Saving Energy: Occupancy Sensor Lighting

An Independent Sustainability Project
Submitted for Consideration to Professor Barry Muchnick
For ENST 450: Applied Sustainability Practicum

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Abstract: In order to supplement campus efforts to reduce carbon emissions, I have conducted research on tactics to reduce lighting energy use. This included the history of sustainable lighting at St. Mary's College, case studies from other institutions, and technical specifications of lighting options. After I established a substantial body of research on the best options available, a project was devised to implement occupancy light sensors into all of the dormitory hallways. In conjunction with the Sustainability Office and Student Government Association members, grant money has been secured to make this project a reality. When implemented, these sensors will not only save energy and money, but teach a new generation of students the importance of ecological responsibility.

Introduction

Most people do not even contemplate lighting energy; it is an integrally embedded constant in our built environment. I decided I wanted to do something to change that. With this my project began, and it began with a habit. I have become a somewhat obsessive light flipper, turning off lights when I leave not only rooms, but also hallways and stairwells. From this daily interaction with the light switches, I began to wonder how I could bring more people into active sustainable practices. I thought of signs perhaps, or education on how to save energy.

After some research, I realized more permanent change could be actualized. Architecture is a communication in itself. From a piece by David Orr, I came to realize the built environment as a sort of crystallized pedagogy. People are constantly being influenced by their environment. By designing a building in an intelligent and ecologically cognizant way, users will recognize and physically see the benefits of sustainable practices. "The design and operation of buildings is an opportunity to teach...ecological engineering for cleaning wastewater, aquaculture, gardening, and solar engineering."[1] To this list I would add energy efficient lighting design. I decided to improve the actual lighting infrastructure as a means to change student perspective on the environment.

I was not the first person with such goals in mind. In 2010, administration at St. Mary's College contracted a 'test' hallway of occupancy sensor fixtures. The entire first floor of Prince George Hall was fitted with an auto-light setup. This 'test' was installed in order to see how the light sensors functioned and how much energy they saved. The hallway still has functioning sensor lights to this day. Unfortunately, data on its success or failure to save energy was never collected. Ideally, data would have been taken on use before the installation as a control, and

[1] Orr, David. *Earth in Mind: On Education Environment and the Human Prospect.* (Washington DC: First Island Press, 2004), 115.

then energy would have been measured again after to estimate savings. Since there is no record of such a study on campus, I was required to do my own research, a subject I will detail later. Despite these setbacks, the test hallway gave me a tangible vision of what the finished product of my work would look like. The original contractor installation costs were found in Operations records, and I was able to estimate the cost for my plans from these figures. One can think of this project as an expansion of what the school already has in place, broadening the scope to the halls of every traditional dormitory on campus (Dorchester Prince George, Caroline, and Queen Anne.)

The initiation of a large scale, monetarily demanding project is no easy task and has become an ongoing process for the whole semester of Spring 2015, for myself and many who have helped me, and will continue to next semester. It is a fantastic realization to find that by working on an individual project such as this, I have already inherently drawn community members into more actively sustainable roles. At first I imagined this project was my responsibility alone, but in practice it developed only due to the hard work and help of many other people. In this way, projects in themselves supplant momentum to sustainability goals and bring helping hands from the community working towards these goals. Sustainability at large has suffered from a lack of drive; stagnant and without popular support. From this experience I have found that active projects and community involvement positively reinforce one another. I have developed a project idea then let it seed, grow, and thrive within the greater community. This document outlines my process, as well as its context in academia, case studies of a similar nature, and outcomes; with an eye to future student proposals.

Context

Imagine you live in Illinois in 1893. You are headed to bed, and blow out your candle. All of your lamps are out, all is dark. Lying in bed, almost asleep, your significant other tells you that she read about an invention called 'electric lamps,' those of which will be displayed at the World's Columbian Exposition.[2] You both excitedly talk, and decide to go see this mysterious device.

A few days later you are at the fair. You spend the day amused by mechanical devices, silly things such as the Ferris wheel. As the sun is setting, you begin to think about going to the hotel; there is nothing more to see as it will soon be dark; and then you remember. Quickly running outside, the sun well down by now, the entire building is lit up, as if by magic. You are in awe of the beauty, the power of electricity at work.

