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**KCPA LED Lobby Lighting**

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In the words of Valerie Oliveiro, Assistant to the Senior Associate Director of the Krannert Center for the Performing Arts, KCPA is “dedicated to the advancement of the education, research, and public engagement mission of the University of Illinois through the pursuit of excellence and innovation in the performing arts.”[[1]](#footnote-1) These words exemplify the importance of KCPA to the campus community. A hub of social interaction and innovation, Krannert has a unique role as a leader and innovator in sustainability initiatives at the University of Illinois. This unique importance is what drove KCPA to the idea of implementing LED lighting in its lobby. After more than two years of research and experimentation, consideration to the developing goals of the Illinois Climate Action Plan (iCAP) and joint funding from the Student Sustainability Committee (SSC) and the Illinois Clean Energy Community Foundation, KCPA finally decided to pull the trigger on The University’s largest LED lighting project.

LEDs, or Light Emitting Diodes, were invented in 1962 by University of Illinois alumnus Nick Holonyak Jr.[[2]](#footnote-2) Understanding how LEDs work and their benefits is important to grasping the entire concept of sustainability in relation to LEDs. LEDs are semiconductor diodes that produce light when voltage is applied to them. Essentially, electrical current is applied to the LED, and that current flows through an extremely small circuit board to produce the light, which is focused through a plastic lens. LEDs are an incredibly versatile and efficient source of lighting. They are approximately four times more efficient than current Compact Fluorescent (CFL) bulbs,[[3]](#footnote-3) emitting considerably less heat than incandescent bulbs and requiring minimal maintenance due to their increased longevity - about 25x that of incandescent bulbs.[[4]](#footnote-4) The versatility of LED lighting is only heightened by the variety of shapes, sizes and colors that LEDs come in. Perhaps the most significant benefit of LED technology is where it is going in the near future. While CFL lighting is still efficient and useful, LEDs are considerably more efficient that CFLs, and essentially the only thing holding back LEDs from completely negating CFLs is their price. Once the price comes down on LEDs there will be little competition as to what the most efficient and sustainable type of lighting is.

Now that the basics of LED lighting have been examined, lets move into the specifics of the KCPA retrofit. The KCPA lobby replaced 550 incandescent bulbs with solid-state LED luminary fixtures.[[5]](#footnote-5) The KCPA lobby previously used about 573,800 kWh of electricity each year with incandescents, costing about $62,500. LED lighting reduces the lobby’s energy use by about 80%, using only 132,000 kWh and costing about $12,500.[[6]](#footnote-6) The big inhibitor for implementing LED technology is the cost per unit of the LED, which is considerably higher than that of a CFL bulb. KCPA was an ideal location to retrofit for a few important reasons. In general, payback time shortens, return on investment (ROI) gets larger and the project becomes more efficient with higher kWh rates, higher relamping costs and longer hours of operation.[[7]](#footnote-7) Electricity prices on campus are currently at ~9.5 cents per kWh, a bit below the national average of 12.2 cents per kWh.[[8]](#footnote-8) Despite this, KCPA fits the other two criteria for an efficient LED retrofit with its high use rates and expensive relamping costs, clocking in at 17 hours per day, 360 days a year and $35 per lamp respectively.[[9]](#footnote-9) There were a handful main project goals that KCPA wanted to achieve through its LED retrofitting project, including increased energy savings and decreased energy usage, decreased maintenance and labor costs, no inventory for replacement bulbs, no labor costs for lamp replacement fixtures, and finally a flexible color scheme and lighting control system. This paper aims to examine the LED retrofit project and its goals through the lens of sustainable metrics and evaluation.

An important consideration when evaluating any project is conducting and examining a life-cycle analysis (LCA). KCPA did an extensive LCA when researching and prototyping for their retrofit. A big reason that LEDs were viable was because of their long-life and cleaner life cycle compared to incandescent and CFL bulbs. The LEDs at Krannert have an expected lifespan of 20 years before requiring replacement.[[10]](#footnote-10) A big part of the reasoning behind the shift to LEDs at Krannert was because of the expensive relamping costs that were sunk in with the current incandescent system. Before the retrofit, KCPA was spending $22,674.60 annually to relamp the lobby.[[11]](#footnote-11) The LED retrofit cut this amount down considerably, now only costing only $3,139.56 annually.[[12]](#footnote-12) This is due mostly to the fact that the LEDs have a lifespan far greater than the incandescents and do not need to be replaced at all unless they malfunction. Another part of the huge cost savings has to do with the ability of LEDs to change colors. Previously in order to have colored lighting in the lobby, technicians would need to manually replace the existing bulbs with colored ones, an expensive and time-consuming process.[[13]](#footnote-13) With the LED system in place, Krannert can program individual LEDs to whatever color and brightness they would like. Examining the life-cycles also sheds light on the fact that LEDs are much cleaner to dispose of than other types of lighting. 95% of the LED module is recyclable, with the other 5% (raw metals and PCB circuitry) being easily recycled through e-waste programs present in most municipalities.[[14]](#footnote-14) CFL bulbs, on the other hand, are more numerous when disposed of and also must be disposed of carefully, as they contain harmful metals such as lead and mercury.[[15]](#footnote-15)

