T-REKS

- Liz Merlino
- Stephen McKenzie
- Raj Desai
- Kawther Al Jashmi

Edesign 100

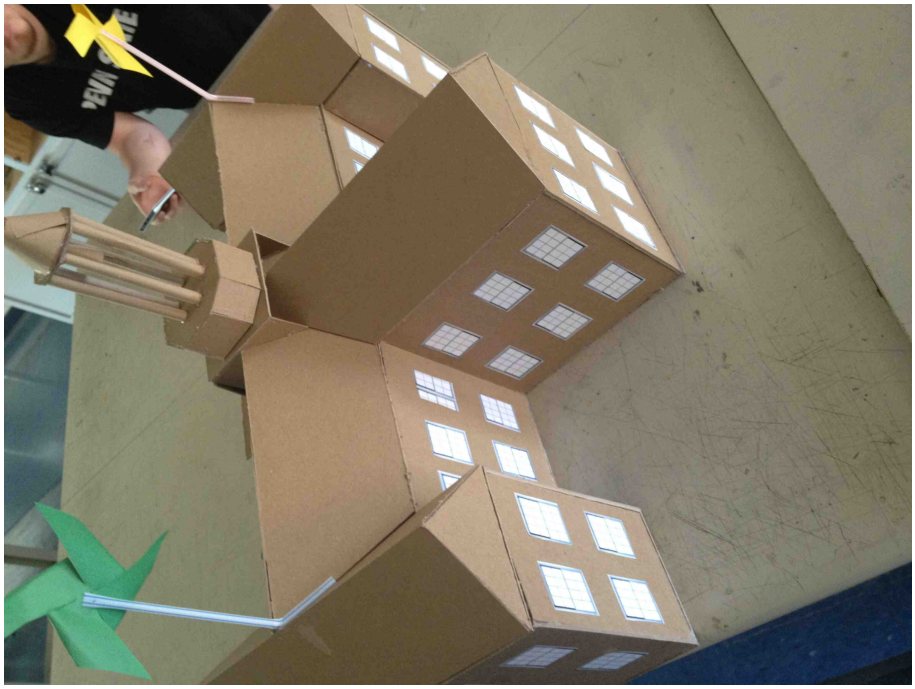
Siemens Sustainability Project

Student Survey Analysis

- Are we going to run out of fuel?
  - 30 out of 32 people said that we will run out of fuel.
- Is sustainability relevant or just talk?
  - Everyone agreed that sustainability is relevant.
- How can we be sustainable?
  - The majority of people said to recycle and to reuse products in addition to reducing your personal electricity use. Other stated that using energy efficient cars, reducing waste, and using public forms of transportation will also help sustainability.
- What do you do towards sustainability? Save/produce energy, recycle, less trash, charity ...
  - A majority of people admitted to not doing much to help sustainability. However, many people said they try to conserve water, maintain their personal electricity use, as well as recycle when convenient.
- What (if any) life style change(s) would you make to help this cause?
  - Most people agreed they would recycle, conserve water, conserve electricity, and all over try to use less energy.
- Do you think it is necessary to make any changes or things are fine the way they are?

- Everyone agreed that it is necessary to make changes starting with their own personal impact and advancing it to a larger scale.

Old Main Models:



Design Process:

- Define Problem – Redesigning a PSU landmark to become sustainable while staying conservative to its historical value
- Collect Information – Energy Usage of the building as well as full, detailed blueprints of its design
- Brainstorm and Develop Solutions – Solar vs. Geothermal, New Physical appearance? Wind Energy, internal layout improvements vs. overhaul?
- Receive Feedback – Student Survey responses, peer/student & professional advice and opinions
- Improve Design/Implement – Work together to find best solution

<u>Need For Green:</u>

It is evident that for the initial questions regarding our fuel supply and the immediate relevance of being sustainable that the people are in accordance. We have realized that there is a serious problem that we ourselves have generated through decades of indifference to our environmental impact. In 2009, the EPA showed that "the amount of trash sent to landfills nationwide averaged nearly three pounds daily, per person, in contrast to about one and one-half pounds of materials recycled." All together, people realize the importance of sustainability and are starting to implement small ways in which to conserve energy into their daily lives. However, we need to continue to stress the significance of energy conservation in order to implement these small changes on a larger scale.

