Proposal Title: Lighting the Way to Savings with LEDs

Total Number of Pages (not counting cover pages): 9

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200 word (maximum) summary of the proposal:

With the majority of traditional style residence halls at Rutgers lit by inefficient fluorescent light fixtures, dorm lighting uses large amounts of energy and costs a substantial amount of money each year. To cut back on Rutgers' energy use, we propose replacing fluorescent lighting with LEDs controlled by occupancy sensors. LED bulbs are at least 75% more efficient than fluorescent bulbs and last 25 times longer. While the initial costs of LEDs are greater, the potential savings make the switch a sound investment.

Lighting the Way to Savings with LEDs

Kyra Frank and Emily Nanneman

Introduction

Each year, Rutgers spends roughly $1.2 million on electricity for traditional style dormitories[1], and, according to the US Energy Information Administration, 17% of that cost[2] (or about $204,000 per year) goes toward lighting. A large portion of this cost is due to a requirement in New Jersey's building code, which stipulates that "means of egress, including the exit discharge, shall be illuminated at all times the building space served by the means of egress is occupied," (Chapter 10, Section 1006). This means that the lights in dorm hallways and stairwells at Rutgers are required to be turned on at all times. With the majority of dorms lit by inefficient fluorescent light fixtures, dorm lighting uses large amounts of energy and costs a substantial amount of money each year. To cut back on Rutgers' energy use, we propose replacing fluorescent lighting with LEDs. LED lights are at least 75% more efficient than fluorescent light bulbs and last 25 times longer[3]. While the initial costs of LEDs are greater, the potential savings make the switch a sound investment.

[1] Calculated based on electric utility data for Jameson and Woodbury residence halls on Douglass using the average monthly cost per kilowatt hour from June 2015 to May 2017, multiplied by the average monthly electricity usage per student and the total number of students living in traditional residence halls, and then multiplied by 12 to get the yearly cost.
[2] Business Energy Advisor
[3] Energy.gov

The Solution

The solution we propose for Rutgers' lighting problems is twofold: the first part of our solution is simply swapping LEDs for the fluorescents currently in place; the second part is putting two settings on these lights, controlled by motion sensors. At times of low activity, the lights will be dimmed to lowest level allowed by the NJ building code, and at times of higher activity, they will be at full brightness. The combination of LEDs and dimmable fixtures means Rutgers will reduce its energy use and create less light bulb waste, saving money in the long run.

Table 1: Comparison of Sample LED and Fluorescent T8 Tubes

	Fluorescent[4]	**LED**[5]
Cost per unit	10.98	3.00
Bulb shape	T8	T8
Wattage	32 W	10.5 W (equivalent to 32 W fluorescent)
Lifespan (continuous use)	36,000 hours	50,000 hours
Dimmable	no	yes

We chose this solution for several reasons. First, as stated above, LEDs are at least 75% more efficient than fluorescents. Second, it is relatively easy to swap LED bulbs for fluorescents. The majority of the light fixtures at Rutgers use fluorescent tubes. Often, LED tubes can be installed in existing light fixtures using the existing ballast. In situations where the LED tube does not fit in the existing ballast, all it takes is a few relatively simple modifications to the current fixture.[6] Third, LEDs, unlike fluorescents, have full dimming capabilities and work well with occupancy sensors, making it easy to install the motion activated dimmers we have

[4] www.1000bulbs.com
[5] www.1000bulbs.com
[6] Premier Lighting

proposed. Fourth, LEDs produce a better quality of light than fluorescents, which has been shown to increase the productivity and mood of a building's occupants.[7]

Cost Benefit Analysis - For Trial Run at WBC and Jameson Dorms

Number of light units to be replaced to LED units: 200 units

	Fluorescent	**LED**
Cost per unit	$3.00	$10.98
Cost for 200 units	$600.00	$2,196.00
Electricity use per year	56,064 kWh	18,396kWh
Electricity cost per year	$5,253.20	$1,723.71
Lifespan (continuous use)	36,000 hours	50,000 hours
Lifespan when used for 24 hours a day, 7 days a week	4 years 1 month 10 days	5 years 8 months 18 days
# of times a fluorescent fixture replaced during the LED lifespan	1.25 replacements (250 replacements overall)	n/a
Cost of replacements in LED lifespan	$750.00	n/a
Cost of recycling[8]	$0.35 per unit ($87.50 overall)	n/a
Cost per unit for occupancy sensors[9]	n/a	$55.19 ($496.71 for nine units - one for each hallway)
CO_2 emissions per year	6,167.04 kg	2,023.56 kg
Social cost of carbon per year	$259.02	$84.99
Total cost over LED lifespan	$32,857.15	$12,602.85
Total savings over LED lifespan	$20,254.30	
Break-even point	7.5 months	