The conducted LCA also shed some light on how drastic the energy savings from LED lighting would be. As previously stated, with the old incandescent system, KCPA was using 573,800 kWh of electricity annually, costing them about $62,500. LEDs reduced this by 80%, using only 132,000 kWh and costing $12,500.[[16]](#footnote-16) This was a huge reduction; the project could pay itself off in 7 years just from the energy savings alone, amounting to over 8 million kWh saved over a 20-year life cycle. Electrical efficiency is not the only reason that LEDs cut electricity use so much. The incandescent system was contributing over 85,000 watts of heat energy to the building.[[17]](#footnote-17) In the winter this heat is useful, as it keeps heating costs down. Over the course of the year, however, the extra heat was costing KCPA about $40,000 in energy costs to keep the building cool.[[18]](#footnote-18) The LED lighting system combined with the recent update to KCPA’s HVAC system has cut energy use and chilled water use considerably, making the building much more efficient overall in terms of its energy use. In terms of the embodied energy of LEDs, only 1-3% of embodied energy comes from manufacturing, transport and disposal; 95% is how much energy the unit uses while its working.[[19]](#footnote-19) Most of a light source’s embodied energy comes from its use, which is why the efficiency of LEDs made them a superior light source for the project. The straightforward success and clear, hard data make energy savings a great metric to look at when determining the effectiveness and overall sustainability of the project. If there was one way to make this metric better it would be to implement KCPA energy statistics on the new Illini Energy Dashboard website. The dashboard displays energy used for electricity, heating and cooling for over 40 campus buildings, all in real time. Though KCPA is listed, there is no data being displayed. Having this data calculated, analyzed and displayed in a real time manner would be a useful tool when examining the projects continued effectiveness.

Another important metric used to measure the sustainability of the LED retrofit is the reduction in emissions from the project. According to Student Sustainability Committee one kWh of electricity generated through the University’s mix of fuels equates to 1.672 pounds of CO2 emitted into the atmosphere.[[20]](#footnote-20) As mentioned before, the incandescent system was using 523,260 kWh annually. This was the equivalent of 437.45 tons of CO2 emitted into the atmosphere annually. In terms of some other metrics, the annual kWh use under the incandescent system equates to more than 380,000 pounds of coal burned, or the annual electricity use of 50 homes in the United States.[[21]](#footnote-21) LEDs cut this number by about 76%, with annual kWh consumption coming in at 117,315 kWh annually. This is the equivalent of 97.95 tons of CO2, 87,000 pounds of coal burned, or the electricity use of 11 homes annually.[[22]](#footnote-22) LEDs are a powerhouse of efficiency, and this strength is exemplified through the 20-year life cycle analysis. Over the course of their estimated 20-year life span, the LEDs are projected to save 8,118,900 kWh of electricity, equating to an expected offset of 6787.4 tons of CO2 emissions. [[23]](#footnote-23) Under another comparative metric, this amounts to a lifetime offset of 1,025,058 therms of natural gas, which is one of the primary fuels burned at Abbott Power Plant.[[24]](#footnote-24) The University of Illinois reduced its emissions by 54,985 metric tons of carbon between 2009 and 2010, which was during the KCPA lighting project.[[25]](#footnote-25) KCPA contributed ~272 metric tons of that reduced carbon, which is about 0.5%. While this number seems small, it is important to look at the bigger picture of the emissions metric. Half a percent of total emissions reductions came from replacing 550 incandescent bulbs with LEDs. There are reportedly over a million light bulbs on campus.[[26]](#footnote-26) These are primarily CFL bulbs, and there are so many light bulbs that there is a taskforce of individuals dedicated to servicing and replacing them. The efficiency of LEDs is only getting better, and the price is only getting lower. It’s very realistic to envision an affordable and efficient LED future for the University. If 500 lights could cut emissions by half a percent then there could realistically be some serious cuts in emissions and energy consumption through the implementation of LED lighting campus-wide.

