Sustainable Dorm Living: Re-evaluating Bigler Hall

EDSGN 100

Team 8 (aka Team N-Finite)

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2/22/2013

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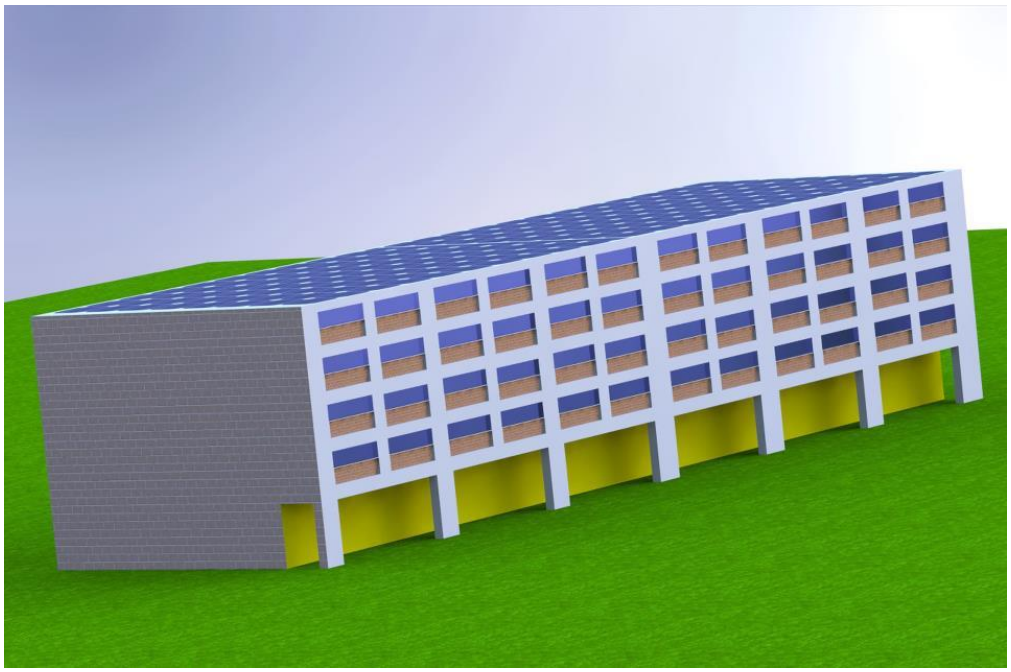

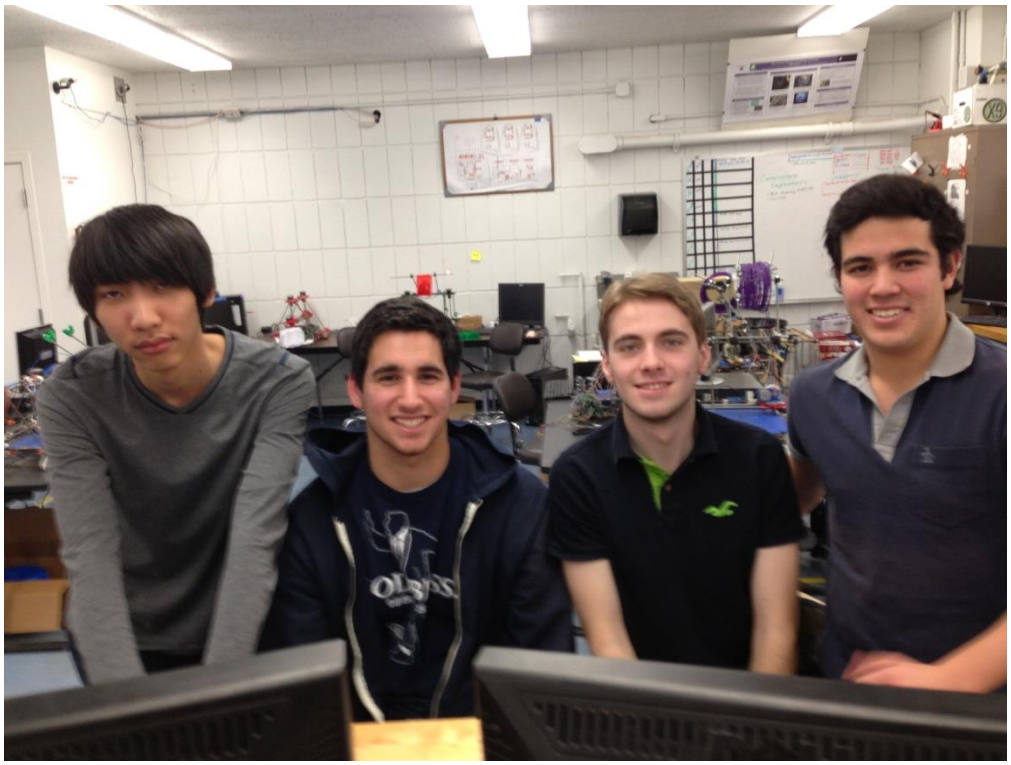

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Executive Summary

As a team we are designing an improvement to Penn State's University Park campus. We are examining the campus as a middle-sized town and specifically looking at Bigler Hall as a building within the city. We are using the "sustainable city" idea to accomplish our goal and improve on some of the negative aspects of the city. This project is funded through the Siemens Corporation headquartered out of Munich, Germany. The company employs over 300,000 and is involved in many markets including energy and power, industry and automation, information and communications, healthcare, transportation, and lighting. The objective of this assignment is to take our city as it is now and make specific improvements both internally and externally to achieve sustainability. We will be focusing on the efficiency and sustainability of Bigler Hall. We will improve certain aspects of the building from energy sustainability, waste management and recycling, and water usage.

Our findings have stated so far that solar panels are the most reliable energy source available to us so far. The most important sustainable buildings in the country and the world have implemented this system to aid their electrical needs and most of them had succeeded. The building requires to decrease the amount of electricity they use and produce as much energy as possible to reach the desired grade of sustainability.

The only risks of solar energy reside in the management of the solar panels itself. If the PV's are not given the treatment they require, there can be a short circuit causing fire. Technically they are much safer, because there is no fuel that can produce an explosion or a large scale fire. We will mitigate this risk by providing correct maintenance to the solar panels that are going to be in the building's roof. Besides, we will carefully minimize our programmatic risks by adhering to strict schedule that will provides us sufficient time to correct any technical issues, thus we will deliver the project on April 29th 2013.

