All of the Lights

April 26, 2013

Siemens Sustainable Campus Project

EDSGN 100 Section 020

Justice-Seeking Jeremick & His Crime Fighting Accomplices

Figure 1: Team Photo. From left: Jeremick Agudelo- design and prototyping, Katie Raudenbush- poster presentation, Emily Pringle- costing and energy collection data, Richie Whitehead-final project report

Penn State's residence halls house almost 30,000 students each year. From personal experience and strongly corroborated by surveys, residence halls waste large amounts of energy because lounge and bathroom lights are left on all the time every day and along with countless vampire appliances. Through a series of simple changes we have been able to significantly decrease the amount of wasted energy. The materials and installation for a motion sensor system in the lounges and bathrooms costs $11,025, have a payback time of 3 years and would save $3,658 a year in electricity. Removing microwaves from rooms and having 3 community microwaves per floor does not cost anything and saves $1,819 per year. The combination of these results, previously calculated for Pollock Residence Halls, projected for all Penn State halls would save $27,375 and 404,480 kWH a year.

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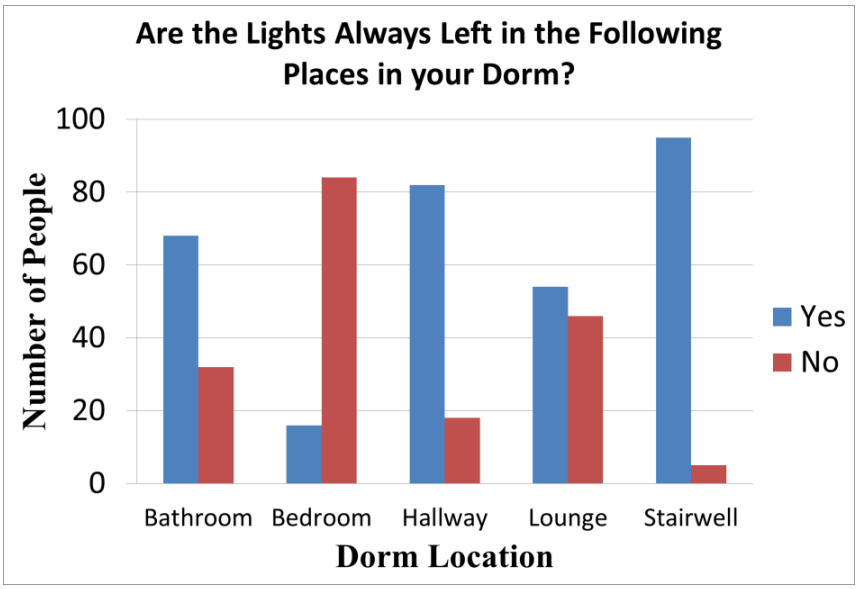
Introduction

Penn State's University Park campus is one of the largest college campuses in the United State with over 46,000 students. About 63% of the student body, or slightly less than 30,000 students, live on campus in the resident halls. Despite providing lodging for such a large population, efficiency and conservation are not goals that have been seriously considered. The 24-hour lighting in a majority of the residence halls along with the vast number of vampire appliances, appliances that use energy even when turned off, combine to waste significant amounts of energy across campus. This unnecessary waste of energy strongly contradicts what our group and Siemens hope to achieve with campus housing; sustainability. After careful consideration of what it means, our group was able to define sustainability as economically reducing negative human effects on the environment so that the current and future generations can continue to thrive and enjoy their cultural values. Therefore in order to achieve this goal, our group started looking for ways that we could save energy in Penn State's residence halls.

We knew that one of our major areas of interest would be cutting down the electricity used for lighting in public places. To ensure that this was indeed a problem, as well as what locations had the greatest need for cutting down on lighting, we took a survey of a hundred random Penn State students who are currently living in the dorms. The results, shown in Figure 2, indicate that indeed in the majority of dorms the lights are constantly left on in multiple locations, specifically the stairwells, hallways, and bathrooms.

Figure 2: Survey Results



Our second area of interest for saving electricity was developing a solution to the constant-energy using vampire appliances. Again before diving into brainstorming, we wanted to make sure that there was enough room to save energy so our effort would not be wasted. We used a Watt meter to measure the amount of electricity that different appliances used when they were "off" or

not in use. The microwaves in the dorms use 3.6 Watts and the refrigerators used 550 Watts. The refrigerators were clearly an area to investigate and while the microwaves might seem as if they do not use a lot of energy, the large number of them on campus add up to use a significant amount of energy consumption.

