Siemens Sustainable Campus Project Report

The Pennsylvania State University

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Siemens

EDSGN 100 Section: 020

Nittany Designers

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Summary:

Penn State currently produces 13,000 tons of waste, uses 1 billion gallons of water, and consumes 400 million kWh of electricity. Based on student surveys and information from the Pennsylvania State Sustainability Office, we have concluded that the development of a "Sustainability Learning Module" would significantly reduce these actions. If implemented, the learning module would be an interactive online tool that would educate Penn State students on how to live eco-neutral lives. This would have an estimated up front cost of $60,000 and could potentially save Penn State $6.5 million every year.

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Introduction:

Problem Statement:

Penn State currently does not efficiently use energy. The University needs a sustainability education system that increases energy efficiency, cost savings, and is readily adopted by the Penn State Community.

Definition of Sustainability:

Sustainability creates and maintains the conditions under which humans and nature can exist in productive, long-lasting harmony.

Early Selection Process:

In the early selection process we brainstormed many unfeasible ideas. This was often due to the fact that Penn State already has an office devoted to improving sustainability at University Park. This made it very challenging to choose a problem that had not already been addressed by the Sustainability office or the Penn State Office of Physical Plant. Many efforts have already been thought through and problems have either been solved or are in the process of being solved, in order to improve sustainability campus-wide. Initially, we decided to focus on the efficiency of buildings at University Park. We believed that redesigning the classroom scheduling system would have enabled us to shut down buildings for part of the day and therefore, reduce the use of energy on campus. However, with further research we came to find utter disorganization of the system with no central control over all classrooms. Many individual departments/colleges have control over certain classrooms making it nearly impossible to collectively reschedule classes to fill buildings at specific times. A comprehensive scheduling system could have allowed for the shutting down of entire buildings during the school year to conserve energy use. Unfortunately, this idea was further complicated by the fact that very few buildings on campus are classrooms only. Many buildings are mixed use incorporating classrooms, faculty offices, libraries, and study areas and thus, cannot be entirely shut down. These two problems, individual department control and the mixed functionality of

buildings, prevented our group from developing the concept of redesigning the scheduling system, further rendering the project unfeasible.

Focusing on the general idea of energy efficiency, we proposed our second design idea. Our idea consisted of entirely powering down computers around campus at night or on weekends. Upon measuring the average energy use of the computers and their corresponding monitors (approximately 74 Watts and 25 Watts respectively) our concept of turning off the computers and monitors seemed like a very simple and effective way to conserve energy use. However, upon speaking with an employee from Penn State Information Technology Services, this idea was deemed unfeasible. Through this employee, we became aware of the "deep" sleep mode that the school puts the computers in at night and on weekends. This process conserves enough energy to make it inefficient to power them down. In fact to power down and power back up the computers on campus, it would take more energy than if the computers were left on all the time.

With our first two main design ideas behind us and several other proposed solutions proving to be impractical in the brain storming phase, our group had a week and a half until the design showcase. Our project focus had grown from transportation efficiency, to building rescheduling, to computer energy conservation, back to square one without anything to show for it. But through failure comes success. With less than two weeks until the design showcase, our group came up with the idea that sustainability has to start at an individual basis. With this idea in mind we proposed having a mandatory class to teach students about sustainability. From this idea we also proposed including sustainability education during first year seminars, and possibly creating a learning module similar to the SAFE (Student Alcohol Feedback and Education) and AWARE (Sexual Assault Awareness learning module) modules that are completed by students before their freshman year.

Concept Development:

Analytical Hierarchy Matrix (AHP):

	Cost	User Opinion	Ease of Implementation	Energy Efficiency	Length of time to implement	Aesthetics	Provides Employment	Total	Weight
Cost	**1.00**	**2.00**	**7.00**	**1.00**	**8.00**	**9.00**	**9.00**	**37.0**	**0.304**
User Opinion	**0.50**	**1.00**	**7.00**	**2.00**	**8.00**	**8.00**	**7.00**	**33.5**	**0.275**
Ease of Implementation	**0.14**	**0.14**	**1.00**	**0.13**	**1.00**	**0.50**	**3.00**	**5.91**	**0.048**
Energy Efficiency	**1.00**	**0.50**	**8.00**	**1.00**	**1.00**	**9.00**	**9.00**	**29.5**	**0.242**
Length of time to implement	**0.13**	**0.13**	**1.00**	**0.11**	**1.00**	**0.50**	**2.00**	**4.87**	**0.040**
Aesthetics	**0.11**	**0.13**	**2.00**	**0.11**	**2.00**	**1.00**	**3.00**	**8.40**	**0.069**
Provides Employment	**0.11**	**0.14**	**0.33**	**0.11**	**0.50**	**0.33**	**1.00**	**2.52**	**0.021**
							Grand Total:	**121.7**	

