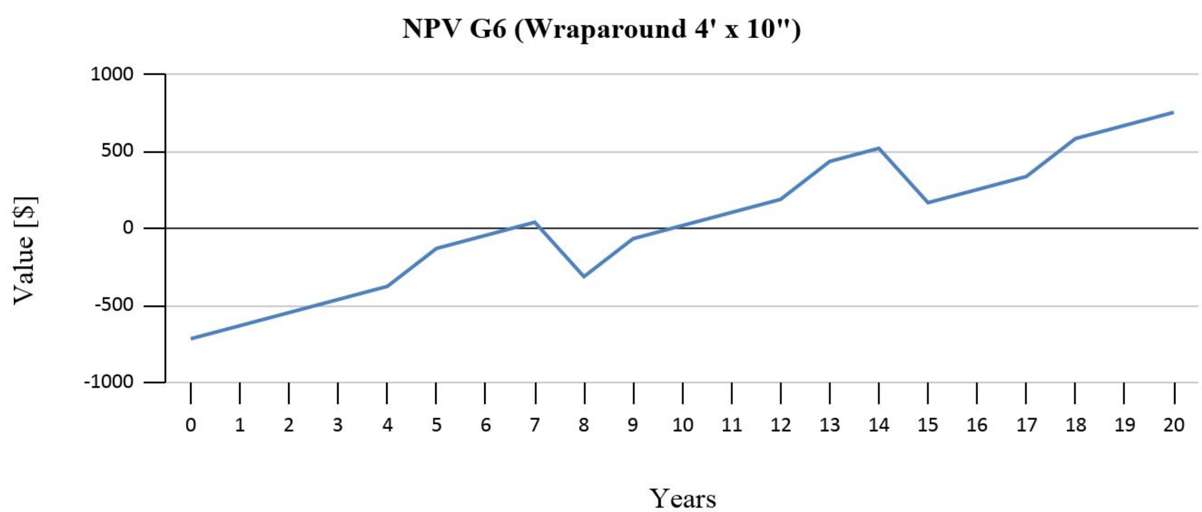

Figure 7. ROI for 4’ Fluxstream

These fixtures are located on the ceilings inside the East and West stairwells. Though the profit is not large compared to the two previous examples, the energy savings are profitable consistently after 11 years. At the end of a 20 year period, the university can expect an excess of $755 due to the retrofit. The savings provide a good justification for the retrofit in this case, but the priority is lower since the quantity is much lower than G1 and G4.

The last fixture evaluated in the ROI report was G9. Fixture G9 accounts for 12 of the lights we observed in the geology building and are all located in the restrooms. Surprisingly the NPV revealed that the retrofit for this fixture is not profitable at any point and is shown in **Figure 8**.

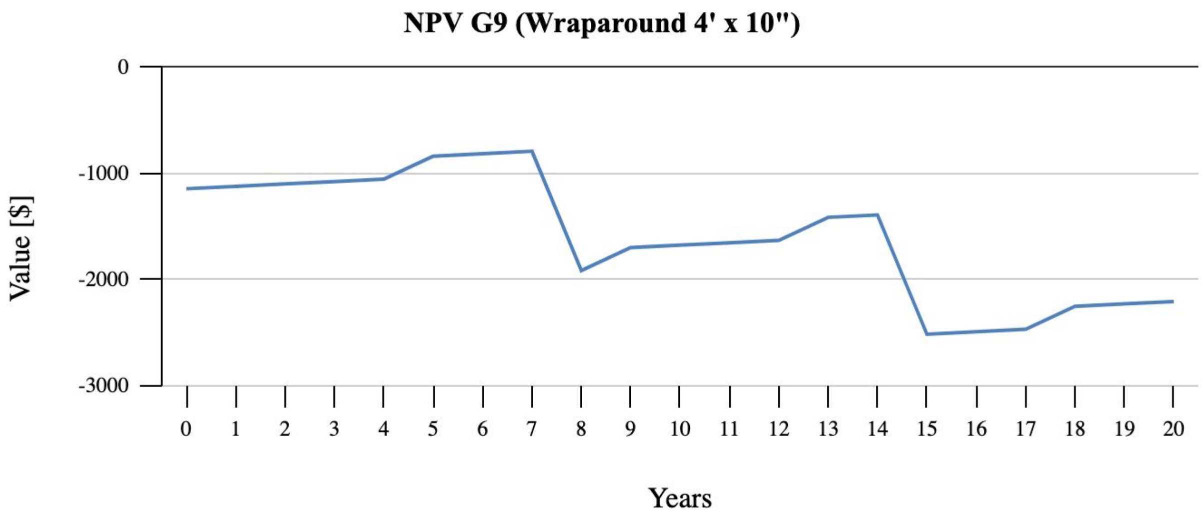

Figure 8. ROI for OWL Wraparound

The LED wraparound has a small difference in wattage compared to the fluorescent so the savings on energy is minimal. The energy savings of about $18.02 are not enough to balance the fixture cost of $1144 making this retrofit a horrible investment from an economic standpoint. Although replacing the wraparound with a 4' fluxstream LED strip would be more profitable, there amount of lighting needed for the restrooms led us to choose an OWL LED Wraparound. Since the restrooms have two G9 fixtures adjacent to each other, they could be replaced with just one LED fixture which is shown in **Figure 9.**