1.0 Introduction

In 2010, 82 Percent of Americans lived in cities, and in 40 years 90 percent of American population will live in cities. This prediction calls for sustainable city design due to amount of energy city consumes. Cities consume around 30 percent of energy used. For example, 60 percent of all water consumption 70 percent of all greenhouse gases produced are from cities energy consumption. Due to population increase in the cities and enormous amount of energy consumption, sustainable city design is essential for higher quality of life, lower cost, and for green environment in near future.

In 2012, Pennsylvania State University and Siemens have joined alliance. As result, recruiting relationships enhanced, research collaboration is formed, and cooperation for University program is launched, including Sustainable Cities. For this project, considering Pennsylvania State University, specifically the University Park campus as a small city, students will design many elements of campus that will make campus near-self-sustainable, while increasing quality of students' lives and decreasing the cost of running the campus.

1.1 Initial Problem Statement

It is important for us to redesign the town of University Park because efficiency is becoming extremely important. Because the campus holds over 40,000 students, the smallest inefficiencies can cause millions of dollars of wasted funds. This project is funded through the Siemens Corporation. Siemens is a multi-national company that is headquartered in Germany. They focus on many aspects of home life including energy, power and communications. The need for this production comes from current population transition back to urban areas. It is assumed that nearly 90% of Americans will live in cities by 2050. The need for these cities to hold the new influx in an efficient way is extremely important.

1.2 Objectives

Our design will show the different rooms within Bigler Hall and how we change them. The rooms that will be included are dorm rooms, a common room and the bathroom. This will be shown in a "dollhouse" fashion where each room can be clearly seen. On top of the model, our solar array will show how our panels will power the building

2.0 Analysis of Customer Needs

2.1 Customer Requirements

The sustainable city project was fairly simple, take University Park as a medium sized city and improve its sustainability. We started off with the idea of improving Penn State's waste management. However, after delving into the intricacies of waste management we decided that we may want to switch ideas. We then looked at the water usage and Penn State and how it can be improved. Well, it turns out that Penn State has a very sustainable water system, owning six dams in total to supply the campus with water. Finally, we settled on the improvement of a single dorm building on campus. After analyzing project description, the following customer needs we established:

2.2 Customer Needs

Number	Need	Imp
1	Town will be University Park, PA	5
2	The building will use energy efficient technology to maintain energy levels	5
3	The building will use water saving technology to reduce waste	5
4	The building will have in depth recycling tactics	5
5	The building may change its current exterior	1
6	The building will have an efficient system for disposing of human waste	4

2.3 Renewable Energy Survey

In a survey done to 10 Penn State freshmen students living in residence halls, they were asked basic questions, concerning on sustainability. The questions asked were:

Do you use any alternative or green energy source in your house?
Does your Penn State residence hall use any alternative or green energy source?
Do you turn off the lights when you leave your dorm?
Do you toss your trash in the special trash bins that are located in your floor?
What kind of alternative energy do you think Penn State should use more?
Would you like that Penn State used more green energy sources?

For question number 1, none of the questioned students used any form of green energy source. Many agreed that they would like to implement one, but they said that they have heard that it was very expensive.

On question number 2, seven students said there wasn't any and three that they didn't know.

For the third question, two students responded that they always turned off the lights before they left their dorm. Seven students said that they always tried to turn the lights off, but sometimes forgot and one student said that he never turned the lights off.

Concerning waste on question 4, 2 students replied that they always threw their trash in the special bins. 5 students alleged that they tried to throw their trash in the special bins and 3 said they never tossed the trash in the specialized bins.

For the fifth question, six students said that Penn State should have Solar Panels to produce energy. One replied that the university should use biomass and the remaining three did not respond.

Question number six was unanimous, all the interviewed subjects answered that they would like Penn State to use more energy sources.

3.0 Establish Target Specifications

3.1 Product Specifications Metric

Metric #	Customer Need #	Metric	Imp	Units
1	1	Location in University Park	5	list
2	2	Renewable energy sources	5	kwh
3	3,6	Water effienecnt faucets	4	gal
4	3,6	Water effienecnt toilets/urinals	4	gal
5	3	Water restrictions and limits	3	list
6	4	Specific bins for recycling of materials	4	list
7	5	Exterior features	1	feet

3.2 Product Specifications Matrix

		Metrics						
		1	2	3	4	5	6	7
Number	Need	Location in University Park	Renewable energy sources	Water efficient faucets	Water efficient toilets/urinals	Water restrictions and limits	Specific bins for recycling of materials	Exterior features
1	Town will be University Park, PA	•						
2	The building will use energy efficient technology to maintain energy levels		•				•	
3	The building will use water saving technology to reduce waste			•	•	•		
4	The building will have in depth recycling tactics						•	
5	The building may change its current exterior							•
6	The building will have an efficient system for disposing of human waste						•	

3.3 Benchmarking/External Research

LEED Platinum rating is currently the highest degree of sustainability a building can get in the US. This rating system has recently begun certifying buildings outside the US.

Perhaps one of the largest LEED Platinum certified building in Pennsylvania is the Vertical Screen World Headquarters located in Warminster. Even though it's not meant to be a building for residential purposes, the Vertical Screen Headquarters provide us with a great example of sustainability in Pennsylvania. The building maintains a comfortable temperature throughout the year thanks to a Geothermal HVAC System. The building also reduced the need of artificial light by placing huge 40 foot glass curtain walls in the east and west side of the building. These screens have light sensors that monitor light levels. If there is too much light, the screens will get dimmer in order to let less sunlight inside the complex. The building possesses 900 solar panels as well. These provide 163 kilowatts of power, which accounts for 20% of the buildings total electricity need.

Figure 1 – This is the top view of the Vertical Screen World Headquarters. The building features 900 solar panels and 40 foot tall glass curtain walls.

The creators of the building felt it was not enough to just save on electrical bills, so they collect rainwater that accumulates in the roof and use it for the bathrooms. This improvement reduced the building's need for freshwater by more than 75%.

Finally the building has a considerable amount of objects created with recycled materials like:

-Carpeting from used car tires and other recycled materials.
-Countertops made with recycled glass.
-Café tables made from scrap machine-shop metal shavings.
-Chairs made from Coca-Cola plastic bottles.
-Cork flooring

Figure 2 – Pomona Hall gained its LEED Platinum accreditation in 2011.

One of the few LEED Platinum certified residence halls are located in the New Pomona College. The college is located in Southern California in an area that deals with nearly template weather.