Table 1: AHP matrix for user needs to be met

In order to develop a design, our group had to decide what design aspects were the most important. By creating an Analytical Hierarchy Matrix (AHP) we determined that cost, user opinion, and energy efficiency were the most important aspects to be included in our design. As shown in Table 1, the average weight of each of these aspects is about 27%. When developing our solution these aspects proved to be the leading factors guiding the decisions regarding our final design.

Design Selection Process:

When deciding which aspects were most important in a sustainability project, many things were considered such as cost, user opinion, and how efficient such a product would be. Based on the criteria previously mentioned, one concept met our requirements. Based on our Design Selection Matrix (Table 2) and our AHP (Table 1), the module required a much lower cost than creating the class or adding it to the first year seminar. The module was ranked 5 for low cost whereas the class was ranked a 2 and the first year seminar addition was ranked 3.

Therefore, it is clear that the module is cheaper to implement. In addition, the time to implement a module is far less than the time it would take to make up a class or even to write an amendment to a syllabus of a first year seminar. Lastly, based on a survey taken (Figure 1), 75% of students claimed that the learning modules already in place did indeed impact their decisions. Moreover, it is apparent that more students would be receptive to a module instead of a class or a first year seminar addition. Overall, the module satisfies all the requirements and criteria established, making this the best solution of the problem mentioned.

Feature	Module	Class	First Year Seminar Addition
Low Cost	5	2	3
Time to implement	4	2	2
Energy Saved	3	4	3
User opinion	5	3	4
Job creation	1	3	1
Total	18	14	13
	5=meets feature extremely well		
	1=fails to meet the feature		

Table 2: Design Selection Matric comparing concepts

Survey Results/ Preliminary Research:

After deciding to develop a learning module to educate Penn State students about how they can live sustainable lives, we sent out a survey to current Penn State students inquiring about the effectiveness of the learning modules already in place(the SAFE (Student Alcohol Feedback and Education) and AWARE (Sexual Assault Awareness learning module)). The questions selected were focused solely on the effectiveness of the learning modules and not about students' current actions towards living eco-neutral lives. This distinction was made due to the multiple definitions associated with sustainability.