It seems as though since we were children, the concept of being "green" was still thrown around and people would say that they wanted the best for the environment, but when it came down to making sustainable choices, we found it easier to stick with our old ways. The blue recycling bin is no new innovation, but it needs help to actually get people to use them. We believe that positive incentives are the way to do this, the sad fact is that most people won't respond to changing their daily routines and decisions unless they see a more direct, personal gain from doing so. Let's say we put a trash and recycling station – old main already has them, but in the hallways instead of the rooms - (trash/paper/plastic…) in the corner of every room and above it we can put a Penn State® (branded, to raise good publicity) poster with two objectives. The first would be the direct incentive, for example, "Monetary Prizes for top five recycling rooms, Let's Make PSU Green!" The second could be more of a psychological incentive, for example, "For every ton of paper recycled, we save almost 20 trees and 7,000 gallons of water…With all the metals recycled last year, the EPA reports that we effectively eliminated over 25 *million* metric tons of greenhouse gas emissions…Most metals can be recycled into good shape with 5% of the energy it would take to do the same with raw materials

of the same metal!" It doesn't have to stop with recycling either, a school with the resources that PSU has is able to reach out to its students in many ways, we can hold fundraisers, advertise on the PSU channel and even have some sort of giveaway to an innovative, "green" idea from a student every month and in doing so, we can make PSU a regularly sustainable campus.

Customer Needs Analysis

The goal of our latest project is to rebuild, reconstruct, or completely remake a building on Penn State that is 100% self-sustainable. We chose Penn State's Old Main for many reasons. Old Main has a history at Penn State and we felt it deserves the attention of the public since the building is a landmark among the buildings. It is also located centrally in PSU and the location provides excellent wind for windmills and a large yard in front to use for geothermal heating.

Customer Needs

- Heating
- Water
- Electricity
- Sewage
- Recycling
- Latest Technology

Target Specifications

Specifications	Number	References
Gas usage - Eliminate – convert to electric	54.5 tons/month	Excel sheet
Steam Usage -eliminate – convert to electric	1000 klb/month	Excel sheet
Electric Usage - Cut down 10,000 kwh per month + use more energy efficient ways to get electricity	70,000 kwh/month	Excel sheet
Transportation - Drive less	25 miles per gallon/month/person	Internet

- Walk/bike more	(on campus)	
Cleaning - Green cleaning (reduce the use of chemicals)		
Water Usage - Reduce by 50,000 gallons per month. Promote water saving and reusing	700,000 gal/month	Excel Sheet

Generating System Concepts

Problem:

Large buildings use an immense amount of energy that is not necessary and is very wasteful. This is a major problem everywhere in the world that needs to be taken seriously. Old Main, a building at Penn State contributes to this energy waste. Our goal is to make this building more sustainable and use the most efficient forms of energy. Making Old Main more sustainable will encourage more buildings and schools to follow in its foot steps and therefore help to conserve energy everywhere.

External Research:

After doing some research, we have come across some universal ideas that people have used in order to achieve sustainability. One idea is to reuse the waste water, also known as grey water, for water that does not have to be completely clean. One way to do this is to use the dirty water from washing your hands in the toilets or to water any plants that may be in the building. You can also use rain water as grey water so a system to catch the rain water could be implemented. One way of doing this is called the AQUS grey water recycling system. Another way to make a building more sustainable is to use solar panels. Solar panels are a way to make energy by simply using the sun. This energy can be used to power electricity in the building. Wind mills also create clean energy that can be used to power the building. Geothermal energy is a clean source of energy by using heat from the ground to heat the building. In addition, using more energy efficient appliances such as computers, printers, energy efficient lights, elevators, and heating and cooling will overall help conserve energy in the building.