"The residence halls, which opened June 1, house approximately 150 students. The suites have three to six single bedrooms, a common room, shared bathrooms and a kitchenette. Combined, the buildings are 78,000 square feet and occupy a 4.3-acre site. The total project cost was $53 million." The residence halls have a 2,000-gallon solar hot water system, which provides 80% of the buildings' needs. It also has rooftop solar voltaic panels providing 80 kilowatts of power (an estimated 14% of the building load).

The buildings also feature shaded windows, which let less heat inside the building, besides a mechanical ventilation control in order to turn the fans off when the windows are open.

Figure 3 – Ackerman Hall from Western Oregon University has saved 35% of electrical power.

The biggest LEED Platinum certified residence hall is located in Western Oregon University. The residence hall can house up to 330 students. The building uses rainwater for flushing toilets, solar panels and heat ducts that heat air and water, and occupancy sensors to save energy in unoccupied space.

In its first year, the building saved 75% water compared to other buildings its size. The building also saved approximately 35% of electrical power.

Figure 4 – Colorado Court Affordable Housing produces all of the energy it consumes.

Colorado Court Affordable Housing is one of the few housing projects that have reached the LEED Platinum rating. The building has two on-site energy generation systems. According to AIA (The American Institute of Architects) it is the first neutral affordable housing project. The complex has a PV panel system and a natural-gas turbine cogeneration system. The heat produced by the turbine system also warms water. Unfortunately a large part of the building's sustainability is due to the lack of air conditioning systems in the building, something that is possible in Santa Monica, but would not be very pleasing for the extreme temperatures that are predominant in State College.

Concerning to new technologies other than photovoltaic energy, the BIQ building in Hamburg, Germany has just been inaugurated this April. The building is powered entirely by algae. The algae are used as biofuel. The façade absorbs the light that is not used by the algae to generate heat, like a solar thermal unit, which is used for heating air and water. If the energy exceeds the amount needed "it can be cached in the ground using borehole heat exchangers — 80 meter-deep holes filled with brine." The algae also help to give shade during the summer, decreasing the amount of air conditioning needed to keep a comfortable temperature in the building.

Penn State's greenest building is the relatively new Stuckeman Architecture Building is the only full LEED Gold certified building in the University Park campus. The building was finished in 2005. The exterior is made of recycled cooper, brick and energy conserving windows with exterior sun-control louvers, which minimize glare inside. Just like the Vertical Screen World Headquarters, the building has a HVAC system to keep the inside temperature of the building comfortable for its occupants. The building does not have solar panels or a considerable energy producer, but it is very efficient in decreasing the amount of electrical power that a building of its size would need.

Figure 5 – BIQ Haus in Hamburg, Germany produces algae to use as a biofuel.

Figure 6 – Stuckeman Architecture Building, the only building in PSU with full LEED Gold accreditation.

4.0 Concept Generation

4.1 Clarify the Problem

Once we understood the customer needs, we were able to clarify the problems that we were faced with in the design. Our current issue of sustainability revolves around 3 main issues: power issues, water issues, and heat issues. To best address this concern for the sustainability of the campus, we decided to focus on addressing these issues for an individual building. If the sustainability problems of a residence hall, such as Bigler Hall, were addressed, we can apply our findings to the university as a whole. The following is the research involved finding the best possible option for our issues.

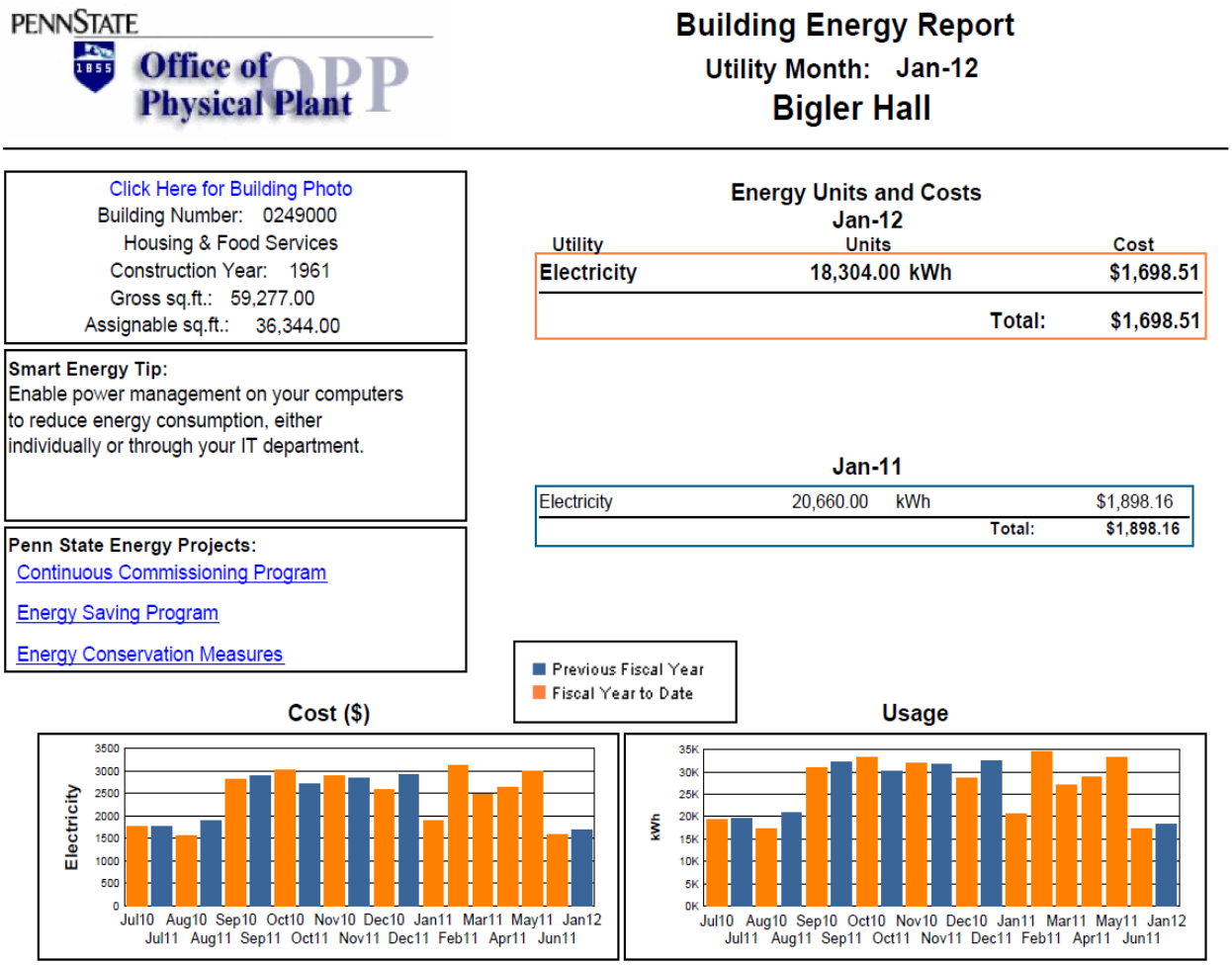
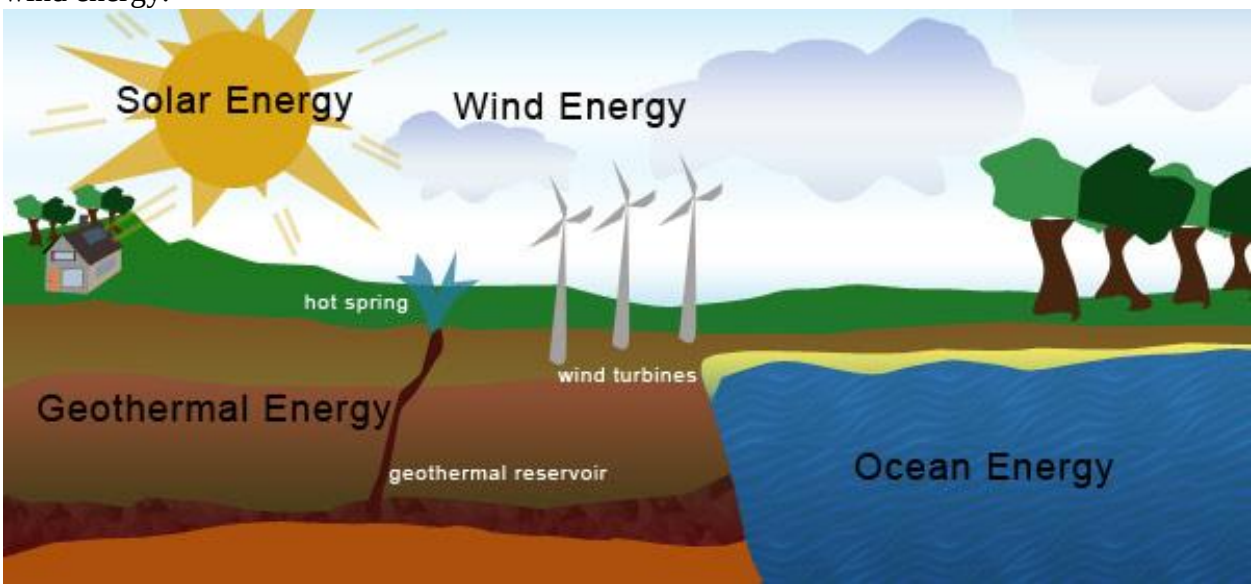