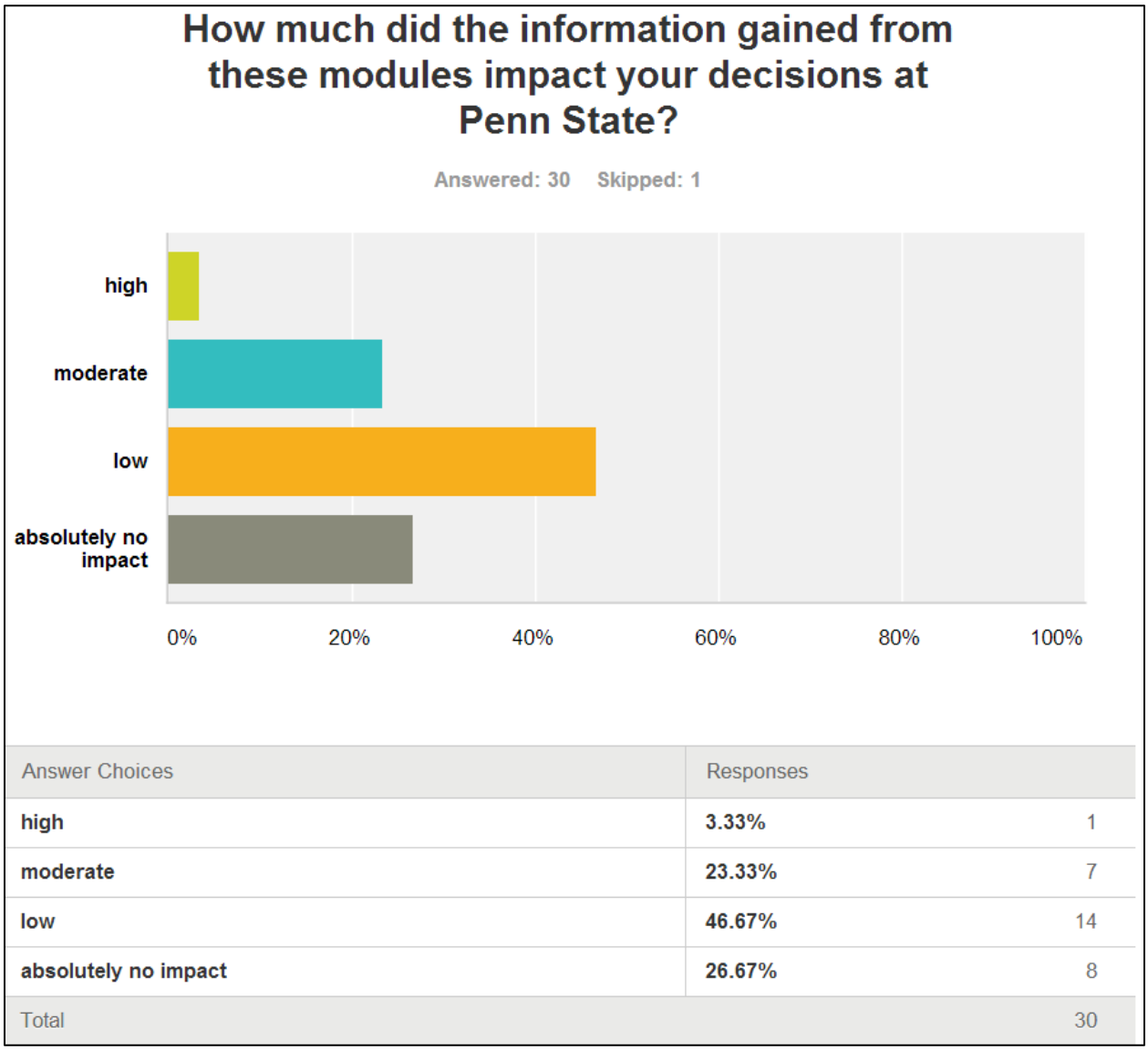
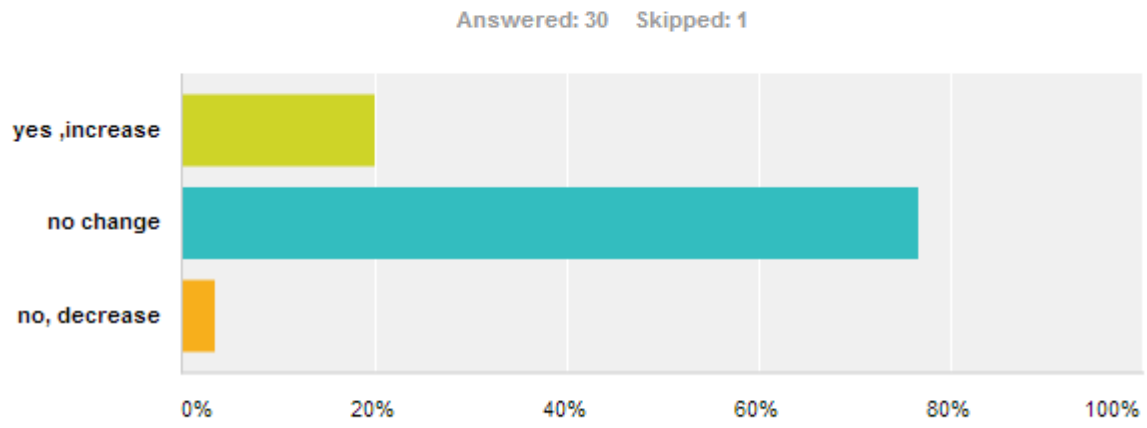


Figure 1: Survey taken by students regarding modules

As you can see from Figure 1, 75% of students admitted that the learning modules directly impacted their actions once at Penn State. This is an impressive number especially when one considers many students strongly dislike these modules. Being that students gained useful information that directly impacted their decisions, leads us to the conclusion that a sustainability learning module would be effective in leading students to live more sustainable lives.