Concept Development

After learning that residence hall lighting and vampire appliances were areas in which we could make improvements we began brainstorming. In order to save energy by cutting back on lighting we initially considered decreasing the total amount of lights in the public spaces, such as stairwells where sunlight could be used during the day. Then during the night a timer could turn on the lights. However, we learned that these public spaces needed to have a certain level of lighting for safety reasons and we did not think the difference in levels of lighting would save enough energy to be worth the effort. The next idea we had for dealing with the hallway lighting was to reduce the current amount of lighting. Our thoughts were to simply only have one light on for every 3 light fixtures. This again brought up the issue of safety. Our following idea for cutting down on lighting is to put them on a motion sensor system. Installation of motion sensors in places such as the bathrooms and study lounges would allow the lights to be turned off automatically when no one has been in the area for a certain amount of time. This system would directly address the unnecessary lighting during the late evening and early morning hours when students are asleep as well as any other time the spaces are not in use.

In dealing with the vampire appliances we wanted to develop a system that would cut power to certain outlets during the night time or when they were not in use. The first idea was to create a power supply system that would cut power to certain outlets every third hour or so. After discussion we concluded that this would anger students as well as potentially disrupt their schedules such as turning off alarm clocks or computer charging.

For our second idea, we wanted to rewire parts of the dorm rooms so that students would have a light switch they could control to cut off power to certain outlets when they were not using the appliances plugged into them. This way, students could cut off electricity to items not in use, like phone chargers, lamps, printers, etc, and still have another outlet to use. We emailed Clark Colborn, a Facilities Administration Officer in Penn State's College of Engineering, about how much this project would cost. He estimated that materials along with installation could cost

anywhere from $1,000 to up to $2,500 per room. Due to such expensive initial costs and not enough energy and money saved due to the product we had to rule this idea out.

With the first two ideas not working out, we thought about combining the motion sensory capabilities of our solution to the lighting problem with turning off outlets. We searched the internet and discovered a power strip that was on a motion sensor system and turned off certain outlets when it was inactive.

The final idea we had during the initial brainstorming was dealing with the energy used by the microwaves and refrigerators in each dorm room. These two appliances require lots of energy even though they are just comforts and not completely necessitates. We decided that if we were to remove microwaves and refrigerator units from the dorm room and replace them with community units in a common room we would be able to save a huge amount of energy at no to very little initial cost.

When transitioning from brainstorming to more in-depth prototype development, we used an AHP matrix to weight different product characteristics against one another and determine which were the most important. Our AHP matrix, Table 1, shows how we ranked the product characteristics against each other and ranks them in terms of importance based on the their weight, the far right column. The matrix showed us that our top two characteristics were safety and user acceptance, which we kept in mind moving forward.

Table 1: AHP Matrix

	Upfront Costs	Amount Saved per Year ($)	Efficiency (Wattage Saved)	Safety	User Acceptance	Difficulty of Installation	Total	Weight
Upfront Costs	x	0.5	0.5	0.25	0.75	4	6	0.11
Amount Saved per Year ($)	2	x	1	0.167	0.5	5	8.67	0.15
Efficiency (Wattage Saved)	2	1	x	0.5	0.25	4	7.75	0.14
Safety	4	6	2	x	3	7	22	0.39
User Acceptance	1.33	2	4	0.33	x	3	10.7	0.19
Difficulty of Installation	0.25	0.2	0.25	0.14	0.33	x	1.17	0.02
							56.3	

Detailed Concept Development

For our final solution we decided to install motion sensors into the bathrooms and lounges and to remove the microwaves from the individual rooms. The motion sensors in these two areas did not create any safety concerns. For this reason we decided not to focus on the lighting in the hallways and stairwells. When looking at the vampire appliances, our team liked the idea of giving each student in the dorm a motion sensor outlet. However, we did not pursue this idea further because we were not able to quantify any of the data. Penn State does not track how electricity is being used in the dorms. It just tracks the amount used per hall. Therefore our team could not figure out how much electricity is used from the outlets. Also, the amount of energy that is consumed from the outlets significantly varies from person to person. So because of those reasons, our team chose to pursue looking at microwaves as a vampire appliance. We also chose to only look at the dorms in the Pollock area. This made collecting and tabulating our data much easier. We then used that data to expand it to all of the residence halls.