Figure 1: The image above shows the report of Bigler Hall. It is a report from January of 2012.

http://www.opp.psu.edu/services/energy/building-energy-reports/january-2012/at_download/file

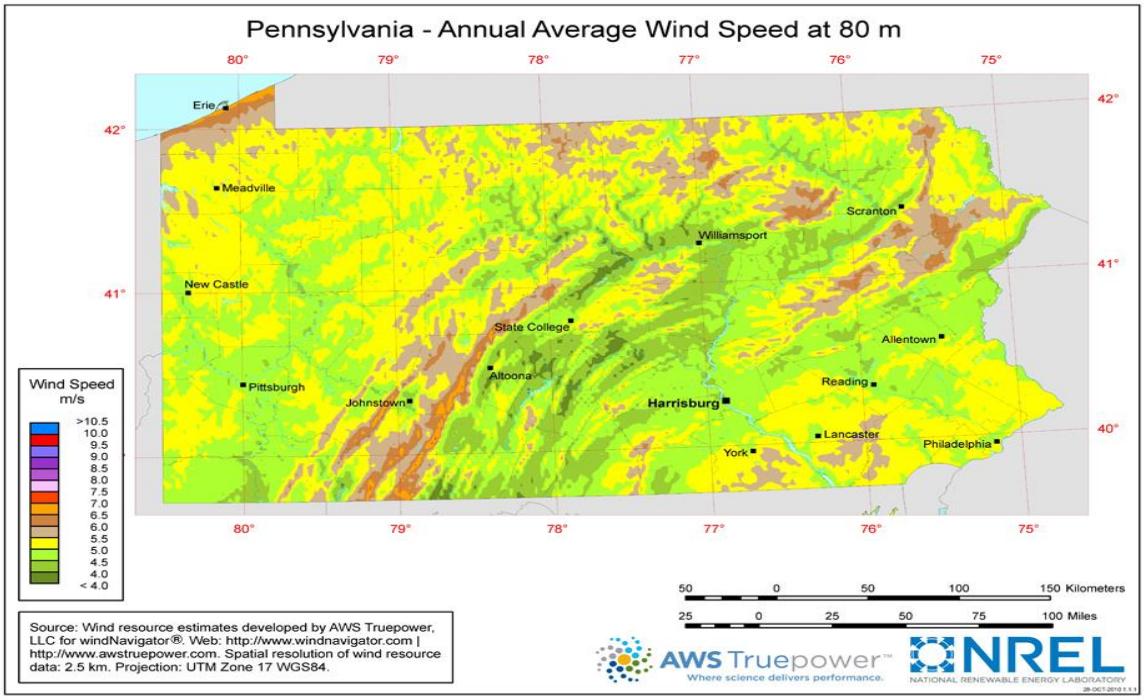
4.2 External Search

Possible energy sources include geothermal energy, moving water energy, solar, energy, and wind energy.