A rather unique, less traditional metric to consider with the KCPA project is the idea of an education-based metric. Inside the Business Instructional Facility (BIF) there is a dedicated screen displaying energy use statistics for the building, which is a sustainable hallmark on campus. KCPA could greatly benefit from something like this. There are numerous screens in the lobby with a constant cycle of videos and other content being displayed. While a dedicated screen would be the most effective, having anything regarding the LED project, energy efficiency or overall sustainability would be a great step to take. KCPA takes pride in its green initiatives, evident from the “We’re Green!” page on their website.[[27]](#footnote-27) The analysis on the project is out there, all that would need to be done is to start displaying the data and drawing more attention to the ramifications of the project. KCPA is one of the most trafficked buildings on campus, with the high volume of events that take place there as well as daily tours that go through the building. Perhaps an effective metric for evaluating the efficiency of education is to analyze the number of people who traffic the area to gauge how effective a screen of statistics would be. User-satisfaction is another way to measure and evaluate the project. Other projects on campus and similar LED retrofits across the United States have had positive feedback.[[28]](#footnote-28) A KCPA feedback survey was part of the SSC funding proposal, but there is no evidence of whether this survey took place or not. Unfortunately, KCPA staff involved in the project were unable to be reached in order to further evaluate this metric. Overall, evaluating and harnessing the education benefits that are present with the project can only lend to its overall effectiveness.

Perhaps the most effective and telling metric and means of evaluation was the overall return on investment for the project. According to the LCA done by Facilities and Services, the net savings from the project were $1,161,996.51.[[29]](#footnote-29) The costs for the project were $450,000, thus having a net return on investment of 158.22%. The project paid itself off in about 4 years, meaning there are 16 full years of savings before the LEDs need to be replaced. 128% ROI is a good number, and clearly shows that the project was effective. The project becomes even more attractive, however, when the future is considered. If you were to cut the costs of LEDs by 50%, you would also halve the payback period while nearly tripling your ROI.[[30]](#footnote-30) LEDs are getting cheaper every year, and it is a very realistic if not certain to presume that LEDs will have increased efficiency and decreased cost when they need to be replaced after the 20-year lifecycle. Since the housings for the LED modules are already in place at the lobby, any increase in efficiency or decrease in costs will drive up the ROI for the project. So, 128% will certainly be surpassed for the next cycle of LEDs. The return on investment and consideration for the future of LED technology gives a sense of sustainable longevity to the project.

In the end, the true beauty and effectiveness of the KCPA LED retrofit lies with evaluating and synthesizing all of the metrics discussed here. The retrofit created a strong framework for evaluating ROI, efficient and overall sustainability for lighting projects on campus. The KCPA project is a benchmark for the future of LED lighting at the University, as it required large-scale analysis incorporating multiple variables, time frames and metrics. There are a variety of LED projects on the horizon on campus. LED lighting is a huge part of the iCAP sustainability and emissions goals, the new ECE building is sporting over 50% LED lighting, and there is a new Bi-level adaptive parking lot project aimed at combining motion-activation with LED technology to eliminate “always on” lighting systems and create more sustainable habits. All of these projects will look to the KCPA retrofit at an example of how sustainability should be implemented. It is not as simple as examining just the amount of kWh saved. In order to truly evaluate the sustainability of these types of projects, deeper, more complex variables need to be considered. Life-Cycle Analyses, embodied energy, sunk costs, emissions reduced, the energies used to create the electricity being used, the nontraditional metrics associated with a project; these are aspects that need to be fully fleshed out through evaluation if a project is to truly be marked as sustainable and effective. The KCPA LED Lobby lighting project is a hallmark of the effective implementation of sustainable technology on campus. 272 metric tons of CO2 offset annually, 405,845 kWh of electricity saved and ~$60,000 of total cost savings annually.[[31]](#footnote-31)128% ROI that will grow down the line, creative metrics for pushing education and sustainable awareness and the creation of a detailed framework on how the complex variables of sustainability should be evaluated and implemented. This is the legacy that the KCPA LED Project leaves behind. This project has paved the way for the future of LED lighting at the University of Illinois, and has laid out in black and white the evaluative measures and metrics that must be considered when defining sustainability.

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