The first solution that we actively pursued was to install motion sensors into the bathrooms and lounges in the resident halls. We found these were our best options because they were relatively cost effective and would be widely accepted by the students. These would be accepted by students because they would not need to change their behaviors. By installing motion sensors we were finding a way to make sure the lights would be turned off when no one was in the room. As previously stated in our surveys, the majority of bathroom lights are left on all the time as well as the lounges. As a team we knew that we wanted to put motion sensors into the bathrooms and lounges but had to do extensive research to decide on an appropriate model. This was done on the internet. We first looked at motion sensors that replaced the current light switches. These types of sensors were the most cost effective out of all of our options. However, upon further research this type of sensor would not work for our situation. The current light switches are in locations that would not detect motion when entering through the door. They would not be able to detect the motion from people who are using the showers. For those reasons, we decided to move our search to ceiling mounts. The ceiling mounts would be able to recognize a greater range of motion. There are two types of ceiling mount sensors; wired or wireless. As a team we wanted to install battery powered sensors. These require about 15 minutes each to install and the battery is said to have a 10 year lifespan. With a ceiling mount, only one sensor would be needed per bathroom or lounge. This cuts down on some of the costs because if we were to use a light switch sensor multiple would be

needed per room. The labor costs are also reduced by using wireless sensors with less installation time. The sensor that we thought would be best for these locations is the Lutron Radio Powr Savr Wireless Ceiling-Mounted Sensor. This sensor has a 360° view and with new technology can see the slightest motion. It has a timer that will shut the lights off after a period of 15 minutes without any motion. This time can be decreased if desired[1].

When looking at the cost, energy savings, and cost savings, the motion sensors for lights would be effective in Penn State dorms. Table 2 shows the totals for how many sensors are needed and the cost for that many sensors. With materials, labor, general and administration the initial investment into the light motion sensors for the entire Pollock Residence Halls would be $11,025. The sensors were assumed to be completely off at least 6 hours.

Table 2: Cost for Pollock Sensors

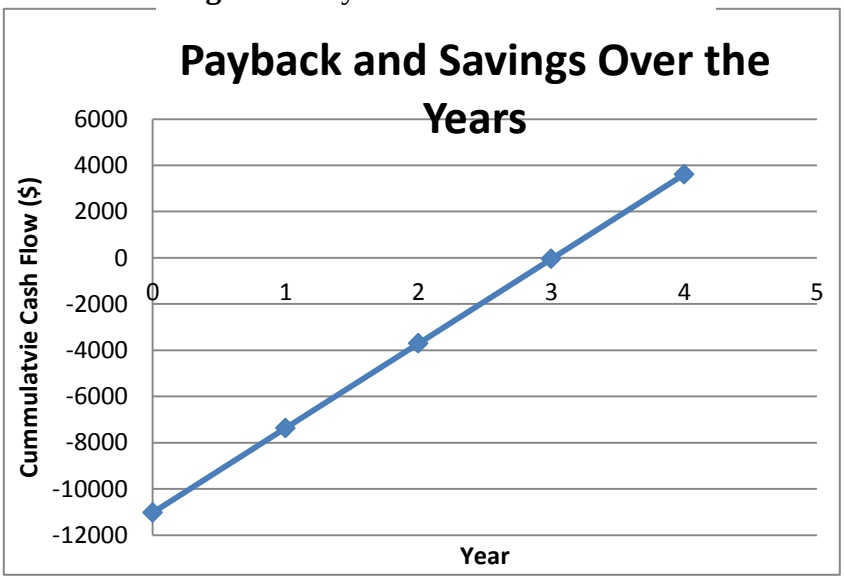
Total Sensors For Pollock	Total Cost For Sensors For Pollock
125	$5,250

Table 3: Light Motion Sensors for Bathrooms and Lounges

	Without Sensors	With Sensors	Savings	Percent Savings
Energy (kWH)	216,127	162,095	**54,032**	25%
Cost	$14,632	$10,974	**$3,658**	25%

It was also assumed that Penn State pays $.0677 per kWH[2].Being off for this amount of time saves Penn State money and reduces the amount of kilowatt hours used. This data can be seen in Table 3. The payback for the light sensors is 3.01 years. A graph showing the payback period can be seen in Figure 3. Along with looking at installing light motion sensors, we also looked the microwaves in individual dorm rooms.