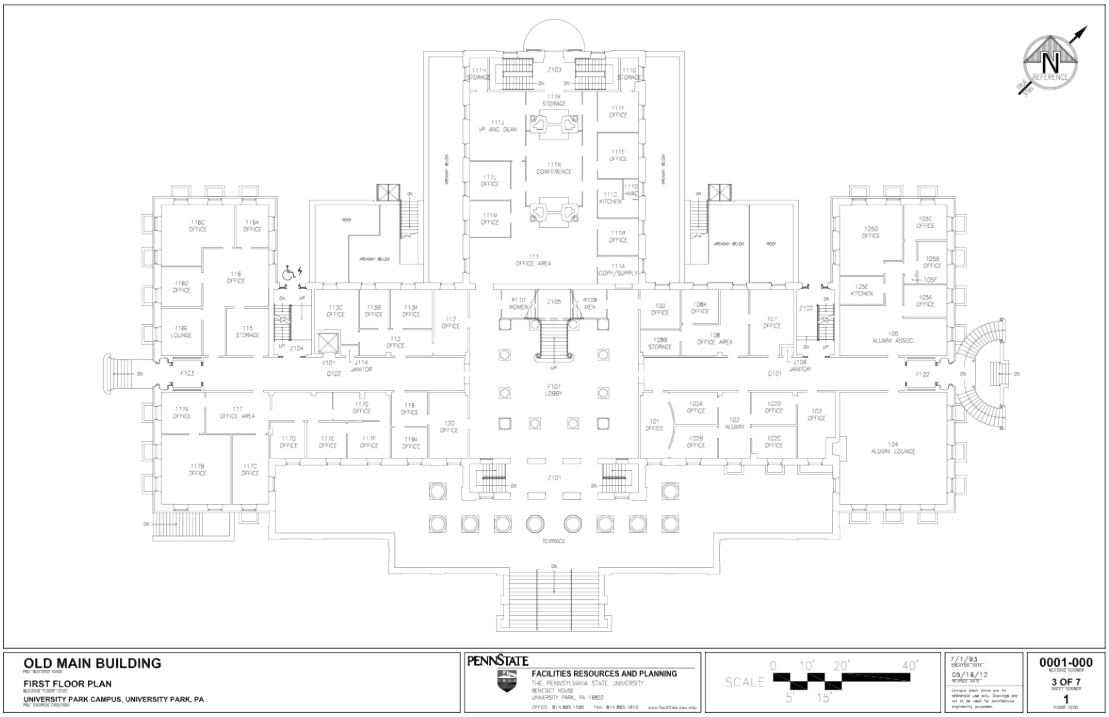
Internal Research:

We have each sketched our own design of how we are going to make Old Main more sustainable. Most of our ideas include solar panels, wind mills, and using

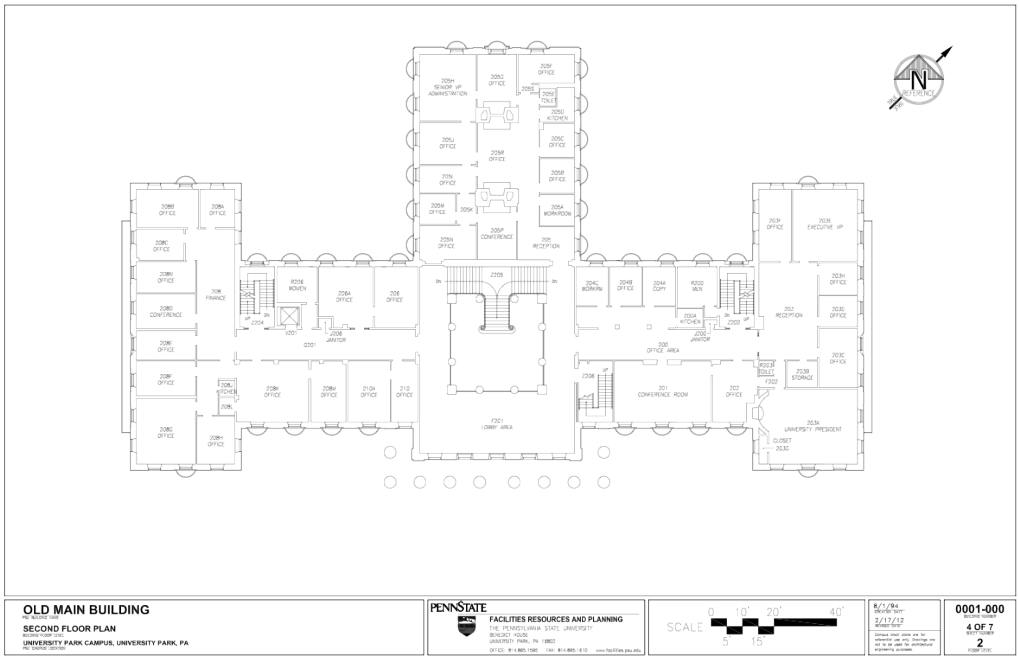
more energy efficient appliance like others have done. In addition, we have considered using automatic lights in order to save energy when people aren't in the room. We have also considered using lower powered toilets and sinks in order to reduce the amount of unnecessary energy used. We have decided not to alter the outside of the building a lot because Old Main is a historic landmark for Penn State so we are focusing more of how to save energy inside the building.