The above story exemplifies how electric lighting made its way into popular use. From that first wide exposure at the World Fair the light bulb was a coveted addition to any household. It is important to understand the development of lighting technology and the results of its success in order to correctly apply new technologies. The commercialization of electricity had enormous implications for society. The night no longer controls our day, all we must do is flip a switch to have the power of light. How novel it must have been to first experience such technology. And so is it not surprising that lighting technology spread quickly across the globe. Gas lamps, fires, candles, all became obsolete and are now the novelties, not the norm. This all contributes to the attitude towards lighting. It involves man's power over nature, the pride of science at work, and industrialization. Now, more than a century later, it is time for a change.

[2] "World's Columbian Exposition of 1893" Paul V. Galvin Library Digital History Collection, Illinois Institute of Technology, accessed April 14, 2015, http://columbus.iit.edu/

Sustainability has been picking up momentum since the 1970s. With breakthroughs like the Clean Water Act (1972) and the first Earth Day (1970,) a new movement began its course to the present. Literature has shaped and led the development of the movement. Monumental works such as Aldo Leopold's *A Sand County Almanac* have brought environmental concerns to public attention. From this public worry for our environment's health a complex interaction between the economy, politics, and cultures of our world has sprouted and at the center is a balance for which sustainability strives. My project is an investigation of this balance, building upon the work of those before me. The context of my work extends through the centuries, adding one more sentence to the changing definition of sustainability. A path can be traced from the ideas expressed by the first 'environmentalists' such as Henry David Thoreau, to the movement's contemporary manifestation.[3] From everything from the technology and engineering to the literature of the past I have both unknowingly and purposefully drawn from these works laid before me.

Among such inspiration is the work done by students at other universities. Higher education plays a vital role in research, advancement and change for our future. Like my research, other schools are developing curricula with sustainable ideas bridging disciplines boundaries. The science behind ecology is uniquely tied with philosophical arguments for ethical treatment of animals and our environment. The literature of the transcendentalists like Thoreau is paired nicely with mathematical population models to inform intelligent decisions. Therefore it is important for all disciplines to communicate and share their breakthroughs. In turn, great progress can be achieved through the transparent communication between colleges and universities across the globe. I have drawn from examples implemented at other schools for my

[3] Edwards, Andres R. *The Sustainability Revolution: portrait of a paradigm shift.* (Canada:: New Society Publishers, 2009), 11-27.

own project. By reading reports, staying connected, and following good examples, colleges can help each other to make higher education (and the world) green.

Case Studies

Other schools and organizations provide examples of sustainability in action, allowing a smoother start to my project because effectively it has been done before in a similar format. From studying other schools' sustainable initiatives, I have absorbed much for replication. A community approach to any sociopolitical movement is vital. College campuses have acted as a grounds for this sort of community in the past, and the "Sustainability Revolution"[4] is no different. With the help of progressive individuals all sharing their knowledge through academic publications, a movement can quickly become an entire study discipline. Outlined below are several case studies of good sustainable initiatives; each a piece of the contemporary sustainability movement.

The U.S. Green Building council was founded in 1993. and in March of 2000, unveiled its Leadership in Energy and Environmental Design (LEED) certification system.[5] This revolutionary idea has promoted green building to stand as the face of breakthrough architectural design. A culmination of more sustainable design principles which had been gaining traction, LEED certification made sustainable design marketable. Two years later, in March 2002, Stanford University published *The Guidelines for Sustainable Buildings.*[6] Rather than using the LEED certification levels to dictate new building on campus, Stanford took it upon themselves to make a document more applicable to their own community. This document was the final product

[4] Edwards, *Sustainability Revolution,* 2.
[5] "USGBC History" U.S. Green Building Council, accessed April 8, 2015, http://www.usgbc.org/about/history
[6] Barlett, Peggy F. and Geoffrey W. Chase. *Sustainability on Campus: Stories and Strategies for Change.* (United States: Massachusetts Institute of Technology, 2004), 177.

of a collaboration between students, professors, and administration to make sustainability a priority for campus building design. This project offers particular insight into how sustainable structural changes can be made; and especially all the people they involve. The students had to talk to facilities management and also find support from the greater community. By understanding the web of interaction between students, administration, faculty and staff, one is better prepared to work with required parties to make a project happen. The students at Stanford connected all parts of the system to complete one common goal.