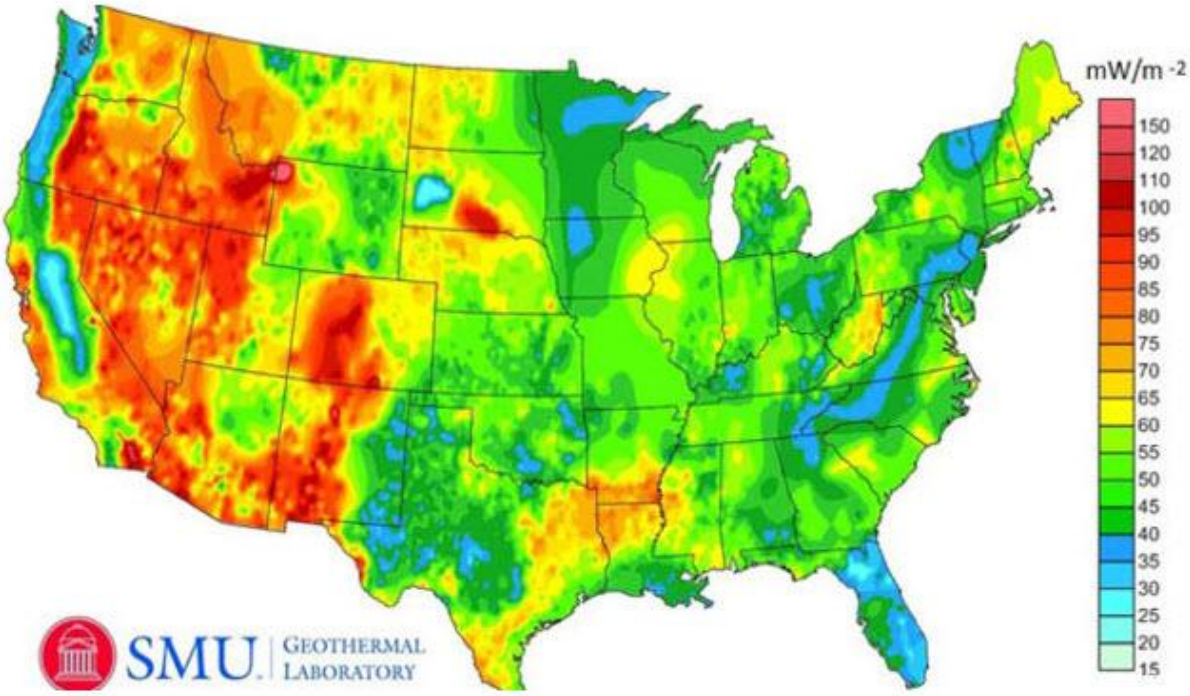
http://windy-future.info/wp-content/uploads/2009/09/solar-wind-geothermal-energy-1475.jpg

According to the diagram below, wind energy would not produce sufficient energy for the State College area.



http://www.windpoweringamerica.gov/images/windmaps/pa_80m.jpg

Although geothermal energy sources are used in the Pennsylvania area, the sheer size of our building will not allow for an efficient source from the geothermal system. The figure below depicts the levels for geothermal energy around the United States. Our area is not ideal.

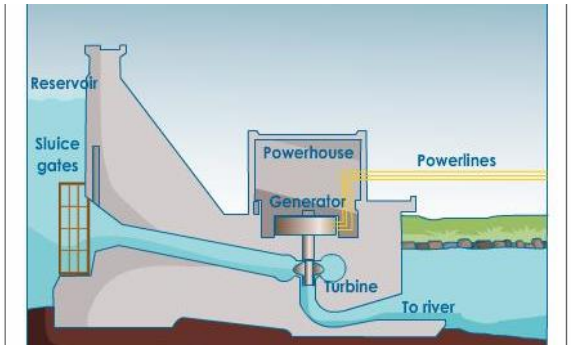


http://coloradoenergynews.com/wp-content/uploads/2011/11/google-geothermal-map2.jpg

PaDEP Dam Number	Dam Name	PaDEP Class	Hazzard Classification
14-121	University Park Airport Pond 1A	C	1
14-122	Bathgate Detention Pond	C	1
14-123	University Park Airport Pond 4A	C	2
14-092	Duck Pond	C	3
31-072	Shavers Creek	B	1
22-090	Hershey Campus - Pond No 1	C	2

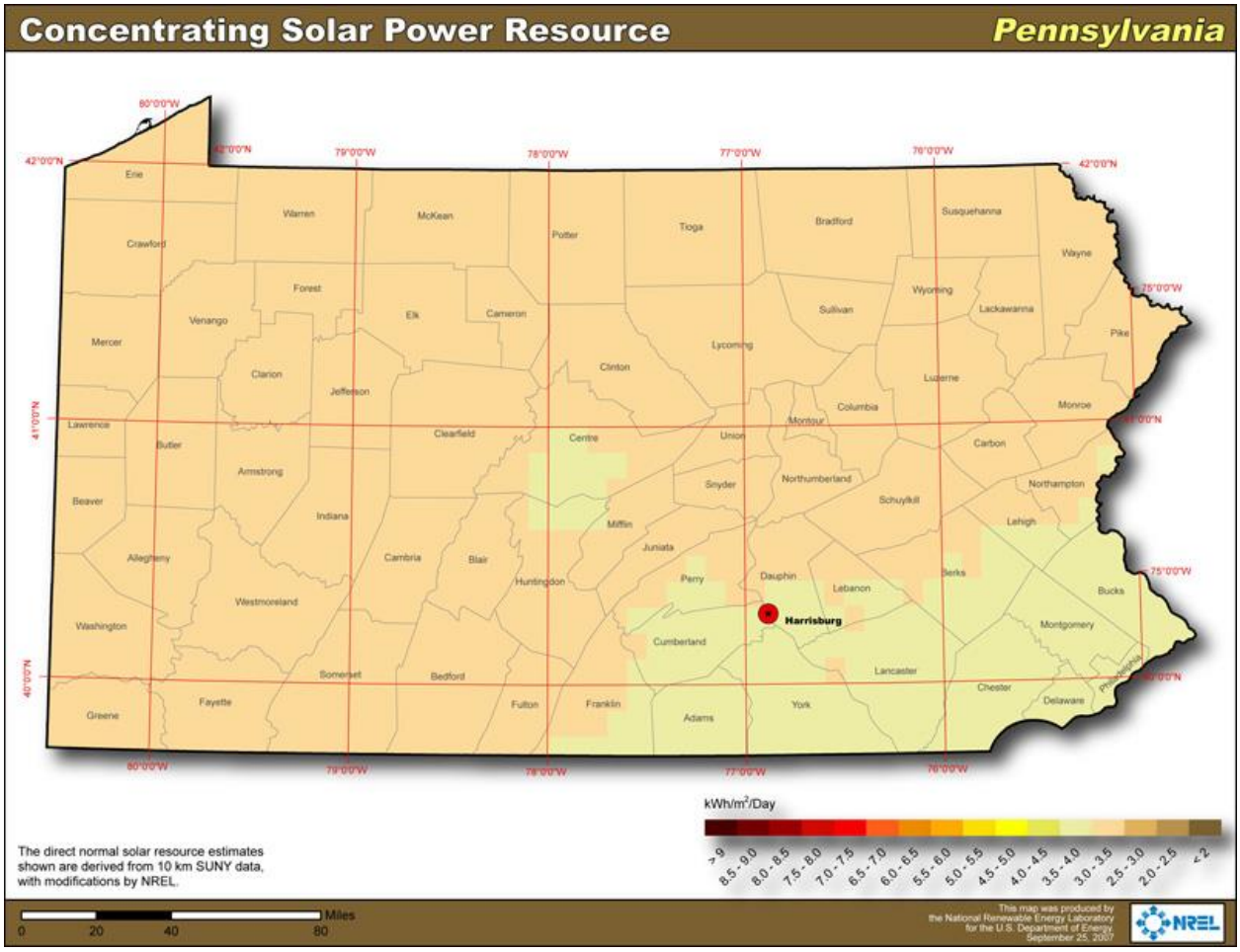
http://www.opp.psu.edu/services/stormwater/images/dam-table-jpeg/image_preview