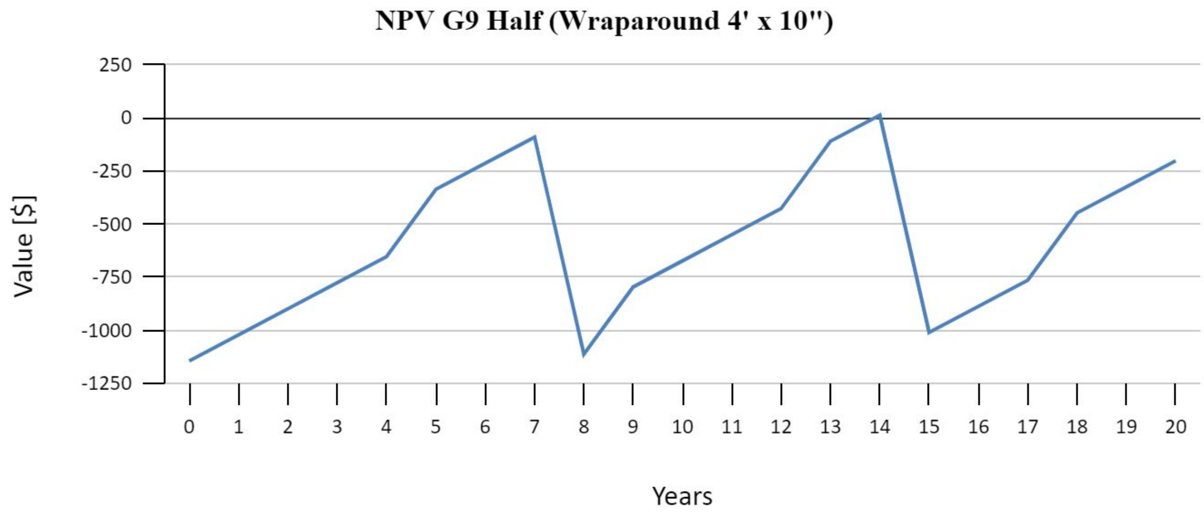

Figure 9. ROI for OWL Wraparound Halved, quantity reduced by half

Reducing the number of LED fixtures in each restroom does improve the value of the retrofit, but the profit is insignificant compared against the other fixtures. The lights will slowly become profitable over time, but the lifespan of the building will likely be reached before the savings are meaningful. These fixtures should not be changed until further research is done or a different fixture is proposed.

All of the non LED lights that we observed in the building are listed below in **Table 5**. Each fixture is listed with the quantity observed, the fixture type, and the proposed LED fixture for the retrofit. G2, G3, and G8 were omitted from the ROI report since those fixtures were already retrofitted with LEDs recently. The lights not recommended for a retrofit (G5, G7, G10) because of their small quantity are also listed in the table, but are crossed out. If the university replaces the recommended lights listed in the table (except G9), it can expect to save a total of over $32,000 after 20 years.

Table 5. Replacement Light Fixtures – Geography/Geology (1002)

Label	Quantity	Fixture Type	LED Fixture
G1	105	Pendant	Philips 60W Equivalent
G4	99	Recessed Troffer	EvoKit LED Retrofit 2' x 4'
~~**G5**~~	~~4~~	~~Wraparound~~	~~4' FluxStream EZ LED Strip~~
G6	10	Wraparound	4' FluxStream EZ LED Strip
~~**G7**~~	~~2~~	~~Wraparound~~	~~OWL LED Wraparound~~
G9	12	Wraparound	OWL LED Wraparound
~~**G10**~~	~~6~~	~~Strip Light~~	~~4' FluxStream EZ LED Strip~~
Exit Signs	46		Rotating Edge Lit Exit Sign

Food Science & Technology (1020)

The primary fixtures in the Food Science & Technology building are the compact fluorescent light (CFL) downlights (F1) and the 2' x 4' recessed troffers with 2 or 4 lamps (F4: 2-lamp and F4: 4-lamp), all of which are primarily used to illuminate the hallways. These 3 fixtures account for 142 of the 179 fixtures that recommended LED replacements are provided for in this building. The ROI and NPV was calculated for all fixtures that were not already LED, with the exception of the lights in the showers on floor 1 (F9) due to concerns over moisture and there only being 2 fixtures of that type in the building. Assumptions were made about the ballasts currently being used due to not being able to access the ballasts or record the needed information without removing the fixture and no information being available on the FMD Plansroom online. The full ROI report for each fixture can be found in the included *ROI-FoodScience&Technology.xlsx* spreadsheet file. The existing fixtures and their LED replacements used to calculate the ROI are found in **Table 6**. Fixtures that are not recommended to be replaced at this time are crossed out.

