MAKING EAST COMMONS MORE SUSTAINABLE

Sponsored by Siemens

TEAM NAME: THE LIGHTNING BOLTS

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Summary Statement:

The East Halls Commons currently uses almost 300,000 kWh of electricity per year on lighting alone and almost as much on heating as well. Our plan involves two simple changes that will lower energy consumption by 80%. To accomplish this goal, Penn State should replace the current light bulbs with LED lights and install dimmer switches. These two changes would cost $13,700 with a payback period of 0.42 years, saving Penn State $33,600 per year. The second change involves installing Solar Drapes in the dining hall, reducing 12,300 kWh of heat per year, with a savings of $1,600 per year. Solar Drapes have an upfront cost of $6, 700 and a payback period of 5.3 years.

Assignment to project deliverables:

Dan Deegan: Costing, **Aesha Kewalramani**: Final report, **Sarah Wood**: Presentation/Poster

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Introduction:

Problem Statement:

The energy efficiency of East Commons is low because of excessive and unnecessary use of lighting and lack of sustainable use of energy.

What is Sustainability?

The act of being environmentally responsible by making sure our non-renewable natural resources last longer and meet the needs of future generations as well.

http://www.pxd.com/images/values-content/sustainable2.png?sfvrsn=0

Early stages of project focus:

Every member in our team is a freshman and as we have lived in the East Halls for an entire year, we decided to make our project focus the East Commons and work to make it more sustainable in terms of its energy efficiency.

We started off by looking around the commons and noticing the details. Our initial ideas consisted of motion sensors, more efficient light bulbs, windows and doors, solar panels and switching the computer and television off.

We later had to reject most of our initial ideas because of the following reasons:

- There is never a time when the commons is entirely empty and therefore motion sensors will not be of much use as someone is always walking around.
- We were unable to find a good location to install the large number of solar panels that would be needed for the commons. As according to the PowerPoint of PSU energy use,

we have 80 acres of roof in U-park where as we would need 503 acres to generate power with PV. Also, the installation cost was very high.

- The computers in the commons are kept on hibernate and never turned off. We initially thought that turning them off would save energy but we were wrong as there as our later research proved that keeping the computers on hibernate doesn't consume as much energy and it is more efficient.

Our final design ideas were light dimmer, LED lights and solar heating drapes.

Concept Development:

AHP matrix:

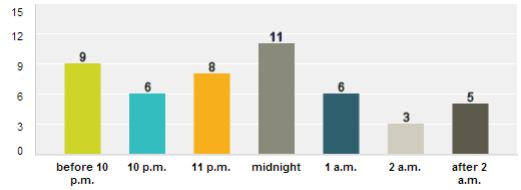
	Ease of installation	Safety	Aesthetic appeal	Energy efficiency	Payback time	Initial cost	Durability	Total	% Weight
Ease of installation	1	0.5	1.5	0.2	0.2	0.3	0.4	4.2	5.2
Safety	2	1	1.2	0.4	0.4	0.5	0.6	6.1	7.5
Aesthetic appeal	0.67	0.83	1	0.1	0.2	0.2	0.3	3.3	1.2
Energy efficiency	5	2.5	10	1	1.2	1.4	1.6	22.7	28.1
Payback time	5	2.5	5	0.83	1	1.2	1.5	17.03	21
Initial cost	3.33	2	5	3.57	0.83	1	1.1	16.83	20.8
Durability	2.5	1.67	3.33	0.625	0.67	0.9	1	10.7	13.2
							Total =	80.86	

Our AHP matrix gave the most weightage to energy efficiency and payback time. The least weightage was given to aesthetic appeal and ease of installation. This helped us decide on finalize our design ideas as most importance was given to energy efficiency and payback time.

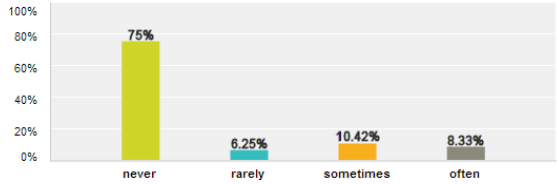
Surveys:

We conducted a survey for the students living in east who spend time daily in the commons and we got 50 responses. The survey and its responses were as follows:

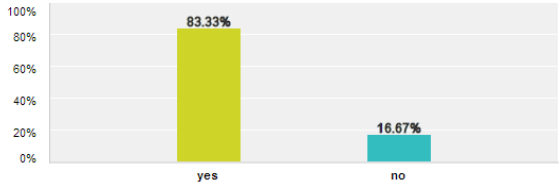
When is the latest that you are in East Commons on an average night?