[7]The Climate Group
[8] Lamprecycling.com.
[9]www.1000bulbs.com

Cost-Benefit Analysis Methodology

The cost-benefit analysis was conducted for the chosen pilot residence halls, Jameson and WBC. Based on the number of fixtures counted in one hallway of the WBC residence hall (17) and the total number of floors of Jameson and WBC combined (9), plus additional bulbs for entrance ways, it was determined that approximately 200 units would be necessary to retrofit both residence halls. The per-unit costs for the bulbs were based on the sample tubes presented in the previous section (the Green Creative 4 ft. T8 LED and the Phillips 4 ft. T8 fluorescent). Yearly electricity costs were calculated using the wattage data for the sample bulbs and the average cost per kilowatt hour for Jameson and WBC from June 2015 to May 2017. That data was plugged into the following equations:

$$E_{(kWh/year)} = \frac{P_{(W)} \times t_{(hours/day)}}{1000\ W/kW} \times 365\ days/year$$

$$Cost_{(\$/year)} = E_{(kWh/year)} \times Cost_{(\$/kWh)}$$

where E is energy in kilowatt hours per year, P is power in watts, and t is time in hours per day.

Using the ratio of the lifespan of an LED bulb to the lifespan of a fluorescent bulb, it was found that during the lifespan of the 200 LEDs installed, 250 equivalent fluorescent bulbs would have to be replaced. Multiplying this by the per unit cost of the fluorescent bulbs, it was found that LEDs would save an an estimated $750.00 in replacement costs and $87.50 in recycling costs over their lifetime.

To calculate the social cost of carbon, first the amount of CO_2 emitted per year was calculated by taking the weighted average of the amount of CO_2 emitted[10] by different fuel types based on the percentage of New Jersey's energy generation[11] provided by each fuel type then multiplying that by the yearly energy use. Yearly CO_2 emissions were then multiplied by the EPA's 2020 estimate[12] for the social cost of carbon per kilogram of CO_2.

Total cost over an LED's lifespan was calculated by summing the initial cost of installation, yearly electricity cost, cost of replacements, cost of recycling, cost of occupancy sensors (where applicable), and social cost of carbon. The break-even point was calculated by finding the difference in energy cost between fluorescent and LED fixtures, then dividing the initial cost by the difference in energy cost.

Cost of labor was not included in this analysis as the workers who would be installing the LED bulbs are already being paid to replace light bulbs, so it would be no additional cost to install LEDs. Additionally, potential energy savings resulting from occupancy sensors was not included, as it is unclear at this point how often lights will be dimmed. Collecting occupancy data to make a better estimate of energy savings will be included in the implementation plan. Though LED lighting had been shown to improve mood and productivity[13], these benefits were not included in this analysis as they are not easily quantifiable.

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[10]EPA - emissions for coal used emissions for "Mixed (Electric Power Sector)"
[11] U.S. Energy Information Administration (EIA) For the purposes of this analysis, the distribution of NJ's energy generation by fuel types was simplified as follows: natural gas -56%, nuclear - 39%, coal - 1.5%, renewables - 3.5%.
[12]EPA
[13]The Climate Group