Table 6. Replacement Light Fixtures – Food Science & Technology (1020)

Label	Quantity	Fixture Type	LED Fixture
F1	59	Round CFL Downlight	Alset 8"-10" LED Frosted Down Light
~~F2~~	~~6~~	~~Wraparound~~	~~OWL LED Wraparound~~
F3	3	Track recessed floodlight	Philips BR30 LED 65W equivalent bulb
F4 (2 lamp)	45	2' x 4'	EvoKit LED Retrofit 2' x 4'
F4 (4 lamp)	38	2' x 4'	EvoKit LED Retrofit 2' x 4'
F4.5	1	2' x 2'	EvoKit LED Retrofit 2' x 2'
~~F5~~	~~5~~	~~Wraparound~~	~~OWL LED Wraparound~~
F6	2	Wide Wraparound	OWL LED Wraparound
F8	6	Speciality	4' FluxStream EZ LED Strip
F10	6	Two 4' T8	4' FluxStream EZ LED Strip
F11	2	Two 2' T8	2' FluxStream LED Strip
~~F12~~	~~3~~	~~Strip Light~~	~~4' FluxStream EZ LED Strip~~
~~F13~~	~~4~~	~~4' x 10"~~	~~OWL LED Wraparound~~

The most profitable fixture to replace is F1, the round CFL downlight found in the hallways on floors 2 and 3 and some bathrooms. Replacing this fixture with the LED equivalent begins to save money very quickly, around 2 years, and over 20 years, it would save the university $28,422. The NPV chart for this fixture is found below in **Figure 10**. Again, years are on the horizontal axis, and dollars are on the vertical axis.

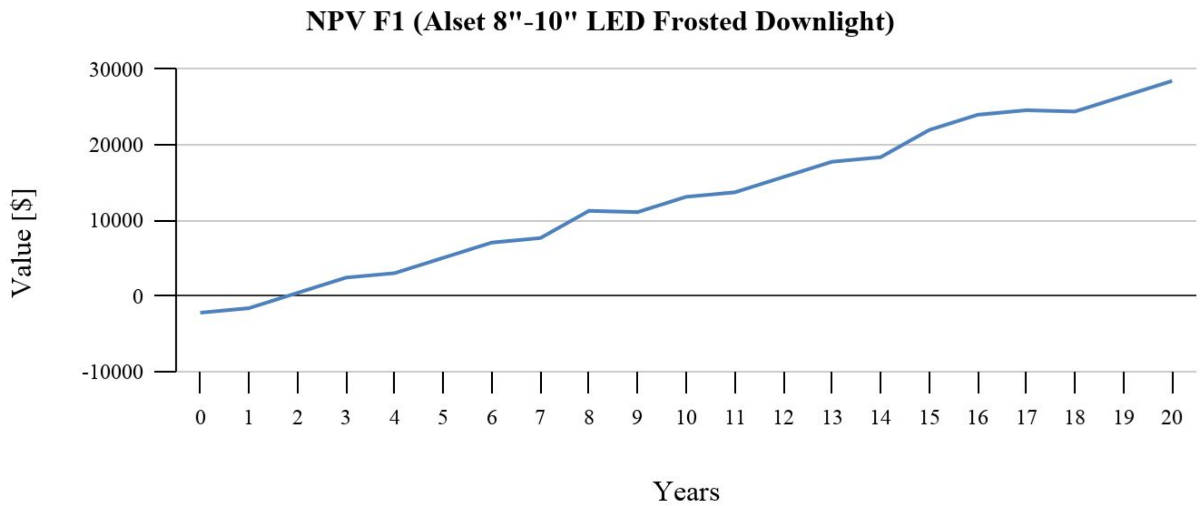

Figure 10. ROI for F1 replaced with Alset 8”-10” LED Frosted Downlight

The next most profitable fixture to replace is F4 (4 lamp), the 2’ x 4’ fixture with 4 T8 lamps. This fixture is primarily found in the hallways of floors 2 and 3. Replacing this fixture with the EvoKit LED would start to profit the university in about 4 years. After 20 years, the university will have saved $14,197 and have fixtures installed that are only a year old. This is shown in the NPV chart for this fixture, **Figure 11**.

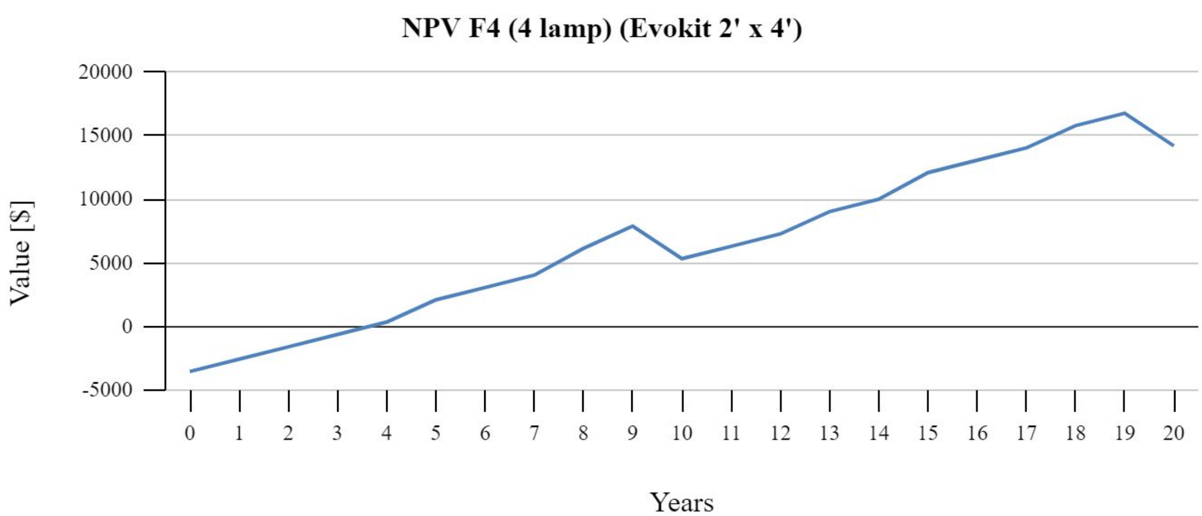

Figure 11. ROI for F4 (4 lamp) replaced with EvoKit 2’ x 4’