Answer Choices	Responses	
yes ,increase	20%	6
no change	76.67%	23
no, decrease	3.33%	1
Total		30

Figure 2: Survey results taken by students

The question presented in Figure 2 stems from the hypothesis that; if students completed the learning modules after having prior knowledge of college life the information gained would be more impactful and would yield greater results. At first glance, the answers in Figure 2 do not seem to support this hypothesis. However, we believe that these results do, mainly because of the nature of the material covered in these learning modules. Students have strong opinions regarding alcohol consumption meaning that the lack of “yes, increase” responses is due to the topic of the module and not the delivery method (the module itself). Therefore, the fact that 20% of students reported an increase and only 1 student reported a decrease leads us to believe that a learning module with less opinionated material would in fact yield a greater impact if implemented later within the academic year.

Detailed Concept Development:

Development of Final Design:

Part of the final development of our design consisted of researching whether online interactive modules (aimed at teaching sustainability) already exist. Two interactive programs were discovered that seemed to be suitable models for a Penn State Learning Module. The Eco Footprint Network Personal Footprint Quiz[1] and the interactive Campus Metabolism Project at

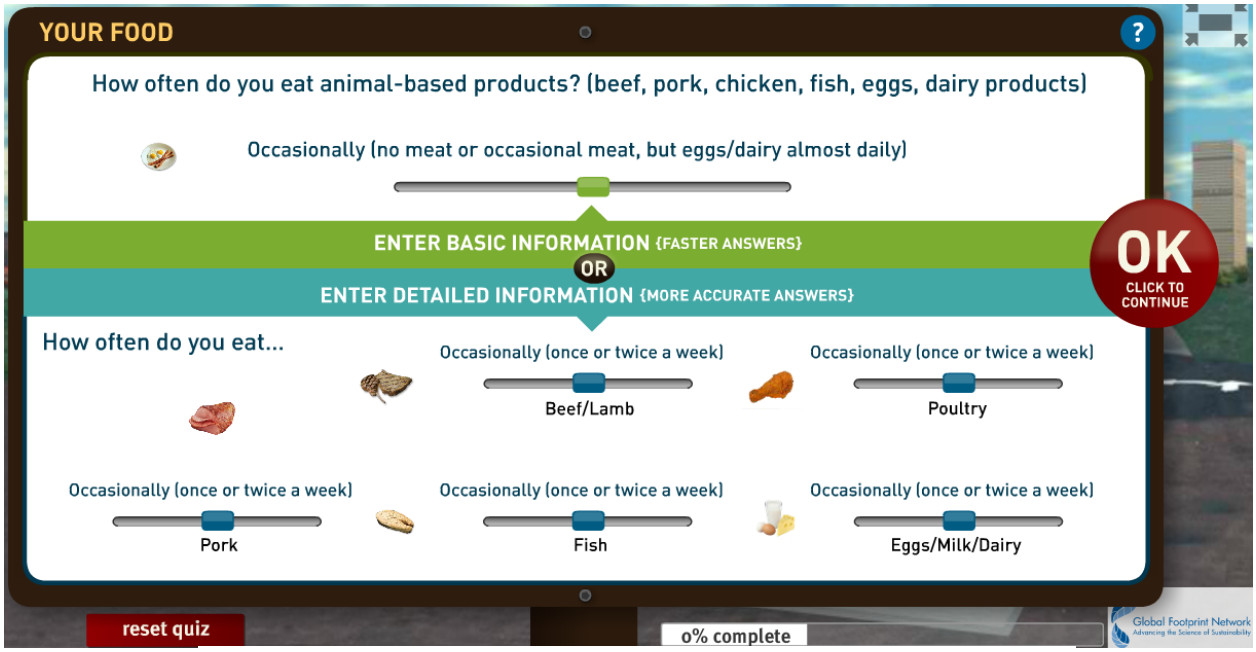


Figure 3: Sample Module Concept from Eco Footprint Network

Arizona State University[2] both are online interfaces focused around educating people about the impacts of their personal actions on the environment.