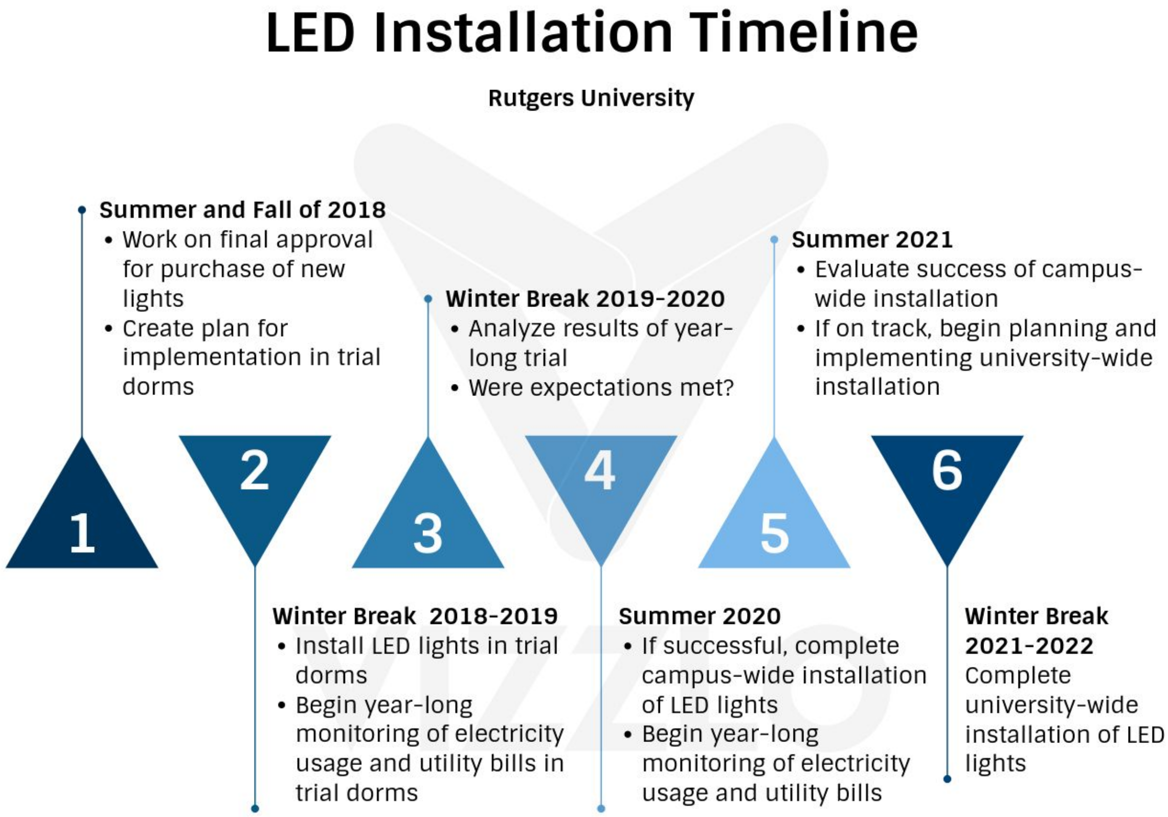
Model of Behavior

To switch hallway light bulbs from fluorescent to dimmable LEDs, upper Administrators who are in charge of approving the costs of purchasing and installing LED light fixtures in the dorms will have to be convinced that this is a worthwhile change. Also, the fact that the maintenance department will be responsible for installing the new lights and properly disposing of the old lights should also be included in discussions.

For upper administrators in charge of the approving the decision factors that affect the decision includes both costs and student and employee welfare. Both of these concerns are addressed by the cost benefit analysis. While the initial cost of purchasing and installing LED lighting is greater than continuing to use and purchase fluorescent lighting, the long run payback on LEDs has proven to be far greater than the costs. The LED lights will break even after approximately 7.5 months of use and continue to save roughly $3,500 a year when compared to the costs of maintaining fluorescent lights. Even though maintenance staff will be required to complete a large scale swap of the lightbulbs during a limited period of time, the overall labor required by LEDs is less because their lifespan is 25 times longer than fluorescents. Lights that once had to be changed every two years must now be changed every 5 years. Additionally, replacing fluorescent lighting with LED lighting will benefit students from LED because it has been shown to improve concentration, motivation, and mood[14]. Without requiring students to change their behavior - something is notoriously hard to do. Rather, the decision is limited to upper-administrators and, once implemented will produce savings themselves.

[14] The Climate Group

Implementation Plan



Implementing our plan should be relatively simple. Installing light bulbs is not a new technology and LEDs are installed just like fluorescents light bulbs, so there will be no training required. The average time it takes to install an LED light, including ballast change, takes approximately 10 minutes[15]. In addition, no new staff will need to be hired to complete the project, because it is already under the jurisdiction of the maintenance staff.

The process will begin by creating a plan for installing the lightbulbs in the dormitories. Heavy student traffic would make it difficult to install the lights during the academic year. Thus, installation should be arranged to take place during the winter and summer breaks. The summer

[15]Family Handyman

and fall of 2018 will be dedicated to planning implementation, approving it, and ordering new lights, so installation will begin during the 2018-2019 winter break. In total, it should take roughly 33 hours to install the new lights in Woodbury and Jameson[16]. This amounts to three hours of work over the course of two, five day work-weeks, a feasible schedule to complete installation over winter break. Installation will pick up again and be completed during the 2019 summer break. After installation, a year-long monitoring period will begin to observe whether the lights are performing as expected. Once the year is up, a review of the lights will take place to determine if they have met their target goal. If, for some reason, the LED lights are underperforming, then troubleshooting will take place and the lights will be monitored and re-evaluated. If the new lights have met their goal, then planning will take place to begin campus-wide (Cook/Douglass) installation of LED lights will take place over the summer of 2020. Another of year of monitoring will take place to determine the results of campus wide installation. If deemed successful, university-wide implementation will begin – starting with planning the process. Installation will begin on all campuses during the summer of 2021 and be completed by the end of winter break 2021-2022.

[16] 10 minutes to install each light * 200 lights = 2000 minutes/60 = 33.33 hours

Conclusion

While our solution may not be radical or ground-breaking, it is comparatively cheap, can be easily implemented by Rutgers, and will provide relatively instant results. Based on our cost-benefit analysis, the installation of LEDs in Woodbury Bunting-Cobb and Jameson will break-even in just 7.5 months and generate $20,254.30 in savings over the course of an LED's lifetime (5 years and 8 months). Additionally, because the lights require little to no maintenance after the original installation and do not require students to change their behavior, the solution essentially takes care of itself. Magnified over all of Cook/Douglass or the whole university, this plan has the potential to save a significant chunk of money in a short period of time. This is a simple and impactful way for Rutgers to lead the way towards a more sustainable future.

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