The energy generated from the local dams is helpful but not enough is produced to make a difference. The primary use of the dams is for a renewable water source. Although Penn State does own six water dams in the area that provide little power, they do contain an efficient and effect water filtration/management system.



http://images.tutorvista.com/content/sources-energy/hydro-power-plant.jpeg

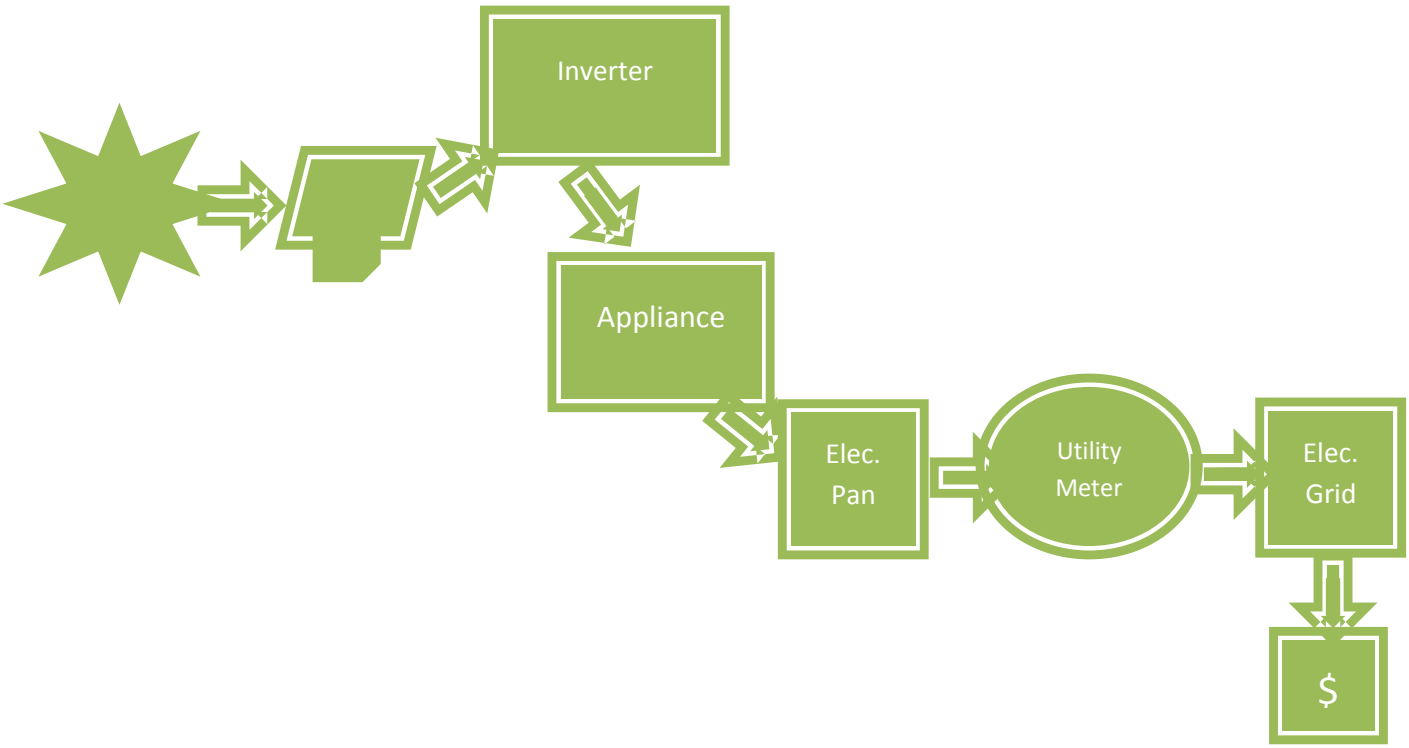
The proper energy source for our situation is solar power. Penn State owns 80 acres of roof space. This is more than enough space to provide an effective and efficient solar panel system. Although as seen in the diagram below, Pennsylvania as a whole is not the best place for this system. We have established that it will be the most effective option we have and will generate enough energy for us to have a surplus. Luckily, our county has more solar power than the surrounding area.



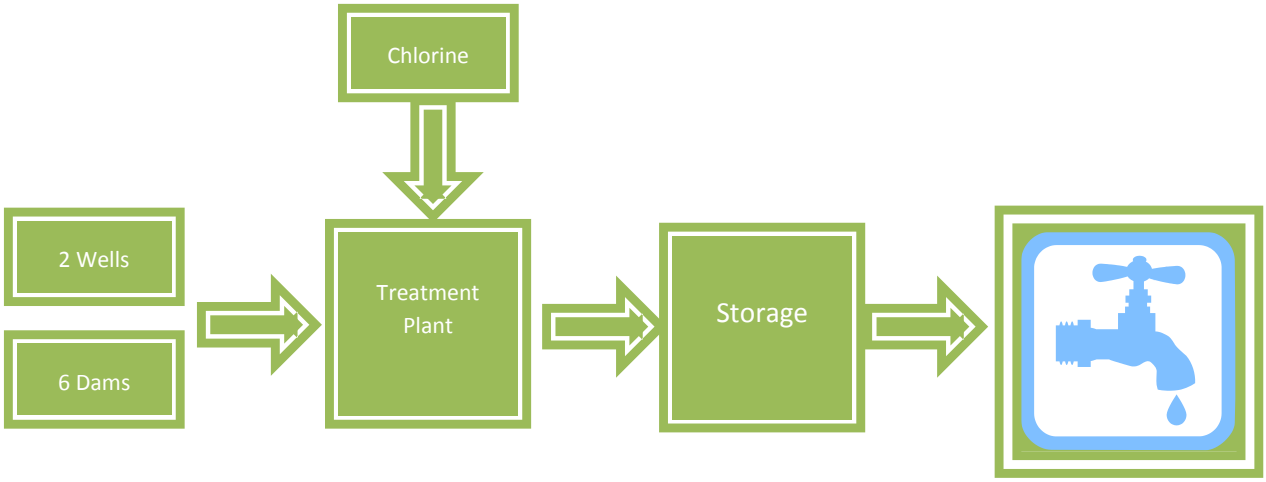
http://apps1.eere.energy.gov/states/images/maps/map_large_csp_PA.jpg