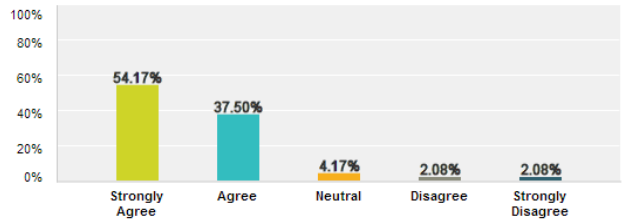
Do you ever turn off the lights in the East Commons' restroom?



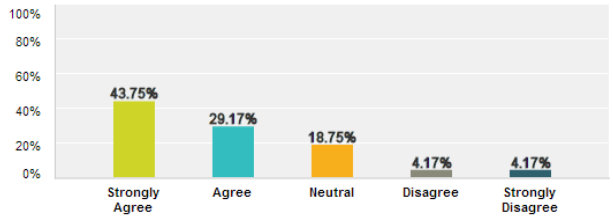
Would you be in favor of dimming the lights in East Commons during the day to save energy? (not including study rooms).



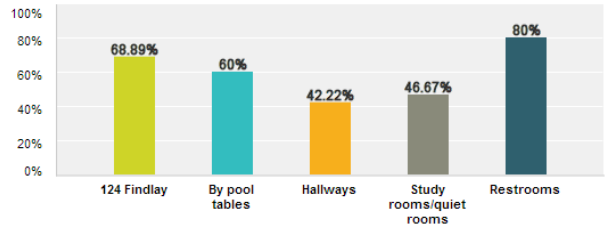
Using solar panels (renewable energy source) for energy use in the commons. Agree or Disagree?



Using motion sensors in the commons to conserve energy:



If you agreed to the previous question, what locations should the motion sensors be placed at? (select all that apply)



The surveys made us realize that students are using the commons 24/7, therefore motion sensors isn't a feasible idea. We also found out that most students are in favor of using light dimmers and using solar energy to make the commons more sustainable.

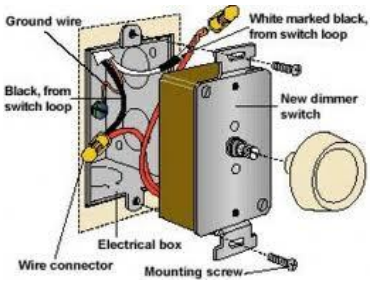
Detailed Concept Developments:

Final design approach:

Our final design approach consisted of 3 designs which were both cost and energy efficient: Light dimmers, LED lights and solar heating drapes.

1. **Light dimmers:** Dimmers are devices used to vary the brightness of a light. They decrease energy consumption and increase the lifespan of the light. They can be easily installed with current lights.

   Dimmers:



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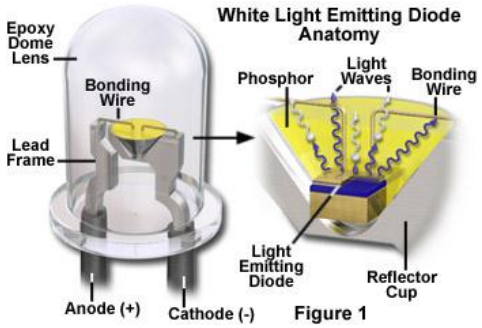
https://encrypted-tbn3.gstatic.com/images?q=tbn:ANd9GcRWbpfzfTHx-r2Nn17ExeK4zVGJNMa7lm8nXddTNtq1E3QOXGyl

2. **<u>LED lights:</u>** LEDs are small solid bulbs which are much more energy efficient than CFL and incandescent bulbs. They have a very short payback time and last 42 times longer than currently installed light bulbs.

   LED bulbs



http://micro.magnet.fsu.edu/primer/java/leds/basicoperation/ledfigure1.jpg

The proposed FEIT Warm White LED light bulb:

https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcSNsYiOHtp3gi3FEyeYQ94qBs9Qi-1OaLLHMZNrwEDK-AclRsxA3w

3. **<u>Solar heating drapes:</u>** Solar heating drapes turn sunlit windows into giant solar radiators. The drapes heat the glass and fabric well above the ambient room temperature, therefore, heat can't escape out the windows and they both become perfect thermal barriers to help keep room temperatures warmer. Hot always travels to cold, so the radiant heat inside the room is absorbed by cooler walls, the floor and furniture, and is

stored for release back into the room when the temperatures drops.

http://www.baliblinds.com/BaliBlindsImages/ProductImages/SolarShade2_Open.jpg

Costing:

	LED Light Bulbs	LED Dimmer Switches	Solar Drapes	Totals
Number of Material Needed	550	6	77	
Cost per Unit of Material ($)	20	30	87.5	
Total Cost of Material ($)	11,000	180	6,737.00	17,917
Cost of Labor ($)	240	225	360	825
G&A Cost ($)	2248	81	1,419	3,748
Total Initial Cost ($)	13,488	486	8,517	22,491
Total kWh saved (per year)	241,228	13,267	12,346	266,841
Total Energy Savings $ (per year)	31,842	1,751	1,629	35,223
Payback Period (years)	0.42	0.27	5.26	

