Solar Charger

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Chapter 1: Introduction

Austin Davis, Austin Luginbuhl, Morgan Grasz, and Colleen Way, with assistance from Professor Benjamin Cohen, developed the idea for this Engineering Studies capstone project. The specifications were fairly general; groups were to create and execute a project, which could reasonably be completed within the last six weeks of the Fall semester. Our group chose to pursue campus sustainability. The planning process, including social context, economic, technical, and political analysis, is detailed in the following pages. The conclusion section explains the outcome of the project, and what follow-up should be completed for the project in the future.

What does it take to install umbrella-style solar charging stations on campus? What kind of demo could illustrate this?

As a higher education institution, it is important for Lafayette College to inform its students of contemporary global issues, such as climate change. The College has demonstrated a lack of commitment to an important aspect of this education, by failing to move forward with proposed initiatives, perhaps due to a heavily bureaucratic administrative system as well as economic restraints. For instance, several Engineering Studies capstone groups have attempted to impose a more efficient recycling system on campus in the past, to no avail. Some initiatives that have been implemented have proven to be unsuccessful, due to their lack of accessibility or relevance to students. One such initiative was a electric car charging area in the Sullivan Parking Lot. Few students at Lafayette drive electric cars, so many were unable to take advantage of this resource. In order to successfully implement a sustainable initiative on campus, it is important to consider social context, and economic, technical, and political feasibility.

Figure 1. An example of the Solar Power-Dok, developed by EnerFusion, Inc. (Enerfusion).

After thorough analysis in the aforementioned categories, we found the implementation of the Solar Power-Dok, created by EnerFusion, Inc., at one of our outdoor eating facilities to be a feasible option for Lafayette College. As defined on the company's website, the Solar Power-Dok is "designed to provide self-sustaining green energy wherever it is placed outdoors with access to direct sunlight." The technology is comprised of a table and umbrella, which is attached to solar panels. This picnic table is a charging station, and would most likely be implemented at Gilbert's Café, due to high traffic and access to direct sunlight.

Figure 2. The proposed area for a Solar Power-Dok, Gilbert's Cafe (Lafayette, 2014).

Some potential challenges we may face with this project include lack of student awareness, cost of implementation, the usefulness of this technology on Lafayette's campus, and administrative acceptance. In order to overcome these challenges, it is important to partner with well-established campus organizations, foster relationships with the manufacturer, model the impact of the solution on campus, and maintain efficient communication.

Figure 3. A student uses the Solar Power-Dok to charge her laptop and cell phone (UMass, 2014).

In order to lower the cost of implementation, we asked the representative from EnerFusion if we could purchase just the umbrella, rather than the umbrella attached to the picnic table. We already have similar picnic tables in front of Gilbert's, and it could have potentially lowered the initial cost of the project. We discovered, however, that the batteries are not compatible to the tables we currently have, so we must purchase the entire table system. The Solar Power-Dok picnic tables themselves are environmentally friendly; they are made out of recycled plastics.

Another challenge we may face is students' willingness to utilize the charging station. As previously mentioned, projects that have been implemented in the past have proven to be either too complicated, or irrelevant to students. We believe, however, that the location, and ease at which students can use the Solar Power-Dok, will address this issue. In order to gauge students' interest in the project, we sat in the Farinon College Center and asked students to sign a petition for the implementation of the solar-powered charging station. We collected approximately 200 signatures, which represents almost 10% of the student body. Therefore, we believe that this project will be widely accepted and used by Lafayette students.

The final hurdle we will most likely need to overcome is Lafayette administration's acceptance of this proposal. If we do make this purchase, it would be a rather large investment for the College. We can justify this cost, however, by explaining the several benefits that are associated with the table. It will raise awareness among not only the current student body, but also prospective students, about the College's efforts towards sustainability. In addition, we have presented our ideas in an organized, understandable, and professional manner, so that our proposal is taken into serious consideration. We have also involved members of the Engineering Faculty, such as Professor David Veshosky, who are willing to offer their support for this proposal.

The success of this project relies on thorough planning. In the following sections, we will discuss the social context, and the policy, technical, and economical analysis to be applied for the implementation of the Solar Power-Dok.