The Eco Footprint Network Personal Footprint Quiz seen in Figure 3 is primarily used for discovering the personal ecological footprint of an individual based upon their current life style. In Figure 3, the user inputs the types of food they eat and how often, and based upon their inputs, their ecological footprint is calculated. The Penn State Sustainability Learning Module if

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Global Footprint Network, Personal Footprint Quiz; 2013 Global footprint Network; <http://www.footprintnetwork.org/en/index.php/GFN/page/personal_footprint/> [1]
Arizona State University Campus Metabolism Interactive Web Tool; 2010 Arizona Board of Regents <http://cm.asu.edu/#> [2]

developed would incorporate a quiz like this, but with the distinction that all of the inputs

Figure 4: ASU Campus Metabolism Web Tool

would be adapted to Penn State and the lifestyles of current students.

This adaption of the Eco Footprint Quiz with college life has already been partially completed, by Arizona State University's Campus Metabolism Web tool. As seen in Figure 4, all potential appliances in a typical college residence are listed. What cannot be seen in Figure 4 is that the image in the background is interactive, allowing students to go through the model dorm and turn on and off appliances to discover what actions they can take to reduce their electricity usage. The combination of Arizona State University's Web Tool with the Eco Footprint Quiz is the example we built our Sustainability learning module off of. Having analyzed the systems already developed by other universities and organizations, we developed a final design that builds upon and improves these current systems for the implementation at Penn State.

With a model to build a design off of, our group began to research the potential content of the Sustainability learning module and the potential implementation of the module at Penn State. The content research was not difficult, because the Penn State Sustainability office was

already trying to educate students about sustainability. Also the "Green Paws Program" served as a very valuable resource when it came to learning about the personal actions students can take to live more eco-neutral lives. The Penn State "Green Paws Program" provides check lists of these actions, including: activating the power saving mode on personal computers, knowing where the nearest recycling bins are, only taking small portions at the commons and going back for more later, and unplugging and not just turning off appliances. All of these actions are small steps towards Penn State becoming a more sustainable campus, but when 45,000 students partake in these steps it can make a huge difference. Our module would be an interactive program that would allow students to choose which action they could perform from this check list and it would output the difference they could make in their 4 years at Penn State if they followed these actions. For example if a student selected "using the power saving mode on my computer" if this was done for four years the average student would save between $5 and $60 so if all 45,000 students followed suit between $260,000-$2.7 million would be saved annually.

Through the research done on Penn State's current efforts to be more sustainable, many sustainability programs were discovered that were not well advertised. The "Lion Surplus Program" and the "Green Paws Program" are both very useful and creative ideas that have not been advertised to the student body. Informing students about these programs and how they can get involved would be another essential part of the learning module. With so many programs focused on sustainability at Penn State our conclusion is that more do not need to be created, but rather the ones that already exist need to be made known. These programs are Penn State specific and are often directly connected with certain aspects of the campus. This lead to the conclusion that this module should not be presented to students who are new to Penn State, since some knowledge of the campus and campus life is required to understand these programs. However, this information should be presented to students relatively early so that they can implement the concepts learned in the module as much as possible at Penn State.

This concept of waiting until students gained sufficient knowledge is supported by the survey results shown above in Figure 2. When students were asked if completing the learning module, after being at Penn State, would have impacted the usefulness of the information

presented; 20% of students polled said that it would increase the impact. The next question on the survey asked the question of why they thought the time difference would increase the impact of the information gained. The overwhelming majority of responses to this free response question sighted that the information presented would be more applicable after having finished their first few weeks as a student.

Final Design:

The final design of our Penn State Sustainability Learning Module consists of two main parts; the module itself and the time frame in which it is implemented. The module itself will consist of two main sections, the first being an interactive program where students can see how their virtual actions impact their overall sustainability and the second informing students of the current programs in place that can aid them in living sustainable lives. In the first section (approximately 45 minutes for completion) the virtual actions chosen will include the immediate results of the action itself, but it will also calculate the impact to Penn State if every other student lived the same way. The data supporting these calculations will come from the technical specs of common electronics found in dormitories/apartments, building and recycling information the office of Physical Plant, and additional information from the Sustainability Office at Penn State. These results will have the effect of informing students about the overarching impacts of their actions, and through this they will be more likely to change their actions. The second section of the module consists of a short informative section (15 minutes) focused around the current programs at Penn State geared towards aiding students towards living sustainable lives. Some of the programs mentioned would include “Penn State Green Paws”, “Lion Surplus”, and the “Take Charge Program”. All of these Programs are run through the Campus Sustainability Office and will become more affective with growing participation.