Figure 3: Payback of Motion Sensors



After reviewing our initial idea for having community refrigerators, we realized that people might not feel comfortable storing food in such a location and left the food vulnerable to contamination and robbery. Having a few community microwaves seemed it

acceptable and realistic. This idea was proposed by observance that some people do not use their microwaves frequently. Also some team members noted that at other colleges microwaves are not provided to individual dorm rooms but offer shared microwaves for everyone on the floor. This made us investigate how much energy was being used from microwaves. When not in use, but still plugged in, a microwave will draw 3 Watts at any given time. Our solution to this is to remove all the microwaves from all dorms rooms. Instead there would be 3 shared microwaves for the entire floor.

Pollock has small study lounges on each floor that would be a perfect location for microwaves to be housed. Table 4 shows the data we found comparing the cost and energy savings for having a microwave in every room and with 3 per floor. This solution has instant savings because there are no materials that need to be purchased.

Table 4: Microwaves in Pollock

	With All Microwaves	**With 3 Microwaves Per Floor**	**Savings**	**Percent savings**
Energy (kWH)	31,098	4,234	**26,864**	86%
Cost ($)	$2,105.33	$286.64	**$1,818.69**	86%

As a team we also wanted to make sure that the Penn State students were aware of how much energy they are using. We found that people did not know how much they were using or did not care about their energy consumption. As a team we think Penn State should implement a campus wide presencing initiative. It was discovered that East Halls currently has a campaign to urge its residents to save energy. We want to take this idea and scale it up to all of the residence halls. However we want to make this an entire school year campaign, unlike East's current campaign that runs only a short amount of time. Our idea is to create a competition between all the halls in each living area. In each commons we would place a scoreboard to keep track of how much energy each hall is using. We are placing this in the commons because this is an area everyone in the residence hall community would see. The competition would take place over the entire semester. The hall from each residence community would win a Penn State prize. The ideas we were thinking about as a team were meetings with Penn State coaches and notable athletes. We

hope that with this presencing initiative, the Penn State students will learn to watch the amount of electricity they consume.

Conclusion

Our team created and developed two straight-forward, yet highly effective solutions that will save Penn State energy and money and help put it on the path to becoming a sustainable campus. The first project, installing a motion sensor system to control lighting in the bathrooms and lounges, directly addresses the waste of energy that happens with constant lighting in these locations. With this system the lights will be automatically shut off during times of inactivity, most likely during night and early morning, but also any other time of when not in use. This solution will save $3,658 and 54,032 kWH a year and pay for itself in slightly over 3 years.

The second project is a big step in beginning to solve the problem of vampire appliances, appliances that are left plugged in and drain energy even though not in use. Due to the fact, that many students use their personal microwaves very infrequently we came up with a solution that removes microwaves from dorms and replaces them with a few per floor. This simple solution has no initial costs and $1,819 and 26,864 kWH per year.

To ensure accuracy, savings for these solutions were only calculated for if they were applied to the Pollock Residential Halls, one of five residential hall groups. If both these changes were enacted across the whole campus, assuming that Pollock dorms are the median size of all hall groups, they could save the university up to $27,385 and 404,480 kWH a year.

Besides the potential to save so much money and energy, the best part of our changes is that they are simple and effective enough that Penn State could easily make them within a year. Provided that they take a larger student survey, to verify the low usage of microwaves, and have an official cost analysis, we strongly believe that Penn State would adopt the community microwaves plan. The fact that it could save so much energy with no initial costs makes it very appealing. We also believe that there is a significant chance that Penn State would implement the motion sensor system plan to cut down on energy wasted in lighting. This change does require an initial investment, but it has a fairly quick payback time of three years and afterwards continuously saves money and energy.

The majority of Penn State’s dorms have fairly old infrastructure, which makes installing new technology or systems difficult and expensive. Our two ideas might not be as drastic or save

quite as much energy as other products, but are very simple to implement. Also our solutions are inexpensive and have a very quick payback time and afterward have pure profit.

One of the major lessons that our team learned from this project was how important and complicated costing can be. Determining an accurate cost of installation, that includes labor, materials, and administration, can require substantial online research, contact with experienced individuals, and calculations. Also the initial cost of a project and its payback time can play a huge role in determining if the prospective organization will consider or reject the idea.

Another lesson we learned with this project was importance of considering how well the users will accept the new technology or change. The majority of our ideas to create a sustainable campus were ones that would directly affect the students and faculty. Certain ideas that would upset or bother these recipients too strongly had to be disposed of or at least altered to change the negative effects. Considering the users was especially important when developing a form of prescencing that would encourage student to save energy and live more sustainably. Only solutions that busy college student would truly accept and be enthusiastic about could be considered.