4.3 Functional Diagram

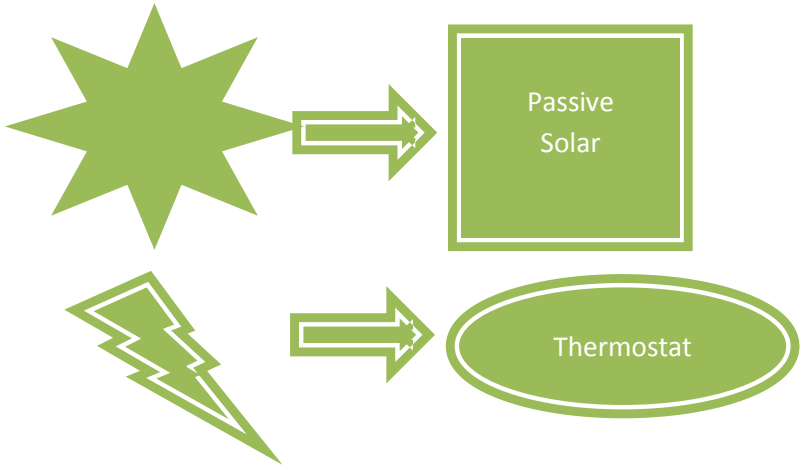
4.3.1 Power



4.3.2 Water



4.3.3 Heat



5.0 Concept Selection

Bigler Hall runs solely on electricity so high-efficiency Solar panels were used to power this building. In the end we went with the Sanyo solar panels. It ranked in the first tier for solar panels and had a much higher efficiency than many of the other 200W solar panels of a similar price(Table 1) Also, since Bigler Hall is both wide and long, we were able to put 810 panels on the roof to generate our electricity (Table 2). This number is generated from using every available square foot of the roof. With our given numbers, we actually consistently generate more power than what is need in the building. With Pennsylvania's Power Incentive, pictured on the following page, we can actually make money off of this excess power. To cut back on energy for lights, more efficient CFL bulbs were used that only require 6-8 watts of power and last for 50,000 hours.

Table 1

Selection Criteria for solar panels	Weighted Score	Sanyo 200 Watt Solar Panel HIT-200BA19 Rating	Sanyo Weighted Score	Sharp ND-200U1 Rating	Sharp Weighted Score	BP Solar SX 3200W Rating	BP Weighted Score
Maintence	10%	2	0.2	3	0.3	1	0.1
Peak Power Rating	20%	3	0.6	3	0.6	3	0.6
Efficiency	40%	3	1.2	2	0.8	1	0.4
Cost	20%	1	0.2	2	0.4	3	0.6
Warranty	10%	3	0.3	2	0.2	1	0.1
Sum of Rank	100%	12	2.5	12	2.3	9	1.8

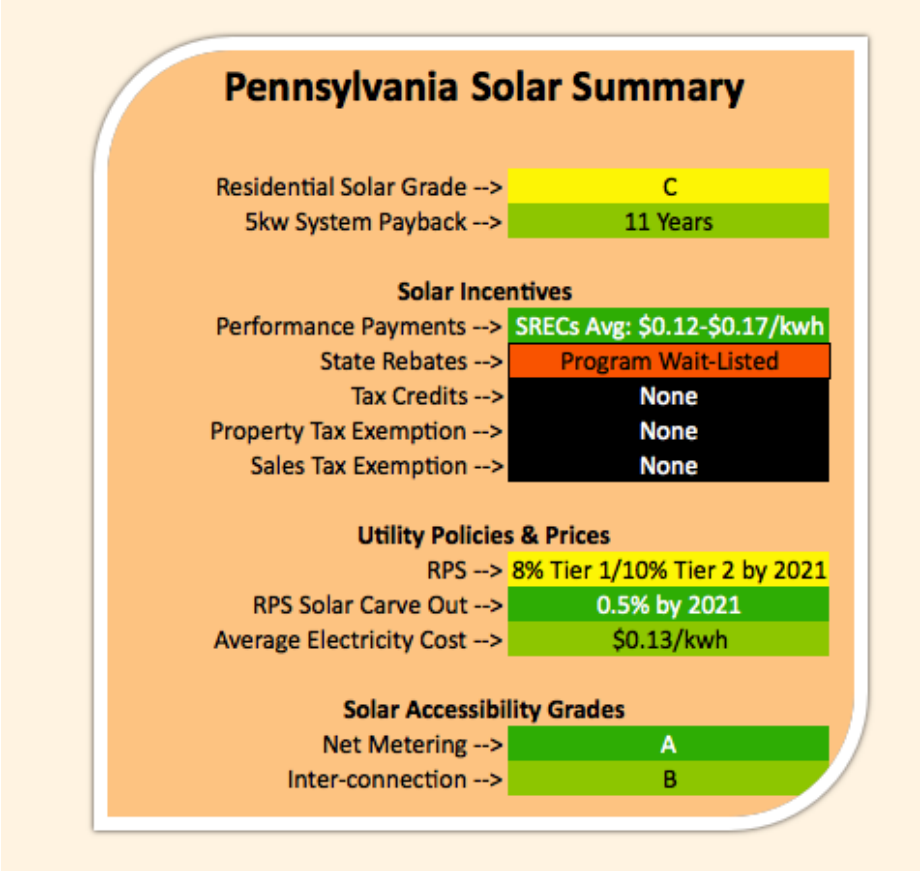
Table 2

Area of Bigler Roof		m2	923
Ref: SolarNutshell.pdf		$/panel	$352
Mfg			Sanyo
Model		Units	HIT-200BA19
Area		m2	1.13
Rating		W	200
Average Daily Solar power acquired per m2 of panel	It	kwh/m2-day	4.5
PV required output	Prated	kW	
Days	t	days/month	30
Efficiency	n		20%
Number of panels			810
Area of panels	A	m2	915.3
Esol=It * A * n * t	Esol	kWh/month	24,713.1

		kWh/day	823.77
Energy Consumption by Bigler in a month in Jan, 2012		kWh/month	18,304
Minimum excess electricity generated per month	kWh/month		6409.1
How much does it cost?			$285,120
Average Solar Incentive in PA		$/kWH	$0.17/kWH
Performance Payments per year to PSU		$/year	$13,074.56
Years until System Payback		years	21.8

To combat waste of heat in the dorms, vent controllers were introduced to have the option to close the vents leading into the individual dorm rooms. Multiple cans were added in each room to separate the waste at the source. Also we changed the door light switch to control all the lights in the room. That way you can turn off all the lights with one simple switch.