Social context is an important aspect of the planning process, because it is important to understand the society in which the technology will be implemented, in order to ensure the highest rate of success. Lafayette College is a unique community, and it is therefore crucial that we take all characteristics (e.g. students' interest, awareness, etc.) into consideration with the planning of our project.

Figure 4. The Solar Power-Dok, customized for Lafayette College. Provided by Tom Davis, Vice-President of Enerfusion, Inc.

Capstone_Bibliography

Continue to the analysis of America's and Lafayette College's social context.

Chapter 2: Social Context

The American culture has often been associated with wastefulness. This idea can be traced back to early development, when Americans were told of the limitless land and resources in the unsettled West. As a result, Americans often do not see the resources and energy they use as truly finite. Within the past few decades, this wastefulness has been connected to climate change. Subsequently, the culture has gradually shifted to focus on environmental awareness and sustainability, which influences day-to-day decisions.

Higher education institutions have been given the responsibility of research and development of environmental sustainability efforts (Emmanuel & Adams, 2011). They not only have the funds to dedicate towards research, but they also have the distinct advantage of being a miniature community. Any sustainable solutions proposed could be tested in a college environment, and the feasibility would be accurately reflected. Lafayette College has taken strides towards achieving some of these efforts, such as renewable energy. Due to the restrictive nature of these projects, many students either are unaware of or do not take advantage of them. The Solar Power-Dok would allow students to actively participate in its utilization on campus, which would not only preserve energy, but would also increase awareness and a sense of responsibility among the students.

As previously mentioned, the American culture has been slowly shifting towards environmental awareness, due to recent data about climate change. The generation, which is currently in higher education, has grown up with this knowledge incorporated into educational systems. Therefore, one would think that Lafayette College students would be proactive about the implementation of sustainable initiatives on campus. This belief, however, is untrue. Unless a task is made easily accessible and efficient, it is very unlikely that Lafayette students will become involved. For instance, there have been several attempts to promote recycling on campus, but students still choose to place their plastic bottles and aluminum cans in garbage bins, rather than the recycling bins a mere two feet further away. We believe that the Solar Power-Dok is a suitable initiative for Lafayette's campus, because it is easy to access and use. Because of its location at a campus dining facility, there will be high traffic in the area, so students will be encouraged to make use of it.

Another reason why Lafayette students may not be so invested in the conservation energy is all-inclusive price of utilities. If students are not paying out-of-pocket for unnecessary energy spent, then they are less likely to be inclined to saving it. Although the implementation of the Solar Power-Dok would not change the energy cost system at Lafayette, it would ideally raise awareness among students that they have the power to limit their energy usage.

COLLEGE COSTS 2014–15

Billed Expenses	
Tuition	$45,230
Activity and technology fee	$405
Room fee (standard room rate)	$8,360
Board fee (20 meals/week)	$5,160
TOTAL	$59,155

Figure 2. The breakdown of annual college expenses. Retrieved from www.lafayette.edu.

Our decision to implement a charging station also involves the culture surrounding portable devices. Portable technology is becoming more and more commonly used, especially on college campuses. Students are typically restricted to the indoors, due to the constant need to charge these devices. The implementation of the Solar Power-Dok would allow students to fulfill this need, while being environmentally friendly.

The Solar Power-Dok would also benefit Lafayette’s campus, because it discourages vampire energy. Also known as phantom load, standby power, or idle current, this term is used for the electricity that outlets suck from plugged-in gadgets (TECH BEAT, 2012). Although this waste of energy can easily be stopped by unplugging all gadgets when they are not in use, many Lafayette students are unaware of it. Because the Solar Power-Dok tables would require students to use their own chargers, which they would unplug when they are done charging their technology, it would prevent vampire energy. In our promotion of this table, we will include information about the ease and importance of unplugging gadgets when they are not in use.

Figure 3. A comical representation of vampire energy. Retrieved from www.environment.utk.edu.