Within the built structures on a college campus come another form of ecological cognizant design. Although the design of new buildings is important, it can also be helpful to look at ways of improving the already existing built environment. This element of design, the retrofit, is the broader scope of my project. Similar to my project on the St. Mary's campus, many other colleges are working to implement light sensors. On the Sierra club's website of their ranking of the 2014 best green schools, an institution in our area ranked number two. American University, located in Washington D.C., has given insight into implementing large-scale lighting retrofits. The school's sustainability coordinator has established use of light sensors into many offices, hallways, and classrooms.[7] Paired with this, Light Emitting Diode (LED) lights were employed in a parking garage as well as the streetlamps that light all of the pathways on campus. Our streetlamps could be supplemented by a similar change. A study conducted by the Technical Research Center of Finland tests a new technology for motion sensor 'smart' LED streetlamps.[8] It is easy to see how projects build upon each other.

[7] American University STARS Report" via Sierra Club, accessed April 8, 2015, http://www.sierraclub.org/sites/www.sierraclub.org/files/sierra/coolschools/2014/pdfs/2014-06-03-american-university-dc.pdf

[8] Juntunen, E, et al. "A smart LED luminaire for energy savings in pedestrian road lighting" *Lighting and Research Technology*, 47.1 (2015): p.103-115.

These are just two ways communities have made sustainability part of daily life. It is a testament to the opportunities still at hand. Still, sustainability projects are not without their problems and failures. One case in point can be found in our campus history at the Michael P. O'Brien Athletics and Recreation Center (MPOARC or 'ARC'.) A project was developed to save energy by employing the same technology of this paper's focus: occupancy sensors. After being installed in the movement room by the rock wall, the sensors soon had to be removed because of complications. I had not even known these sensors ever existed, it was not until I was speaking with a fellow student who was researching sustainability in athletics that I found out about this failed attempt. A frustrating waste results from implementing projects without adequate research. Like any design process, failure is unavoidable. In order to succeed in the application of a project, inherent flaws and issues must be uncovered during the planning phase and not after installation. This is why planning and research absorbed the bulk of my time on this project.

Project Overview

The project began with a compilation of ideas and related sources. I became acquainted with the literature on sustainable lighting, project implementation, and the technology currently available. This research base allowed me to see which technology and ideas would be most helpful for my endeavors. From this preliminary information on simple lighting retrofitting projects, I found that I had roughly three routes I could take: 1) Change the purchase of new bulbs from Compact Fluorescent Lamps (CFLs) to LEDs 2) Implement the occupancy sensors 3) Focus solely on campus education/encouragement of energy saving techniques. Much of my research was devoted to which plan would work best for the situation at hand. LEDs would save more energy overall, but are expensive to install and are often thrown away prematurely,

contributing to unnecessary waste.[9] From this knowledge, as well as decreased user acceptance of some LED lights,[10] I removed the first route from the list of possibilities. Both the occupancy sensors and the educational approaches held promise. I realized that they could easily build off one another. One approach to a problem is rarely unconnected or exclusive from others. Education should be included in any project of this nature, and so I decided to combine both the technical and communicative into my proposal. After coming to the decision of employing the occupancy sensors as a form of education in themselves, I began the practical operation of my plan.

My project is more political in the application process rather than research and development (occupancy sensors are already on the market; my goal was to gain approval from school administration and student government for the project rather than design new technology.) Therefore my research conducted in order to decide the best option for St. Mary's, calculate estimated costs and paybacks, and then gain approval for installation. Due to this nature of the project, I will outline my process in a linear, step by step description.

The first step was to contact the VP of Operations. Derek Thornton holds this title, and responded quickly and efficiently to my emails. I asked him about the previous attempt at lighting in 2010, as well as the logistics of hiring contractors or employing the existing St. Mary's staff. He informed me that contractors are preferred and that outside parties did the installation of the last sensors. I was forwarded an email from several years ago discussing the relative cost of the sensors which marked an estimate of around 1600 dollars per hallway in the dormitories. I therefore needed to figure out a way to acquire funding.