The last of the 3 most common lights found in the Food Science & Technology building and the 3rd most profitable to replace is F4 (2 lamp), the 2’ x 4’ fixture with 2 T12 lamps. These fixtures are only found on floor 1 of the building. Having been added during the 1998 renovation of the building, they are newer than the other fluorescent 2’ x 4’ fixture found in the building, F4 (2 lamp), which explains why they are the more efficient 2’ x 4’. Replacing this fixture would save $3,939 over 20 years, but this number is somewhat skewed by the fixtures needing to be replaced a year prior in year 19. The NPV chart showing this is found in **Figure 12** below.

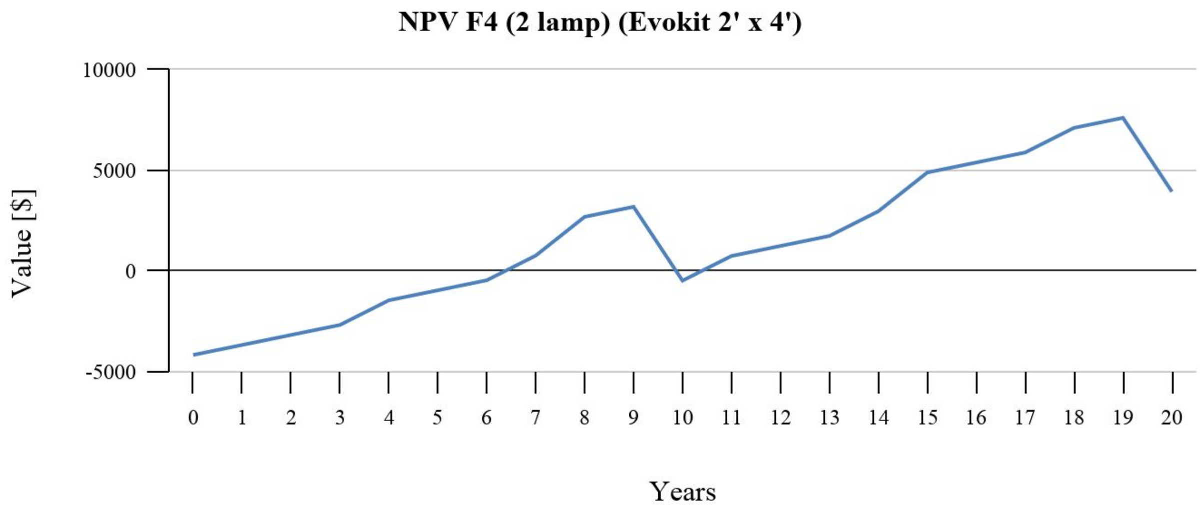

Figure 12. ROI for F4 (2 lamp) replaced with EvoKit 2’ x 4’

Some fixture replacements, contrary to what was expected, returned a negative ROI/NPV when calculated. This is likely due to the standard LED replacement fixture used by the university being too bright for the space provided and there being little or no opportunity to reduce the number of fixtures in the area. The fixture replacements that had a negative ROI are all very uncommon in the building and are not being recommended to be replaced at this time or until further research can be conducted. An example of this is found in **Figure 13** for F13, the 4’ x 10” wraparound light with 2 T8 bulbs found only in the southeast stairwell.