These contexts have discouraged any sustainable initiatives proposed at Lafayette from coming to fruition. As mentioned in the introduction, projects must be easily accessible and relevant for students. In order to successfully implement the Solar Power-Dok, we must thoroughly consider all analyses to be undertaken. Included in these analyses are potential challenges we may face, solutions to these problems, all necessary contacts to be made, as well as technical and economic feasibility. Due to the intricate planning process of this initiative, it can justifiably be considered a project. We will be testing the ability to implement the Solar Power-Dok on campus with our submittal of the capital request form.

As mentioned in the introduction, the problem that the Solar-Dok will solve is the lack of student awareness of and involvement with sustainable campus options. This problem is important to address, because as a group of highly-educated youths, we should be aware, if not active, in the research and development of sustainable initiatives. After our demonstration, previously mentioned in the Introduction, we have deemed the Solar Power-Dok to be a suitable solution to this issue, because students are both interested and willing to make use of an outdoor charging station.

Click here to continue to the Policy Analysis.

Chapter 3: Policy Analysis

In this section we will explore the political environment surrounding the implementation of a solar umbrella charging station here on campus and the growth of sustainable initiatives on college campuses around the nation. We will also outline the channels that have been navigated to bring this project to fruition. The first step in analyzing the project from a policy perspective was to determine the primary stakeholders of this endeavor; simply who this project is for and who can ultimately make the final decisions. The primary stakeholders of this project are the students and community members here at Lafayette, the Engineering Division and the Lafayette College Administration. The students and campus community members will ultimately be utilizing the new system on a daily basis to charge their electronic devices from a sustainable and renewable source. Although the students and campus community members will be utilizing the new technology, they have very little to no say in regards to the approval process. The Lafayette College administrative faculty must handle the approval process; the positions involved in a capital project request application include, but are not limited to, The Director of Facilities Planning and Construction, Plant Operations Director of Physical planning, Vice President of Finance and Administration as well as the Treasurer of the College. This brings us to our final stakeholders, the Engineering and Engineering Studies Program. The Engineering Division has been increasing its education and exposure in regards to sustainable practices and has acted as the branch under which we have worked to make the solar charging station a reality.

There has been a push for increased sustainable practices and initiatives at many of our nation's colleges and universities. A push for a more penchant need for sustainable education that emphasizes a respect for the environment can be seen as early as 1990 in the form of the Talloires Declaration. This initiative was started when former president of Tufts University, Jean Mayer, organized 23 university leaders from around the world in Talloires, France to discuss the state of the world and create a document to outline actions universities must take to ensure a sustainable future. The Talloires Declaration has been signed by 265 university presidents and chancellors from over 40 countries (Clugston, 1999).

It is very easy for an institution to sign a document assuring a shift towards sustainable education and development but their are many organizational barriers that prevent an institution from making this shift. In an analysis conducted by Michael Shriberg on organizational factors influencing campus environmental performance and leadership he concluded that:

"Image-seeking behavior, collaborative decision making structures, collegial atmosphere and progressive/liberal political orientation are strong positive (non-environmental) conditions for success in campus sustainability efforts. However, these conditions are beneficial to campus sustainability only when strongly linked to environmental and social issues by change agents" (Shriberg, 2002).