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[9] Casamayor, Jose et Al. "Extending the lifespan of LED lighting products," *Architectural Engineering and Design Management,* 11.2 (2015): 105-122.

[10] Dangol, R. and M. Islam. "User acceptance studies for LED office lighting: Preference, naturalness and colorfulness." *Lighting Research and Technology*, 47.1 (2015): p.36-53.

I was made aware of the Green St. Mary's Revolving Fund (GSMRF) which raises funds for sustainability projects each academic year. Shortly after learning about this fund, I was put into contact with another student, Kate Cowart, who was working to do the same project under GSMRF. Kate is the lead intern at our Sustainability Office and a representative in the Student Government Association (SGA.) After finding out we both were working towards the same goal, we collaborated. Kate had already begun drafting legislation for SGA. Student government votes on which projects will be funded by GSMRF since the money comes originally from each student's tuition. Since she was handling the submission of the proposal, I worked to find contractors willing to do the job.

Keeping in touch with Kate and the Sustainability Office, I made calls to all lighting outfitters serving our area listed on the Southern Maryland Electric Cooperative (SMECO) website. Although several contractors showed interest, only two made a definitive potential partnership, driving to meet with me and see the dormitories. On the appointed day, I met with the company Improvement Zone's representative. I led the man through Prince George Hall to show him the occupancy sensor setup desired, and then toured him through the other residence halls for him to take measurements. An estimate is currently being developed. On the following Friday, April 10th, I met with a representative of Advanced Energy Contractors. Like the first contractor, information was recorded and taken to form a project plan. I will hear back from this outfit with an estimated cost by the end of this week.

In my research, I made some rough calculations for total materials and installation costs, which totaled to around 17,000 dollars. I also found the estimated payback periods for typical occupancy sensor units and calculated roughly how much time it would take to pay off the material and contractor fees. In my conservative estimate it amounted to around 6 years.

Although not ideal, this is rather quick for a retrofitting project, and the lights have a life much longer than such a timespan. Despite not having a current contractor estimate, Kate used my calculations to present to SGA. The bill was presented by Kate on April 14th, and then our project's fate was left to a vote of our peers. Fortunately, the legislation passed. We will receive funding for the project in two phases, first the installment for Prince George and Caroline halls, and then Dorchester and Queen Anne to follow.

From this point forward, the project will follow as such. We will develop a scope of work and approach outfitters to bid on the job. The company who installs our lights must meet requirements set by the state, and this will assure that they meet such requirements. The contractors I have been in contact with will submit their proposals. I have passed all of this information on the Mary Grube and Derek Thornton, who have met with SMECO for rebate possibilities and are putting together a scope of work so that the contractors can bid on the project. After a confirmation of funds, a reputable contractor will be employed sometime next fall. By this point the GSMRF account will hold more money, as a project for more efficient heat pumps in the Crescents (beginning this summer) will take a large portion of the available dollars. This is why my project is occurring in two phases; the time between will allow the money in the fund to be replenished.

I presented my project at the Spring Poster Symposium. This was a great opportunity to engage fellow St. Mary's residents and gain their insight and spread mindfulness of energy saving though lighting options. This formal presentation acted as a preemptive sample for my more broad advertising of the coming change. Sometime before and after the installation, I plan to put of signs. One set will announce the arrival of the new lights, and the second will be a more permanent fixture to draw attention to the benefits of saving energy for the environment.

Outcomes

The immediate outcome of this project is obvious. The school will save electricity, reducing the demand for energy and in turn the harmful carbon emissions fossil fuels release. This contributes to the college's goal of climate neutrality, stipulated in President Tuajuanda Jordan's signing of the American College and University Presidents' Climate Commitment (ACUPCC.)[11] There will also be monetary savings resulting from the new technology, which can be used for future green projects, as well as education.