<u>Floor plans:</u>

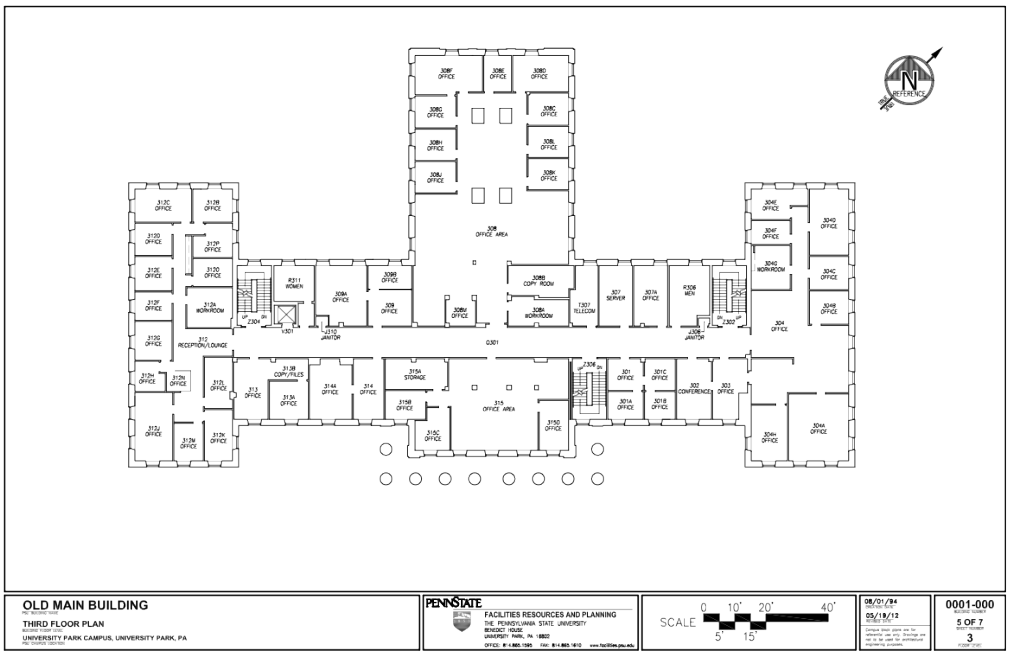
First Floor:



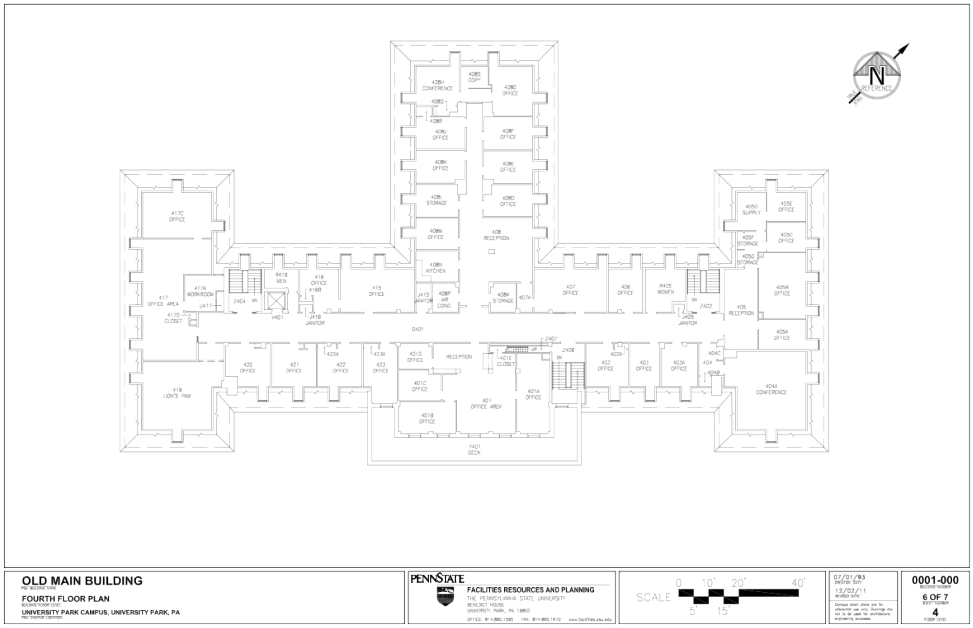
Second Floor:



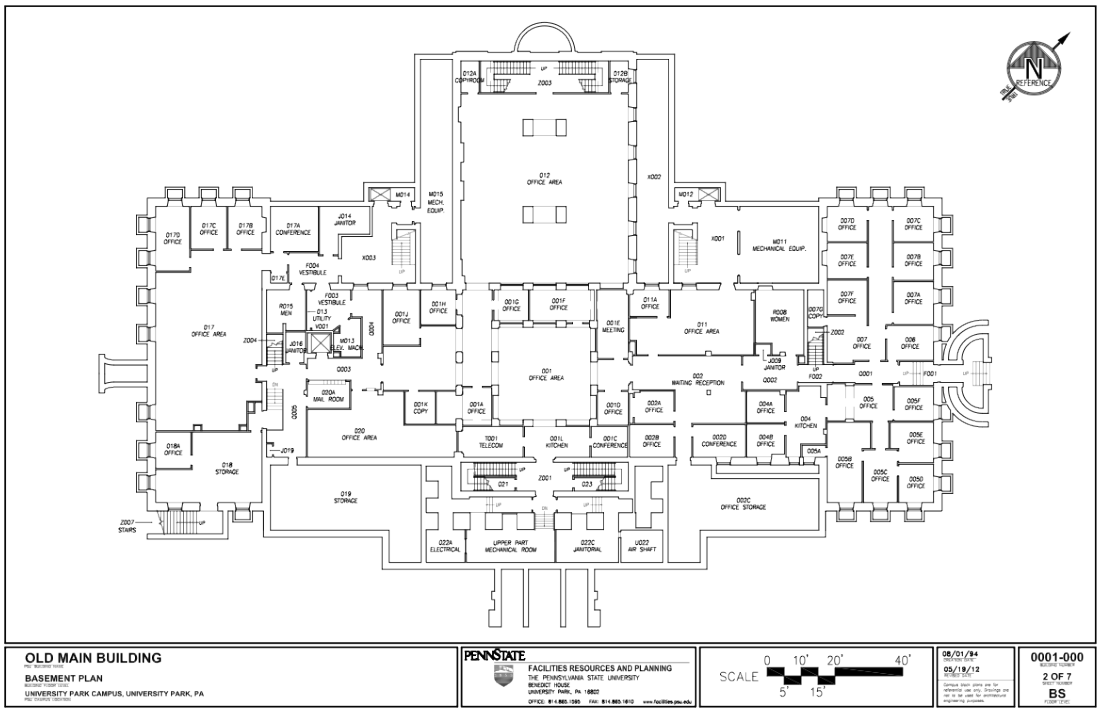
Third Floor:



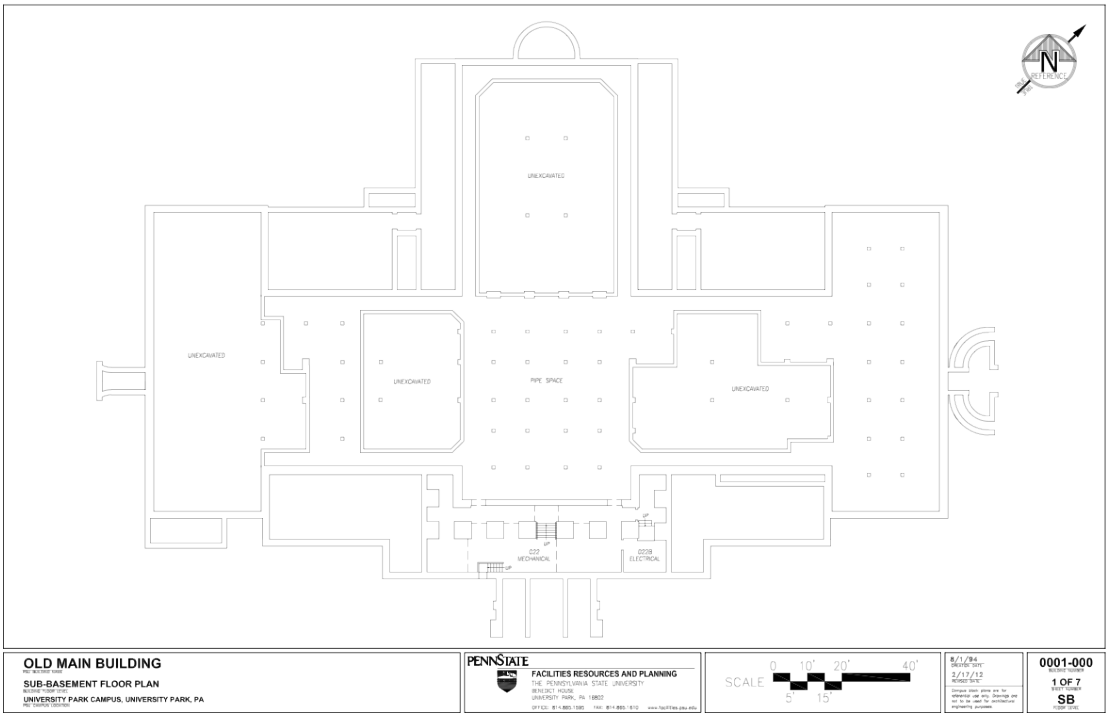
Fourth Floor:



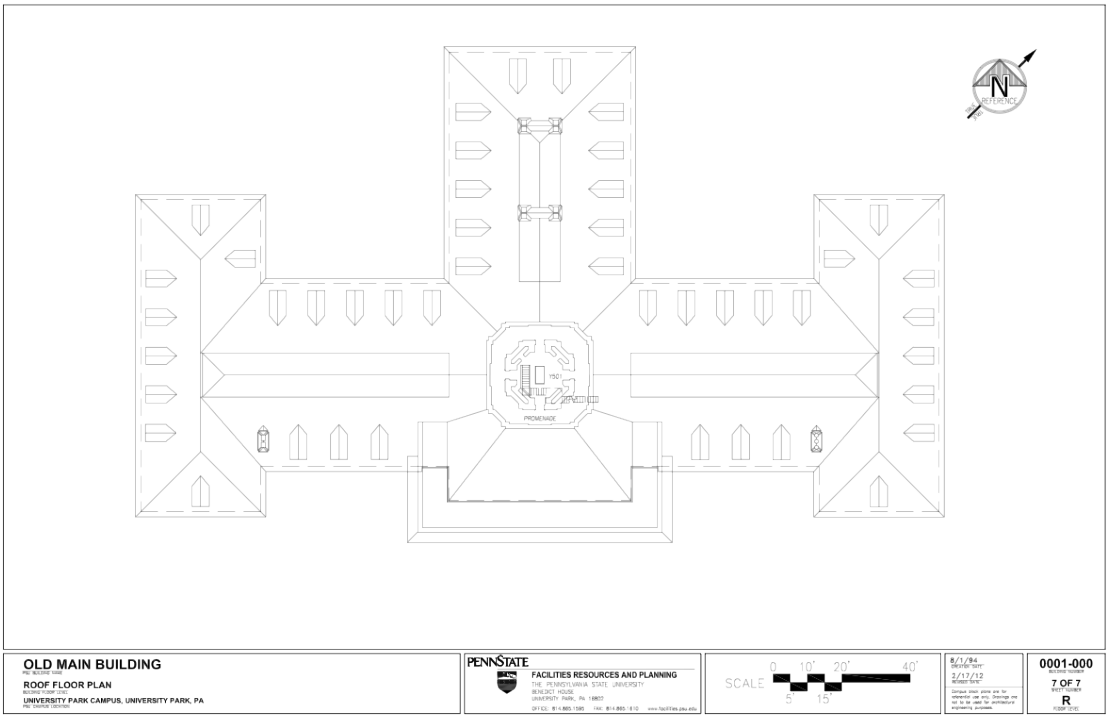
Basement:



Sub-Basement:

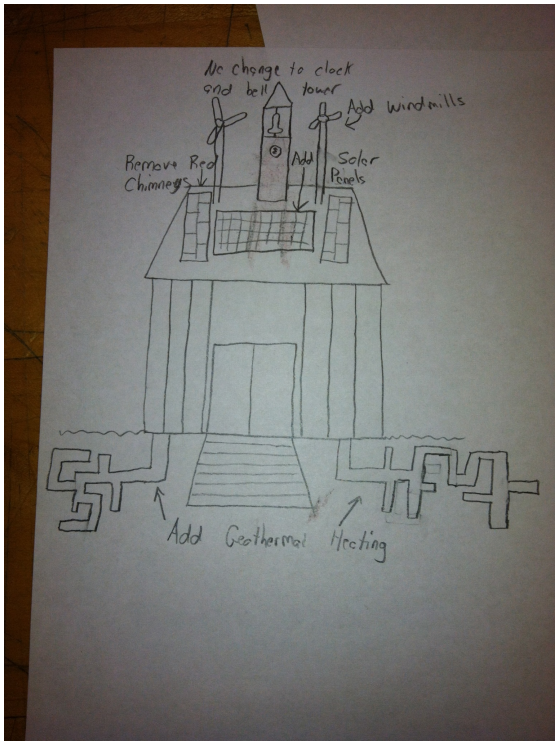


Roof:



Explore Systematically:

We refined our ideas by keeping the same outside structure of the building to keep its historic appeal. However, we will put solar panels on the roof in addition to two small windmills that will both contribute to creating clean energy. We will also improve the insulation so that heat or cold air doesn't leave or enter the building. We considered installing new windows to increase passive solar process, but we decided against it for two main reasons. First we did not want to change the original design and secondly we felt that Old Main had a good bit of solar access anyway, and change was not particularly necessary. Another change we thought about making, but didn't, was adding glass to the roof in places to increase the suns effect on heating the building. We decided against this in the end for the same reason as the windows, but also because the roof only has access to one of Old Main's four floors, and this would not have a large effect on the heating of the building. Instead, we constructed a geothermal system in the ground to provide efficient heat. We will also implement a grey water system in the sub-basement that will allow conservation of water in the building.