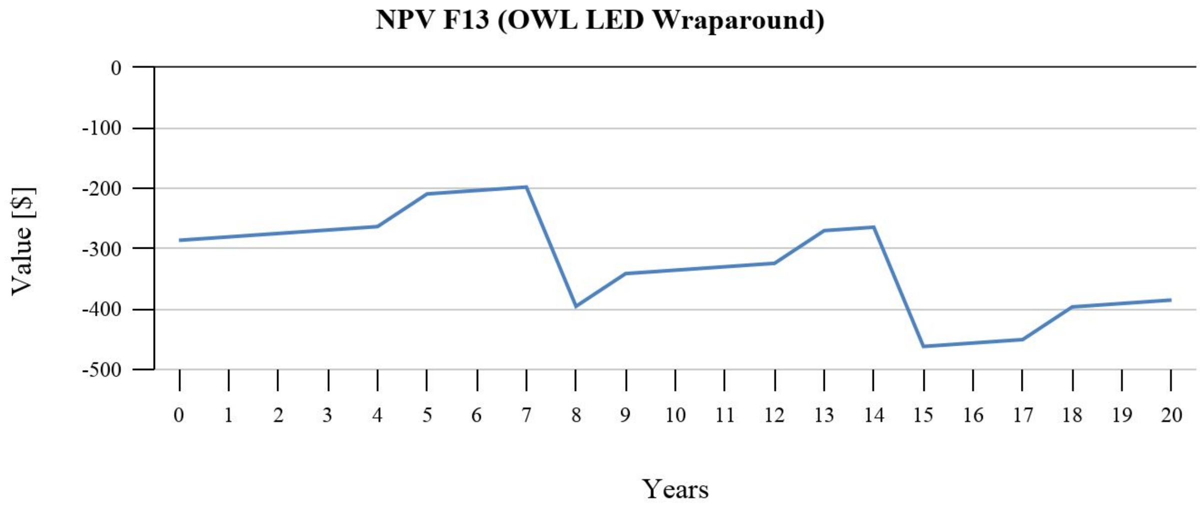

Figure 13. ROI for F13 replaced with OWL LED Wraparound

The recommended fixtures to be replaced, ones with a positive ROI, are F1, F3, F4 (2 lamp), F4 (4 lamp), F4.5, F6, F8, F10, and F11. If these fixtures are replaced as shown in **Table 6**, the university would save $49,278 over the next 20 years just in the Food Science & Technology building. While not recommended, if all fixtures shown are replaced, even the ones with a negative ROI, the university would still save $46,483 over the same timeframe. The majority of the savings could be realized by only replacing the 2 of the 3 most common fixtures in the building to keep things simplified. Replacing only F1 and F4 (4 lamp) would save $42,619 over 20 years.

Installation Schedule

Each fixture has an install time between 10 and 20 min depending on the size and type. The majority of fixtures throughout each of the buildings are recessed troffers, wraparounds, or canned lights. With classes being online, we recommend that these lights be changed prior to the start of classes in Spring 2021. Virtual classes and remote work over the break will provide the optimal time to install these LED fixtures. The hallway and entryway lights for each building should be replaced first given their significant yearly usage. Using the ROI for reference, P2, G4, and F4 should be replaced first due to being hallway lights. These fixtures should be able to be replaced over a two week period and will save the university $53,841 in the first 20 years. Following the replacement of the 2’ x 4’ recessed troffers, we recommend changing fixtures G1 and F1, both of which can be replaced in 2 days. G1 and F1 will save the university $13,204 and $14,197 respectively in the first 20 years. P1 should be replaced next and will save the university over $10,000 within 20 years. The remaining fixtures should be replaced at the convenience of the Operations and Maintenance team taking into account supply of LED fixtures and ongoing projects.

Georgia Power Rebate Report

The Georgia Power rebate for existing building lighting is part of an incentive program organized by Georgia Power to aid and encourage individuals and businesses to conserve electricity and utilize energy efficient fixtures, appliances, or devices whenever possible. This reduces the energy load on Georgia Power and benefits the environment. Generally, a maximum rebate of $25,000 per building per year up to 50% of equipment costs can be earned for a combination of lighting, heating and cooling, business equipment, food service and grocery, pumps and water heating upgrades, unless otherwise noted. For existing building lighting, the fixtures must be Energy Star certified or DesignLights Consortium (DLC) listed and operate for a minimum of 1,000 hours annually. To apply for the rebate for existing lighting in an existing building, Georgia Power requires the quantity of each fixture removed, fixture type, fixture size, lamp type, number of lamps for each fixture, lamp wattage, and ballast type. It is helpful to include the spec sheet for each new fixture as well. This data for each building is found below in **Tables 7-9,** and the spec sheets are in the *LED_Fixture_Spec_Sheets.pdf* file provided. For our purposes, a rebate is available of $25/fixture for the 2' x 2' and 2' x 4' troffers, $2/lamp for the single bulbs, and $10/fixture for the remaining fixtures, the can lights, downlights, strips, and wraparounds.

Table 7. Georgia Power Rebate Information – Physics (1002)

	Quantity	Fixture Type	Fixture Size	Lamp Type	Lamps /fixture	Lamp Wattage	Ballast Type Assumption
P1	92	Wraparound	4' x 10"	T12	2	40	Electronic
P2	55	Recessed Troffer	2' x 4'	T8	3	32	Electronic
P3	12	Strip Light	4'	T12	1	40	Electronic
P3.5	2	Half Strip Light	2'	T12	1	20	Magnetic
P4	1	Pendant	Single Bulb	Incandescent	1	60	
P5	4	Canned	4-Pin	CFL	2	13	
P7	164	Strip Light	4'	T8	1	32	Electronic
P8	2	Specialty (See Image)			2		
P9	4	Recessed Troffer	2' x 2'	T8-U	2	32	
Exit Signs	34	Ceiling Mounted			1		

Table 8. Georgia Power Rebate Information – Geography/Geology (1002)

	Quantity	Fixture Type	Fixture Size	Lamp Type	Lamps/ fixture	Lamp Wattage	Ballast Type Assumption
G1	105	Pendant	Single Bulb	CFL	1	13	
G4	99	Recessed Troffer	2' x 4'	T8	3	32	Electronic
G5	4	Wraparound	4'	T12	2	20	Electronic
G6	10	Wraparound	4' x 10"	T8	2	32	Electronic
G7	2	Wraparound	4'	T8	2	32	Electronic
G9	12	Wraparound	4' x 10"	T8	2	32	Electronic
G10	6	Strip Light	4'	T8	1	32	Electronic

Table 9. Georgia Power Rebate Information – Food Science & Technology (1020)