All energy savings were based off the average cost for electricity in PA, $0.132 per KWh. The dimmers would be set to 80% of the maximum light from 8 AM to 2 AM, and at 50% from 2 AM to 8 AM, which, based off our survey, is when we determined barely anybody is in the East Commons. The solar drapes would only be used 8 months out of the year. During the summer,

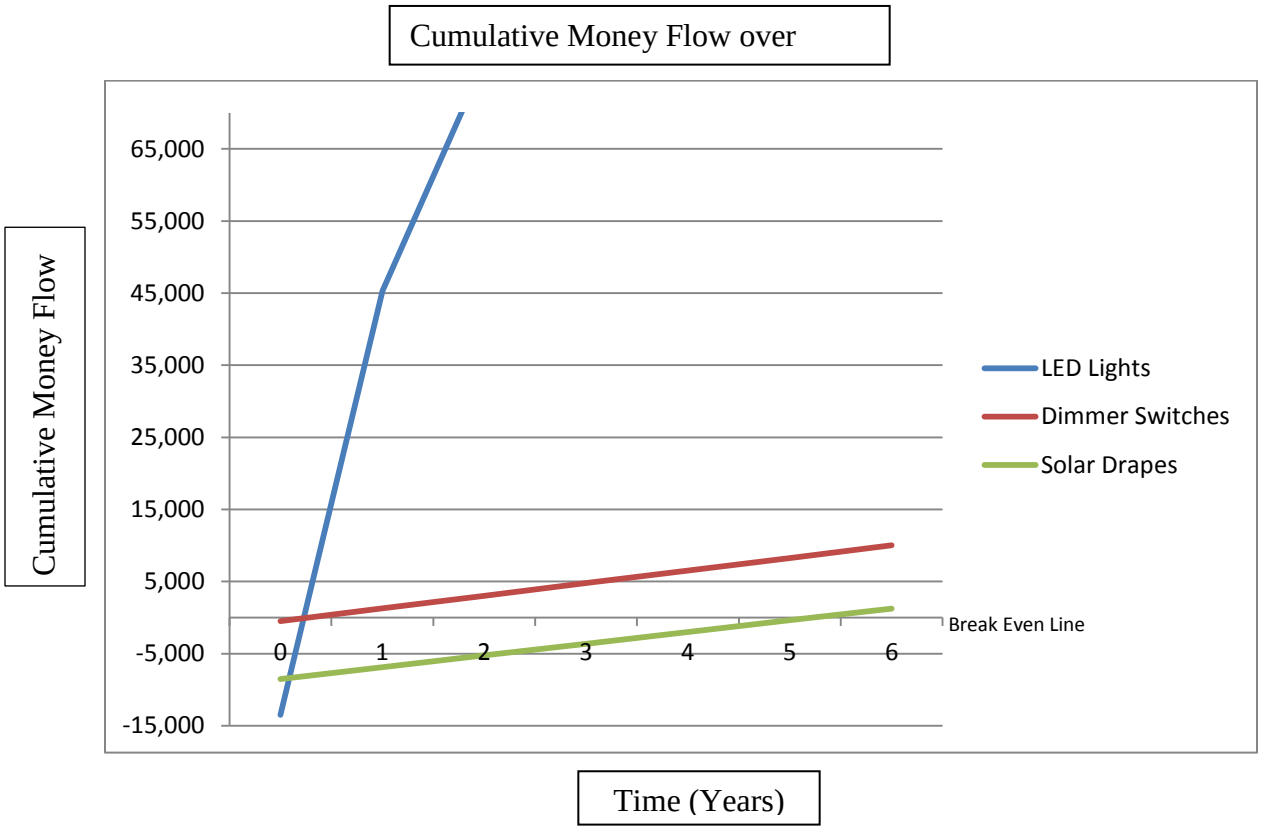
they can either be kept up to block the sunlight or be removed and kept it storage. They work like regular drapes so removing and reinstalling them is very easy and no labor cost is associated with it.

*For detailed costing, look under number 7 in appendix.

Location:

The LED lights will replace the regular lights with the regular bulbs being recycled. The dimmers will be located in the three stairwells, and in the hallways which will cover all the places in the commons except the study halls, offices, dining halls and the computer lab. The solar drapes will be attached to all the windows in the dining commons (77 in number).