Reflect:

Solar panels and wind mills will be a great alternative use of energy that will greatly help to reduce the amount of energy Old Main uses. Also, a grey water recycling system will contribute to recycling waste water that can be used for other

aspects. In addition, using energy efficient lights and other appliances will all help make the building sustainable. We will eliminate natural gas which will help us eliminate steam making Old Main more sustainable. It will take a lot of work to implement all these things but working towards sustainability will be worth it.

Implementation

Geothermal Heating:

Geothermal heating is a very efficient way of transferring energy. It takes the heat from the ground in the summer and transfers it to heat the building. In the winter, geothermal heating will take the heat from the building and pump it back into the ground. This is four times as effective as the most energy efficient gas furnace. Geothermal heating transfers energy as opposed to obtaining it by burning something. Unlike other comfort systems, geothermal does not emit carbon dioxide, carbon monoxide, or other greenhouse gasses which contribute to air quality pollution. This is much more environmentally friendly and can lower your monthly energy bill by up to 70%. In addition, they are very quiet and are not subjected to wear and tear from the environment, which makes them last longer than heaters and air conditioners. Geothermal heating is implemented by a closed loop system, in which the high density polyethylene pipe is buried horizontally at 4 to 6 feet deep or vertically at 100 to 400 feet deep. These pipes are filled with an environmentally friendly antifreeze/water solution that acts as a heat exchanger. The air delivery ductwork distributes the heated or cooled air through the house, just like conventional systems. The estimated cost to implement this is about $50,000. Although this is semi expensive, geothermal heating systems are found to pay back within 10-15 years. Since Old Main is not going anywhere anytime soon, this is a very good idea towards sustainablility.

Grey Water System:

Installing a grey water system will help conserve and reuse water which will contribute to our goal of reaching sustainability. A grey water system takes used water from sinks in addition to rainwater to fill toilets, where fresh water is not needed. After many research, we decided that the AQUS GreyWater Recycling System would be best system to do this. It is a low maintenance, low cost, and highly effective water saving device that would be perfect to conserve water in Old Main. It contains a 5.5 gallon vanity tank that collects the reused water that goes down the bathroom sink. Rain water could also be collected in this tank to contribute to the amount of reusable water. It then filters and sanitizes the water and stores it until it is needed to fill the toilet tank. When the toilet is flushed, a 12 volt submersible

pump, contained within the AQUS Greywater System storage tank, automatically turns on. Any reused water in the storage tank is pumped to the toilet to be used for flushing the toilet. If there is not enough stored water to sufficiently refill the toilet tank, the AQUS Greywater System allows the fresh water supply that normally fills the tank to make up the difference. The unique design of the AQUS Greywater Recycling System prevents the risk of cross contamination with potable fresh water. With the great amount of bathrooms in Old Main, a greywater system could greatly contribute to saving water and maintaining sustainablility. This system would cost $15,000 to implement but would save 190,000 gallons of water per year.

Solar Panels:

The photovoltaic cells in a solar panel convert sunlight into energy. First solar cells were used in space to help power satellites. More often these days solar cells can be seen powering road signs, calculators, and buildings. These cells work at a maximum when they are faced directly into the rays of the sun, so upon instulation, installers will angle the solar panels in such a way to maximize their solar access so that we can employ full use of the panels. DM-solar is prepared to offer a 42 cell system powered at 10.5 Kw. Measuring 64"X39"X1.5", we would install 9 sets to produce 68,000Kwh per month, in other words, 98% of Old Main's power usage. This 9 piece set checks in at $180,000 and although expensive, it is well worth the price when considering the money saved in energy each month.

Wind Mills:

Windmills create energy by using wind to turn the giant turbines or propellers at the top. This rotation causes a generator at the base to generate electricity. The windmill we chose produces 7,200 Kwh/month. We decided that we needed two of these windmills and the combined price would be $48,720. This may seem pricey, but the energy produced will be mostly straight profit. We designed Old Main to produce more energy than needed in order to ensure sustainability.