The set time frame for the completion of this module is before the second semester of attending a Penn State. As stated above, the reason for this time is so that the students have firsthand knowledge of the campus and therefore are able to apply the knowledge they learn directly to how they live as a student at Penn State. These modules will not only be part of the

freshman year, but include a 30-45 minute modules every consecutive year after, to keep students up to date on their own sustainability efforts along with Penn State as a community.

Initial investment/Break Even:

The potential cost savings of this design is hard to calculate due to the variability from person to person and the actions they take. However, according to the Sustainability Office "If all 55,000 Penn State students turned off their computers when not in use, the University would avoid paying between $260,000 and $2.7 million in annual electricity costs" this large variation in savings is due to the number of differing models of computers.

In 2011 12,782 tons of waste was produced by University Park and only 7,382 was recycled (58%). An estimated 67% of the 13,000 tons can be recycled. Meaning 1182 tons of recyclables are going to a landfill. Penn State pays at most 20$ per ton to have it recycled and 70$ per ton to have it disposed of as waste. Using this information; if all of the 1182 tons of recyclables were recycled Penn State would save a minimum of $59,100.

In addition, the Sustainability office conducted an experiment on the amount of money that can be saved at Penn State by a change of culture. They found that the conservative estimate of $15,982 per building in appliances and lighting savings and $23,701 in HVAC savings supports the study: payback period, the time to recoup the money spent investing in the programs (appliances, training, etc.), is likely to be less than two years. This is all relative to the extent of the program expansion. With a complete building savings average (including appliances/lighting and HVAC) of $42,729, and a population of buildings on University Park Campus of over 165, the potential one year savings to be earned from Green Teams and Green Paws with campus wide participation would be upwards of $6.5 million based on the conservative estimates alone.

As you can see in Figure 5, the payback period is less than one year. Spending approximately $1,000 per year after the initial $60,000 can save the University millions of dollars. The graph shown in Figure 5 is exponential due to the fact that this is a culture change

at Penn State, as more and more students become informed after taking these modules year after year, more action will be taken towards sustainability.

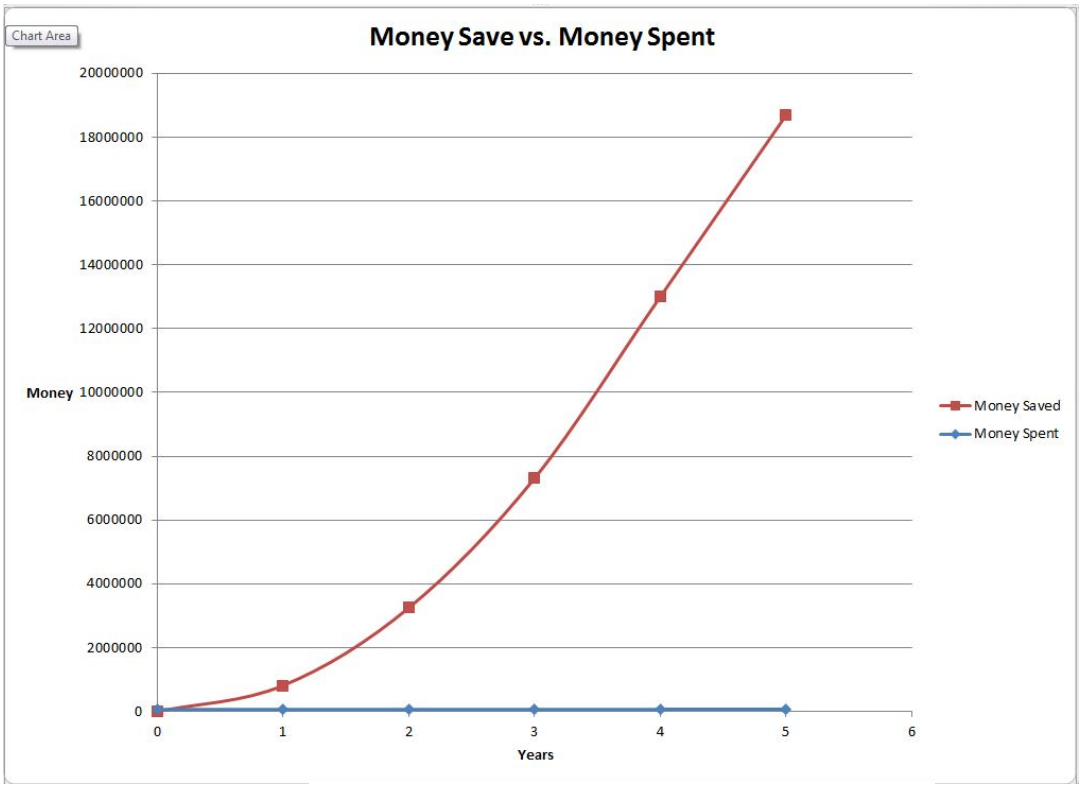

Figure5: Payback period graph

<u>Conclusions:</u>

Positive Features/Design Properties:

Any good design puts an emphasis on the values that a design group finds to be of utmost importance. As for us, our top priorities; total cost, user opinion, and the effect on energy efficiency, were taken very seriously and vigorously researched. Perhaps the biggest upside to our design is the simplicity with which it can be achieved and be effective. All three of our top priorities played a factor into this simplicity and were met by our solution.

First, the total cost for the information to be compiled, the programming to be done, and the final implementation and follow through of the design is lowest possible cost of the three options we looked at (estimated $30,000-$60,00 for module based upon the $150,000

cost for an entire 3- credit World Campus class), as a large majority of the costs going into the design is labor. After the module is completed, the running cost is almost next to nothing. Running costs consists of minor program updates and maintenance. The net potential savings are astronomical in terms of the amount of investment, at an estimated $6,500,000 per year for the University, compared to the savings from the reduced electricity use and HVAC systems alone. The previous number could increase over the years as the culture changes and a larger percent of the student body have been educated on the effort for sustainability and take action.

Next, we looked at the level of effort that would constitute putting this plan into action. Through talking with people familiar with the sustainability effort at Penn State we found that the University has a policy; that if the program or design will not meet a breakeven point within ten years of completion they will turn it down and look for other solutions. Our module design, with the relatively low cost and high potential for return, definitely exceeds this expectation put forth by the University. The savings potential when the campus reaches the peak efficiency for recycling will have a net gain of around $60,000 per year, as stated in a previous section. This impact alone could return the initial investment, neglecting the energy and other utilities savings. Unlike other efforts to increase sustainability, the module will not consist of any disruption to daily campus life to be put into place. There is no construction, just information for the common student to use to help out anyway they can.

Our third biggest factor affecting our design was the actual effect on energy use and the environment on the whole. Based on the data provided by the Pennsylvania Public Utility Commission[3] we found that the current average price per kWh from the power companies stands at around $0.08. With the data of the total money that would be saved from just HVAC systems and general electricity, we can calculate that, through the efforts of Penn State students and faculty alike, the University would not use about 81.25 million kWh of electricity per year. This amounts to about 37 days' worth of electricity use saved based on the current daily consumption of electricity at the University.

[3] Shop for Your Home. PA Power Switch, PUC. 24 April 2013, <http://www.papowerswitch.com/shop-for-electricity/shop-for-your-home/by-distributor/ppl/rs>

Penn State Adoption/Feasibility:

The feasibility of this concept was something our team highly valued. Much of this is stated in the previous section, but what makes this plan work and highly practical are the relatively low costs of the initial investment from the University standpoint. Also this design lacks any construction cost that is often sighted in other sustainability programs. Most sustainability efforts being made are large scale and can cost a lot of time and money along with the closure of buildings and facilities across campus, inconveniencing students and faculty. Our module is in fact so feasible that one of the contacts in the sustainability department here at Penn State said this was a great idea and encouraged us to pursue and develop our plan for actual implementation at the University.

Lessons Learned:

There were definitely many lessons to be learned from this project. The first thing we found was that it is extremely important to brainstorm. We spent the majority of our time thinking of the best way to approach this project and still many of our initial ideas failed. As our transition between topics (transportation-redesign scheduling-efficient building use-efficient computer use) shows, there are a wide range of options to explore regarding sustainability at Penn State. We also learned to question the importance of current actions at the Penn State campus. The one idea we were pursuing (turning off all computer on campus) became a dead end as we found more information regarding the steps Penn State took to maximizing energy efficiency in the ITS department. Our project became scattered as our original idea fell apart; so through this failure we learned it was crucial to communicate and work as a team towards a common goal. We were able to pull together as a group and find a feasible solution to a major at problem at Penn State, by changing the culture on campus to one focused around sustainability.