Beyond these relatively immediate outcomes, more subtle possibilities arise. With an incoming group of first year students who will experience the renovation of the lights first hand comes a new community with which sustainability holds a larger constituent in what it means to be a student of St. Mary's. This project also gives the school one more feather in its cap, so to speak. Prospective students will find a stronger sense of environmental literacy on our campus with each completed project. A strong eco-friendly infrastructure will encourage eco-minded students to apply. In this sense, sustainable projects function as a sort of positive feedback loop. Environmental conscientious individuals are drawn to the emerging sustainability projects. (this could be better achieved by reaching out to admissions, see Recommendations section below.) These students then enroll and design projects of their own. This in turn spreads the message of environmental stewardship, which again strengthens the community and brings in more interested members. The students who interact with such a community will then grow into ecological responsible graduates and continue this trend for the rest of their lives.

[11] "Text of the ACUPCC" Presidents' Climate Commitment, accessed April 7, 2015, http://www.presidentsclimatecommitment.org/about/commitment

Conclusions

A major part of the contemporary concept of sustainability is the balance between environment, economy, and society. A balance of these three values is exemplified in projects that are well thought out and benefit the community (including not just humans but also the ecological system) as a whole. To really make sustainability intriguing to a wide audience, to build momentum, it must have some sort of benefit for the people involved.

Analyzing the project with these goals in mind, several benefits stand out. This project offers a more simple lifestyle to the users (after all they will no longer need to turn the lights on or off,) making it an attractive change on just convenience alone. Along with this, it holds value in the financial world. The school will save money after the initial payback period, an example of a sound business investment. Thirdly, the environment, if not directly helped, will at least be harmed less by the reduction in energy use.

These goals stand as powerful incentives, but will only be reached with work and proper integration to the school community. One such concern is the initiation and completion of this project in relative invisibility. Without showing students that the change is being made, students will disregard lighting energy use just as they do now. The project must be used as a learning tool in order to effectively inspire change in the people and not just the building surrounding them. Although an individual project, an integral part of the completion of my goals will be encouraging ecological mindfulness in others.

I have outlined my process, beginning with the formulation of an idea, continuing through developmental research, and ending with the work to implement the project. In addition, I have reviewed sustainable literature, and explained where my project falls in this lineage of

progress. In the same vein, I had outlined several case studies of successful sustainable initiatives at other institutions which have served as inspiration for my own work.

Recommendations

Even when this project is completed, it does not mean the end of my work. This project has given me valuable experience in designing projects for a college campus. I have also built connections within the school's framework, which will ease future attempts. I intend to use this project to educate others and encourage others to make their own sustainable initiatives.

In the upcoming months, I will be researching the feasibility of replacing the Boyden Gallery's lights with a more sustainable option; such as LEDs. As a continuation of this lighting research, I have a good idea of what to expect in order to reach my goal. I understand the process of research, contacting professionals and concerned parties. By next semester, I will be working like I did this semester to secure funds for the Gallery lights.

To continue the project, it will be necessary for me to develop a means of advertising the change to incorporate residents into the process. This would be most easily manifested in the form of signs in the hallways of all the dormitories. In addition, the information of the change could be passed along to the admissions office so that tour guides could share this sustainable initiative with prospective students. It would also be beneficial to feature all the eco-friendly works on campus in the form of a document or website, so that community members, future students, and alumni could inform themselves of the changes.

For long term objectives, I have several recommendations. First is a campus wide upgrade to occupancy lighting. Certainly there are some places it would not be feasible. Matters of security, user acceptance, and productivity should not be forgotten. Still, all of the academic buildings could easily be retrofitted. This institutionalization could be achieved through an

administrative document; a procurement promise that when lighting systems need to be replaced, they will be replaced with sustainable lighting options. It could also be slowly phased in through similar community led tactics. If one was interested in pursuing such an end, my project overview outlines this process clearly.

Secondly, a policy commitment to purchasing sustainable light fixtures when needed would slowly phase in LEDs in place of the more toxic CFLs. Research would be required to avoid issues such as user discomfort or unnecessary waste seen in LED studies. A procurement plan like this would need to operate as a school guideline; any time a light burns out, it would be replaced with an advanced energy-saving bulb, avoiding the waste of still-functional CFLs. This could be voted by governing bodies as a campus wide initiative, especially if additional funds were secured.

Changes such as these are realistic futures for our school. It is not unheard of at other institutions. We are a community of leaders and our buildings should be the same; leaders in the field of sustainability. There is boundless opportunity for change. By moving forward on the front of sustainability, various groups, disciplines, and forces can be united to improve the world.

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