Green Wall:

A green wall is a wall, either free-standing or part of a building, that is partially or completely covered with vegetation and, in some cases, soil or an inorganic growing medium. We decided to implement green wall in old main as it helps regulate the building temperature, saving energy, providing clean air, works as a sound insulator, and it looks beautiful. It could also be used for environmental classes to maintain its nutrients while also helping to teach a class. The cost of the green wall is approximately $850, which is fairly cheap.

Insulation:

Insulation is very important in keeping hot air inside the building in the winter and keeping the cool air inside the building in the summer. We chose R-Values of 25 and 30 for our floor and walls respectively. We chose these number because the climate in State College requires much insulation in the winter while maintaining cool temperatures inside in the summer. Our R-Values will ensure that we do not lose any heat or cool air and thus reducing our wasted energy. Since sustainability is our main focus it is well worth the extra money to pay for the better R-Value insulation. The return is well worth the investment and the payoff will be within 10 years of use. The price of the insulation itself would be $3,000 but the cost for the installation would also need to be put into consideration and could vary from company to company. The previous values of 20 and 25 do not ensure that Old Main reduce wasted energy and our new R-Values will help make Old Main the sustainable building it can be.

Concept Screening

Criteria	Recycling	Solar	Geothermal heating	Windmill	Grey water	Energy efficient appliances	Green Wall	Insulation
Aesthetic Appeal	5	4	7	2	6	3	1	8
Efficienc	4	1	3	2	5	6	8	7
Cost	1	7	5	8	3	6	2	4
Ease of Implementation	1	6	8	7	4	3	2	5
Sum/Ran	11	18	23	19	18	18	13	24

Cost:

We were very successful at making Old Main more sustainable while keeping the price within reach. Old Main started at using 700,000 gallons of water per month. By eliminating steam, we were able to cut this down to 580,000 gallons. In addition, implementing the grey water system contributed to reducing this number by another 16,000 gallons per month. Altogether, we reduced the amount of water by 136,000 gallons per month. Old Main also used to use 70,000 kWh/month. By using solar panels, wind mills, and geothermal heating, we were able to reduce this amount completely with some left over energy that can be sent back to the grid. We also implemented better insulation so that less energy would be wasted. All of these changes would cost around $300,000. Although this may seem pricey, steps toward sustainability need to be implemented.

Conclusion:

In conclusion, sustainability is very important and people everywhere should put in more effort into it. Making Old Main more sustainable is just one step that could cause other Penn State buildings to look into sustainability, which could then cause other Universities and buildings everywhere to become more sustainable. Old Main is a PSU landmark that has a great influence on the whole campus. In attempting to make Old Main more sustainable, we managed to eliminate a great deal of water usage by eliminating steam and implementing a grey water system. In addition, a geothermal system, solar panels, and wind mills all contribute in creating an immense amount of clean electricity that will eliminate the old electricity that Old Main uses now. We also would install more efficient installation that will reduce the amount to energy wasted. We implemented a green wall that will help conserve energy in addition to making it look good. Lastly, small changes such as buying energy efficient lights and appliances will all contribute into making Old Main sustainable.

Works Cited

http://energy.gov/energysaver/articles/choosing-and-installing-geothermal-heat-pumps

http://aqusgreywatersystem.com/

http://www.wbdg.org/design/sustainable.php

http://www.geothermalgenius.org/benefits-of-geothermal/

http://www.johnsoncontrols.com/content/us/en/products/building_efficiency/energy_efficiency.html

http://dsc.discovery.com/tv-shows/curiosity/topics/10-sustainable-buildings.htm

http://greenliving.nationalgeographic.com/recycling-instead-landfills-2216.html

http://www.wbdg.org/design/sustainable.php

Feldman, Y., & Perez, O. (2011). *Motivating environmental action in a pluralistic regulatory environment*.

Lee, A. M. (2008, January). Do the right thing and get points! *Incentive, 182*(1), 63.

Schulz, P. W., & Oskamp, S. (1996). Effort as a moderator of the attitude-behavior relationship: General environmental concern and recycling. *Social Psychology Quarterly, 59*(4), 375-383.

Shaw, P. J., Lyas, J. K., Maynard, S. J., & Van Vugt, M. (2007). On the relationship between set-out rates and participation ratios as a tool for enhancement of kerbside household waste recycling. *Journal of Environmental Management, 83*(1), 34.

Tucker, P., Murney, G., & Lamont, J. (1998). A decision support model for the management of recycling schemes. *Journal of Environmental Planning and Management, 41*(4), 445-462.