Graphic showing of time breaking even the initial upfront investment:



Conclusion:

Designs positive features:

Dimmers

- Save energy proportional to the percentage they were dimmed
    - Ex: Dimming by 20% saved about 20% electricity
- Increase life of bulb equal to dimming percentage
    - Ex: Dimming by 20% over life of bulb would make it last 20% longer
- Have 99% efficiency (only 1% of energy used produces heat)
- Will last forever barring any electrical damage that is caused by outside forces

FEIT Warm White LED Light Bulbs

- Save nearly 80% on electricity usage compared to typical incandescent bulbs
- Last 50,000 hours (5.7 years)
- One bulb lasts as long as 42 incandescent bulbs
- Uses 13.5 Watts compared to 60 Watts for incandescent bulbs
- Produces 800 Lumens of light
- Produce 90% less heat than incandescent bulbs
- Are becoming cheaper

Solar Heating Drapes

- UV resistant
- 100% Safe
- Odorless
- Easy to use
- See through
- Heat is non-toxic
- Easy to install and use
- Can be easily cut to fit smaller windows with just scissors

Would our design solution be adopted by Penn State?

Yes. We think that Penn State would like to adopt our design solution because of the following reasons:

- All 3 design solutions of ours are easy to install, have a very low upfront cost and reasonable payback time.
- It contributes to make Penn State a more marketable campus as it becomes a role model for a sustainable campus.
- East, which is the first place all the freshman students come to will become a more attractive place to live in.
- If our design solution was implemented in East commons alone, it would save Penn State over $35,000/year. The amount of money and energy saved by the University, if implemented on all the commons on campus as well as other buildings, would be remarkable.

What were the main lessons the team learned from this project?

- We learned about sustainability, its meaning and importance and how little changes made in our routine lives could help make our campus more sustainable.
- We learned about the various aspects that we need to look at to come up with a sustainable solution for our project like payback time and so on.
- We learned to work in a team and the importance of communicating and sharing of ideas within the team.
- This project helped us think like engineers and come up with efficient solutions which will be beneficial to both the company implementing the solution as well as he environment.
- This not only was exercise for what we might be doing in the future, but also gave us a chance to think green and try our best to make Penn State a better place to live in, which made this project much more important.

References and Appendix:

1. http://www.ledlightingexplained.com/led-lighting-myths/
2. http://greenliving.nationalgeographic.com/dimmer-switches-energy-efficiency-2245.html
3. http://www.lutron.com/en-US/Education-Training/Pages/LCE/DimmingBasics.aspx
4. http://eartheasy.com/live_energyeff_lighting.htm
5. http://www.thefreedictionary.com/dimmer
6. http://www.betterearthproducts.com/solar-heating-drapes.html

7. Detailed Costing: Determining the costing and savings was a very complicated process so we decided to go into more detail for those interested.

   LED Light Bulbs: Over the lifespan of one FEIT Warm White LED light bulb (50,000 hours or 5.7 years), only 500 kWh of electricity was consumed. Comparing this to 3,000 kWh used by the current incandescent bulbs used and 2,500 kWh of electricity is saved over the lifetime of one LED bulb. To get the yearly electricity savings per bulb, 2,500 kWh was divided by 5.7 years to get an average of 439 kWh saved per bulb per year. Multiplying this by the 550 bulbs we counted in East Commons and the total electricity saved per year is 241,228 kWh. Multiplying this by the average cost of electricity in PA - $0.132 per kWh – and the average yearly savings by switching to the FEIT Warm White LED light bulb for East Commons would be $31,842!

   Dimmer Switches: We conducted a survey to determine when people were most often in East Commons. The results showed that a relatively equal amount of people were there between 8 AM and 2 AM. Between 2 AM and 8 AM (6 hours) almost nobody reported ever being in building. This led us to decide to dim the proposed dimmers to 50% during that time. This was still above the safety requirement of 40 Lux. We also decided to have the bulbs dimmed to 80% during 8 AM to 2AM (18 hours), because there are plenty of windows that bring in natural light into East Commons. So to get the energy savings per day, we multiplied (500 kWh electricity over lifespan) (50% energy used)*(25% of day)

+ (500 kWh electricity over lifespan)(80% energy used)*(75% of day) = 362.5 kWh of energy used over 5.7 year lifespan for one light bulb. Subtracting this from 500 gives 137.5 which is the kWh of electricity saved over 5.7 years, which equates to 24.12 kWh saved per year per bulb. Multiplying this by the 550 bulbs in our plan and the total average energy savings is 13,267 kWh per year. This results in a savings of $1,751 per year!

Solar Drapes: Each solar drape can produce enough heat per day that would equal the heat output produced by 0.44 kWh of electricity from a heater. Multiplying the 0.44 kWh saved per drape, per day by the total number of drapes (77) equals a savings of 33.82 kWh of electricity per day. Since we only plan on using the drapes 8 months a year (or 75% of the year) because the heat is not needed in the summer, the total yearly energy savings is 12,346 kWh, which saves $1,629 per year.

http://image1.masterfile.com/em_w/03/17/39/860-03173928w.jpg