The final thing our group learned from the Siemens' sustainability project was the ability for small changes to make a cumulative difference. Going into the project, our group had the impression that our goal was to make a major, innovative product that could significantly lower energy usage and save money. After identifying cost and the old infrastructure of the dorms as real constraints, we began to solemnly accept smaller changes as what we were to work on. However, upon completion of calculating the payback time and the energy our changes would save, we saw that while the changes might be minor they were simple solutions that could be easily implemented and have immediate effects.

References

[1]"Lutron Radio Powr Savr™ Wireless Occupancy Sensor Overview." *Lutron Radio Powr Savr™ Wireless Occupancy Sensor Overview*. N.p., n.d. Web. 22 Apr. 2013. <http://www.lutron.com/en-US/Products/Pages/Sensors/Occupancy-Vacancy/WirelessRadioPowrSavr/Overview.aspx>.

[2]*Utility Fact Sheet University Park Campus*. N.p.: Penn State Office of Physical Plant, n.d. PDF.

Appendix A- Energy Calculations

Table 5: Total Electricity usage for Pollock Residence Halls

Campus	Facility	Commodity	Unit	Totals
University Park	BEAVER HALL	Electricity	kWh	638,877.00
University Park	HARTRANFT HALL	Electricity	kWh	253,818.00
University Park	HIESTER HALL	Electricity	kWh	269,442.00
University Park	MIFFLIN HALL	Electricity	kWh	245,066.00
University Park	PORTER HALL	Electricity	kWh	291,255.00
University Park	RITNER HALL	Electricity	kWh	313,720.00
University Park	SHULZE HALL	Electricity	kWh	340,296.00
University Park	SHUNK HALL	Electricity	kWh	215,565.00
University Park	WOLF HALL	Electricity	kWh	276,371.00
				2,844,410.00

Appendix B – Costing Calculations

Table 6: Information on the Pollock Residences Halls

Building	Number of Floors	Number of Bathrooms	Number of Lounges	Total Switches for Building	Total Cost for Switch Per Building	Total Lights in Bathrooms and Lounges
Beaver	9	16	9	26	1092	264
Ritner	8	7	8	15	630	116
Hartranft	7	6	7	13	546	100
Shulze	8	7	8	15	630	116
Hiester	8	7	8	15	630	116
Shunk	7	6	7	13	546	100
Wolf	7	6	7	13	546	100
Porter	8	7	8	15	630	116
Final Totals				125	5250	1028

Table 7: Energy and Savings Information for Pollock Halls with and without the sensors for Pollock Area

Building	Total kW Per Day without sensor	Total kW per year without sensor	Total Cost without sensor	Total KW per day with sensor	Total KW per year with sensor	Total Cost per year with sensor
Beaver	152.064	55503.36	3757.577472	114.048	41627.52	2818.183104
Ritner	66.816	24387.84	1651.056768	50.112	18290.88	1238.292576
Hartranft	57.6	21024	1423.3248	43.2	15768	1067.4936
Shulze	66.816	24387.84	1651.056768	50.112	18290.88	1238.292576
Hiester	66.816	24387.84	1651.056768	50.112	18290.88	1238.292576
Shunk	57.6	21024	1423.3248	43.2	15768	1067.4936
Wolf	57.6	21024	1423.3248	43.2	15768	1067.4936
Porter	66.816	24387.84	1651.056768	50.112	18290.88	1238.292576
Final Totals	592.128	216126.72	14631.77894	444.096	162095.04	10973.83421

Table 8: Microwave Information for Pollock Halls

Building	Number of Floors	Number of Microwaves	Total KW Per day for all microwaves	Total KW Per Year for all microwaves	Total Cost Per Year for all microwaves	Total KW per day 3 per floor	Total KW per year with 3 per floor	Total Cost with 3 per floor ($)
Beaver	9	264	19	6935	469.4995	1.7	620.5	42.00785
Ritner	8	140	10.1	3686.5	249.57605	1.5	547.5	37.06575
Hartranft	7	120	8.6	3139	212.5103	1.3	474.5	32.12365
Shulze	8	140	10.1	3686.5	249.57605	1.5	547.5	37.06575
Hiester	8	140	10.1	3686.5	249.57605	1.5	547.5	37.06575
Shunk	7	120	8.6	3139	212.5103	1.3	474.5	32.12365
Wolf	7	120	8.6	3139	212.5103	1.3	474.5	32.12365
Porter	8	140	10.1	3686.5	249.57605	1.5	547.5	37.06575