	Quantity	Fixture Type	Fixture Size	Lamp Type	Lamps/ fixture	Lamp Wattage	Ballast Type Assumptions
F1	59	Canned	4-Pin	DTT CFL	2	26	Electronic
F2	6	Recessed Wraparound	3'	T8	2	25	Electronic
F3	2	Track Recessed Flood Light	Single Bulb	BR30	1	65	
F4 (2 lamp)	45	Recessed Troffer	2' x 4'	T12	2	40	Electronic
F4 (4 lamp)	38	Recessed Troffer	2' x 4'	T8	4	32	Electronic
F4.5	1	Recessed Troffer	2' x 2'	T12-U	2	40	Electronic
F5	7	Wraparound	4'	T8	2	32	Electronic
F6	2	Wraparound	4' (wide)	T8	4	32	Electronic
F8	6	Specialty Strip	4'	T8	2	32	Electronic
F10	6	Ceiling Strip	4'	T8	2	32	Electronic
F11	2	Ceiling Strip	3'	T8	2	25	Electronic
F12	2	Strip Light	4'	T8	1	32	Electronic
F13	3	Wraparound	4' x 10"	T8	2	32	Electronic

Summary

The transition to LED lights from the primarily fluorescent lights used on campus, if done strategically, has the clear potential to save the University of Georgia a significant amount of energy and money. The recommendations provided have been carefully reviewed so as to ensure the highest possible reduction in energy usage. LEDs will continue to become more efficient and cheaper as the technology advances, but the benefits from their energy efficiency now will continue to reduce the energy used by the university and ultimately reduce their overall impact on the environment. Some further research needs to be done to pick the optimal solution for each fixture, but implementing the changes outlined in this paper would save well over $100,000 over the next 20 years. Hopefully this will serve as a model and encourage UGA to expand and retrofit all buildings on campus. Only the public area of 3 moderately sized buildings were considered in this report, but if expanded to classrooms, offices, and other rooms across the entire campus, millions of dollars could be saved and there would be a significant positive impact on the local environment.

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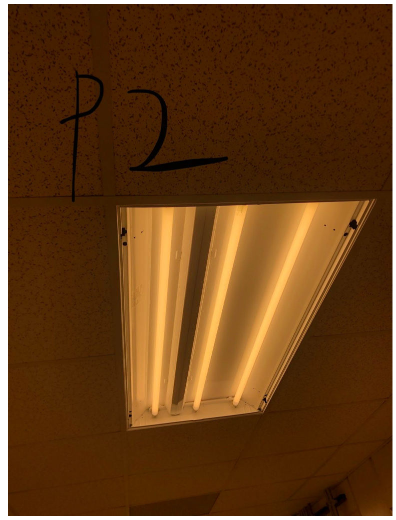
Appendix A: Fixture Images

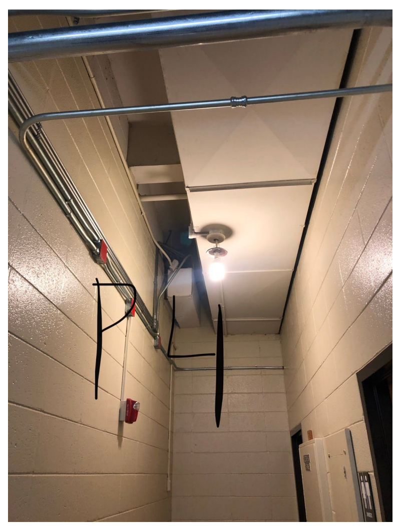
Physics:

Physics Fixture #1

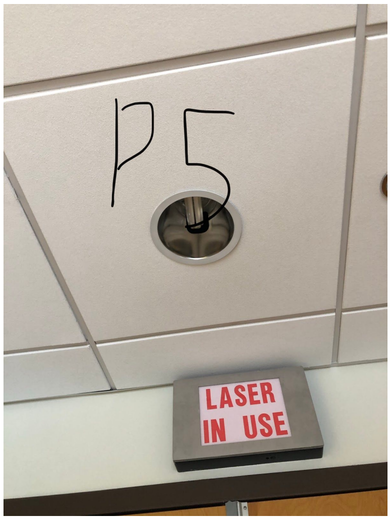


Physics Fixture #2

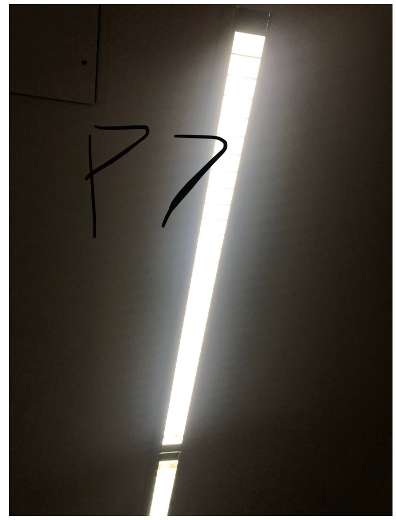
Physics Fixture #3



Physics Fixture #4

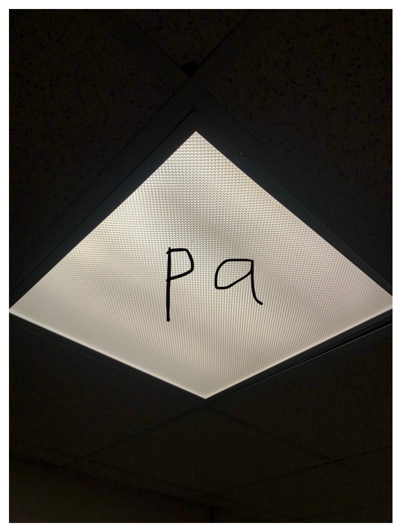


Physics Fixture #5



Physics Fixture #7

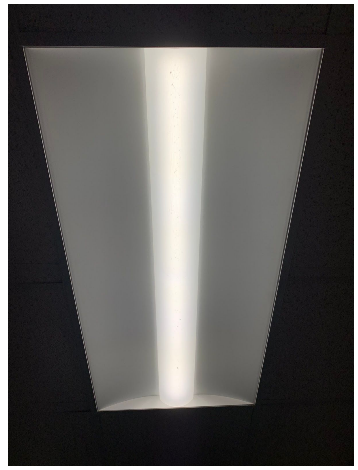
Physics Fixture #8



Physics Fixture #9

Geology/Geography:

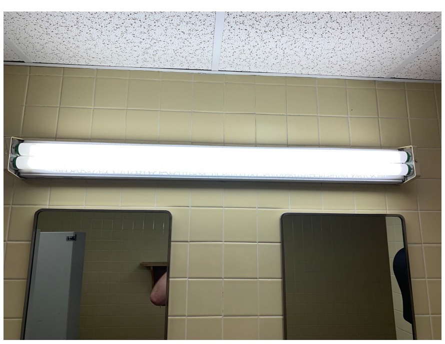
Geology Fixture #1



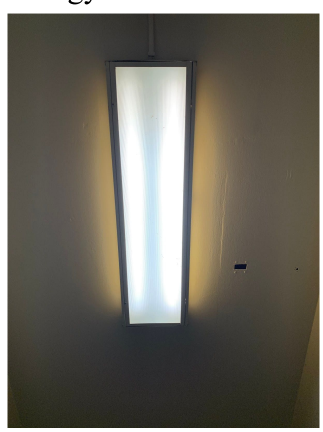
Geology Fixture #2

Geology Fixture #3

Geology Fixture #4



Geology Fixture #5

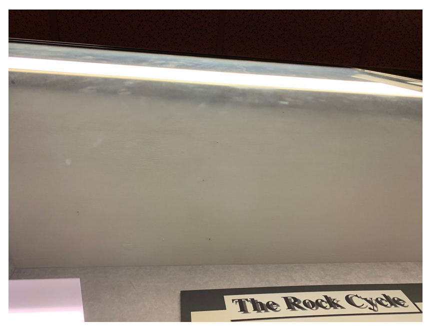


Geology Fixture #6


Geology Fixture #7


Geology Fixture #8


Geology Fixture #9

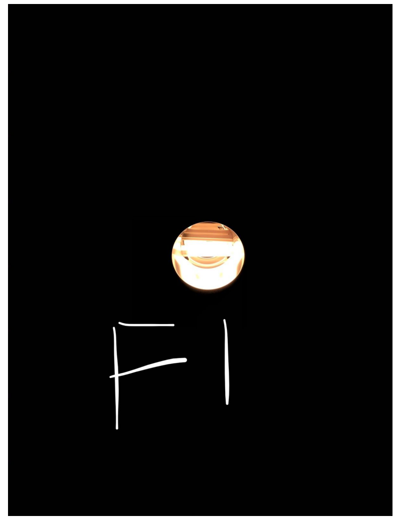


Geology Fixture #10

Geology Exit Sign

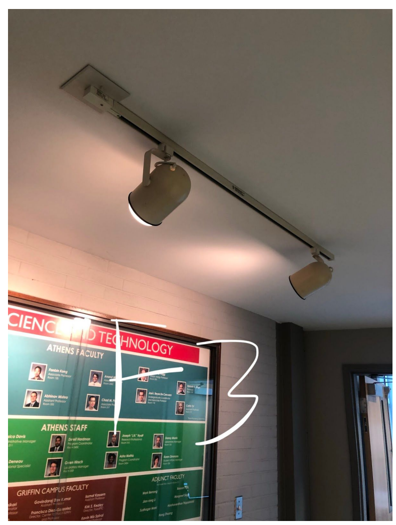
Food Science & Technology:

Food Science Triangular Exit Sign



Food Science Fixture #1

Food Science Fixture #2

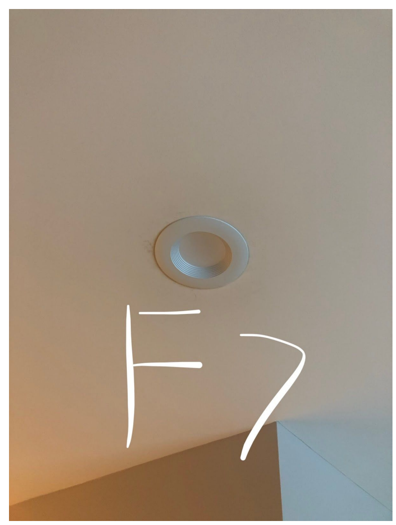


Food Science Fixture #3

Food Science Fixture #4

Food Science Fixture #5

Food Science Fixture #6

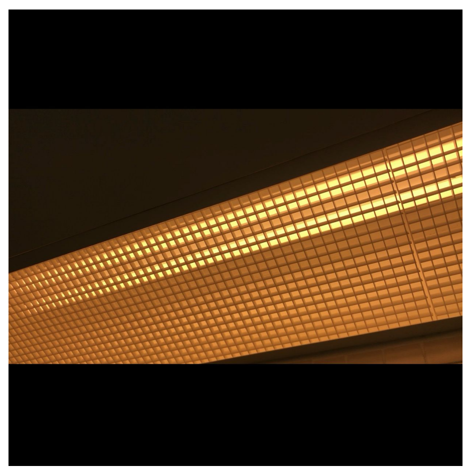


Food Science Fixture #7 (LED)