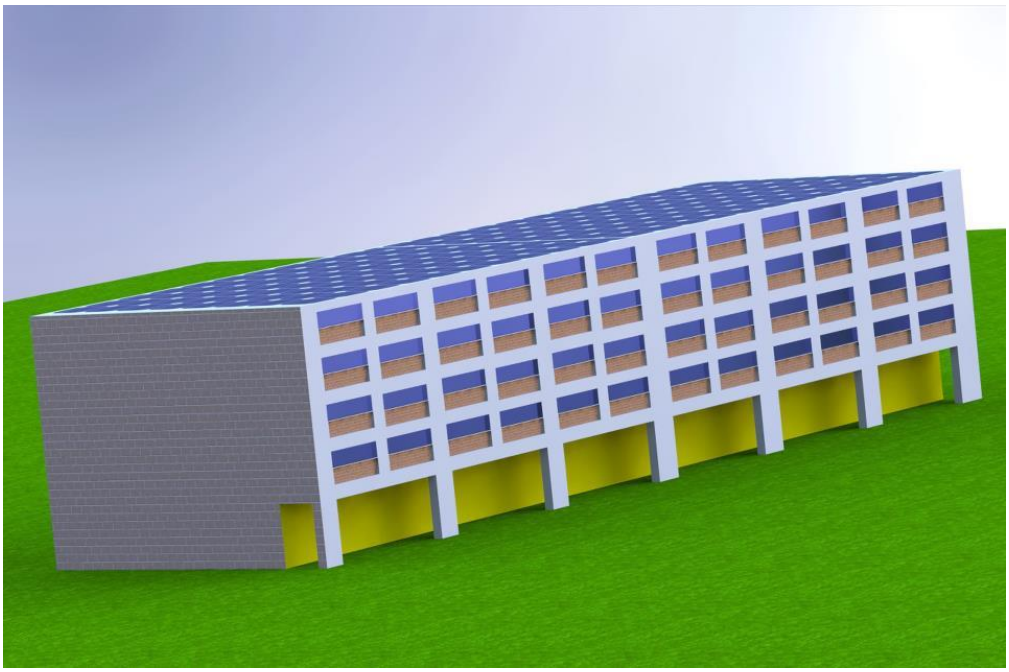
Since the common areas are not in constant use, motion sensors were put in to reduce electric waste in the lights. This same idea was used in the stairwells. Hall ways (Fig. 1) have also been changed to dim during the night. This will keep the halls illuminated, while reducing excess light.



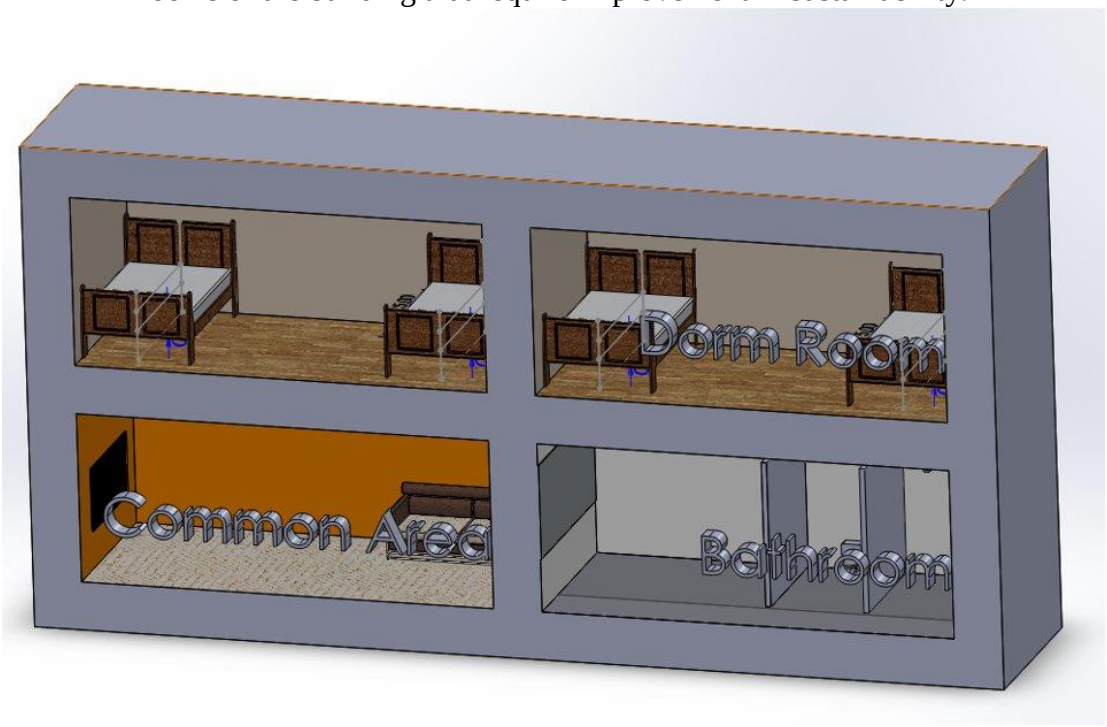
Water conservation is achieved through gray water recycling. This water will be used in the toilets and laundry machines. We also added multi-flush toilets to account for different forms of human waste. Automatic faucets and low flow shower heads also reduce water waste.

6.0 Design

Bigler Hall (Designed in Solid Works)



Our design also features a doll house view. Through this view, we were able to depict the main rooms of the building that require improvement in sustainability.



7.0 Conclusion

We achieved sustainability in Bigler Hall through our efficient use of the buildings characteristics and various changes internally. We utilized the dimensions of Bigler Hall to sustain our energy needs. Since it was wide as well as being extremely long, we were actually fortunate to supply a surplus of energy in the harshest of months, energy-wise. To combat other sustainability flaws we changed our water-using appliances to be more efficient without sacrificing quality of life within the dorms. We became more waste conscientious with the addition of a variety of trash bins for recycling, compost, and trash needs. The changes that we made to Bigler Hall have made it one of the most sustainable buildings within the campus of Penn State.

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