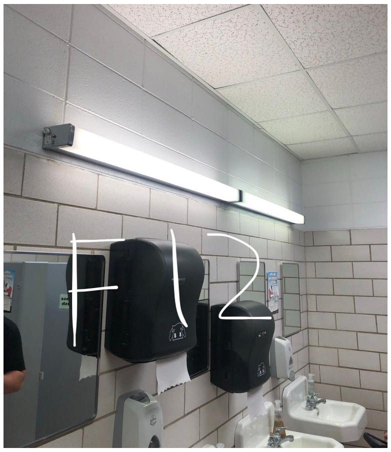
Food Science Fixture #8

Food Science Fixture #9 (Shower)

Food Science Fixture #10



Food Science Fixture #11 (shorter F10)



Food Science Fixture #12


Food Science Fixture #13


Food Science Fixture #14 (LED)

Appendix B: Background
Traditional incandescent bulbs work by running an electric current through a thin metal filament, which heats it up until it glows brightly, producing light. Fluorescent lamps, the most common type of interior lighting currently used on campus, work through a chemical reaction where mercury vapor is ionized in a glass tube, causing the electrons to emit UV photons that are converted to visible light by the phosphor coating on the inside of the glass tube. On the other hand, LEDs emit light through electroluminescence which is the emission of light from a semiconductor with an electric current. This takes place in a p-n junction, as shown in **Figure 1**, formed by a p-type material that has holes (missing electrons) in the valence band placed near an n-type material that has extra electrons in the conduction band.

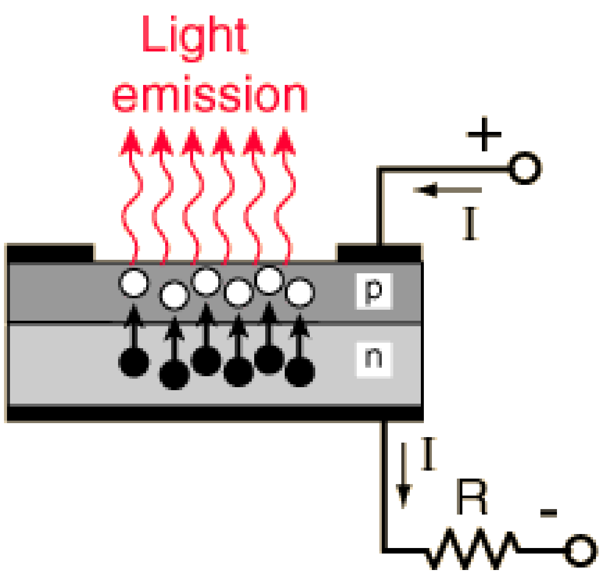


Figure 1. P-n junction (Nave, 2017)

When an electric current is applied to the p-n junction, the electrons in the n-type conduction band combine with the holes in the valence band and emit a photon. The distance between these two bands is known as the band gap and can be manipulated to change the wavelength of the light emitted.

The process for producing light, used by LEDs, is much more efficient than traditional lights because they produce little to no heat compared to the 90% of energy that is lost to heat in incandescent lamps and the 80% of energy that is lost to heat in fluorescent lamps. This benefits the environment by reducing energy consumption and the environmental impact associated with it, like pollution and global warming. For reference, a standard incandescent lamp that produces 650-800 lumens of light uses 60 watts of power compared to 13-18 watts for fluorescent lamps and only 7-10 watts for LEDs. This shows how LEDs can give an energy savings of up to 90% compared to incandescent lamps and are twice as efficient as fluorescent lamps for an equivalent light output. Another significant benefit of LEDs is that they have a much longer average lifespan. LEDs have an average active lifespan of about 25,000 hours of use compared to 8,000 hours and 1,200 hours for fluorescent and incandescent lamps, respectively. This considerably longer lifespan makes up for the higher upfront cost of LEDs, which is about $4 or less for a standard, high-quality, energy star certified bulb LED bulb compared to about $2 or $1, respectively, for a fluorescent or incandescent bulb. For an average daily use of 3-4 hours over 20 years at $0.15 per kWh, only 1 LED bulb would be needed and would cost about $34 for the needed bulb and electricity. In comparison, for the same parameters, 3 fluorescent bulbs would be needed with a total cost of $54 including electricity and 21 incandescent bulbs would be needed, costing $211. At the scale of UGA's campus, this difference in cost adds up quickly to be extremely significant. The cost of maintenance to pay people to change the bulbs is not factored into this calculation, but it is also reduced greatly by the less frequent need for replacements, which is important to note. Furthermore, the decreased frequency of replacing lamps benefits the environment because it reduces the amount of waste produced, and, with LEDs, the waste is nontoxic, unlike the mercury and gas used in other lights that needs to be disposed of specially.

The cost savings and environmental impact from the efficiency and lifespan of LEDs are enough on their own to warrant the adoption of this technology, but they provide even more benefits in addition, like no delay in turning on or off, the ability to dim, and increased resistance to shock or breaking. When considering these benefits it is clear why the FMD is interested in expanding the effort to retrofit buildings on campus with LEDs.