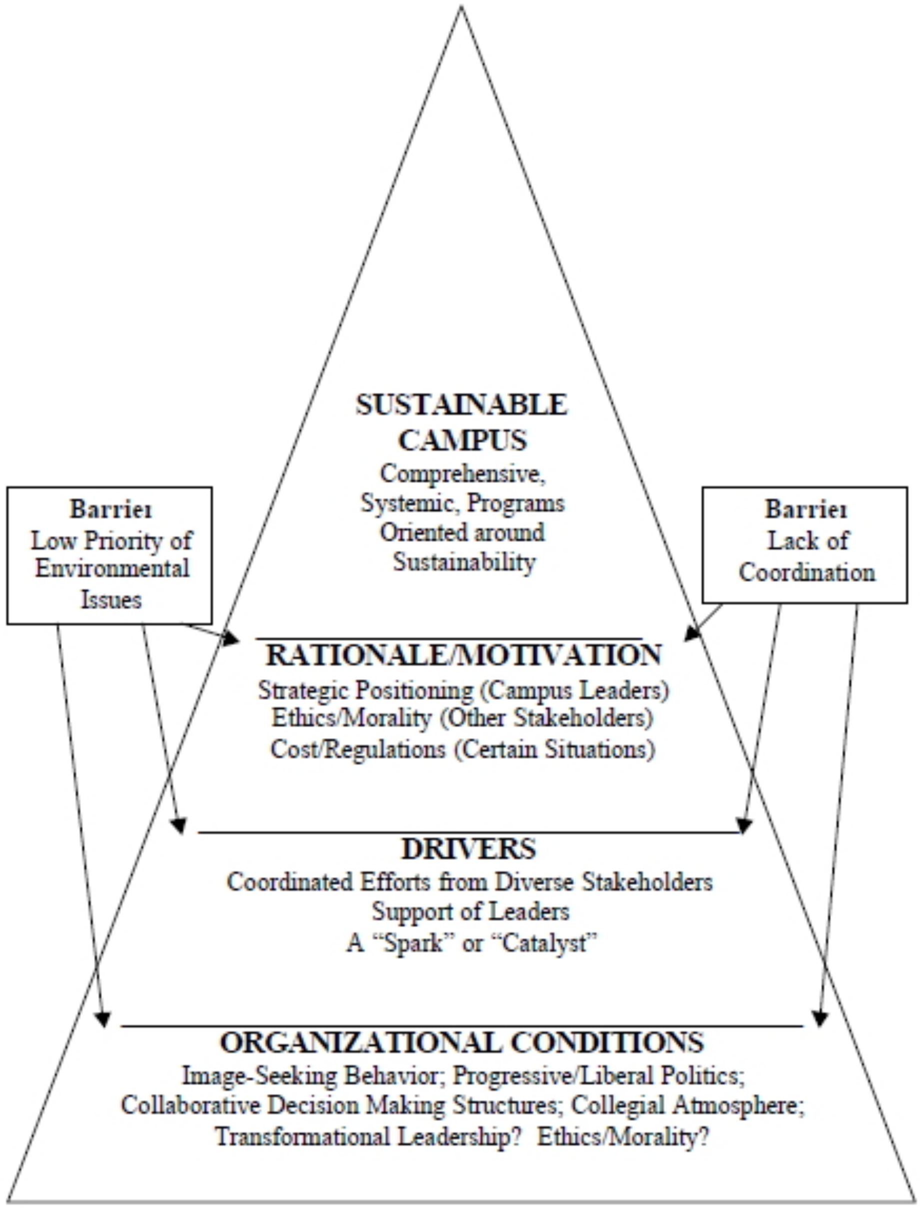


Figure 1: Model of Organizational Factors Leading to Sustainable Campuses (Shriberg, 2002)

Another aspect determining the success of campus sustainability initiatives involves exactly who is facilitating and driving change within a campus community. In order to bring about positive change it is imperative to have a diverse group of stakeholders, with the support of top leaders, to coordinate with each other and take advantage of an initial push for sustainability (Shriberg, 2002). In the case of our project, we have the support of the Engineering Studies Program and Sustainability Committee as well as many student organizations on campus that are looking to expand sustainability on our campus. The only factor holding this sustainability initiative back is the support of decision makers who have to ability to implement projects and initiatives brought forth. Figure 1 on the right is a visual that outlines organizational factors that may lead to a sustainable campus as well as barriers represented between each factor.

An organization that is proliferating the ideas of sustainability on college campuses is the Association for the Advancement of Sustainability in Higher Education (AASHE). The mission of the AASHE, "is to inspire and catalyze higher education to lead the global sustainability transformation". They have established a website that outlines multiple initiatives at higher education institutions around the globe and give countless resources to improve the growing need for sustainable practices. This just demonstrates how more and more groups are getting involved in the sustainability movement and there are countless resources and outlets for more information and guidance for college campuses.

Moving on we will now define exactly who on our campus is able to implement the technology we wish to bring to campus. As stated above, many administrators are involved in the process required to implement a capital project on campus. The most invested is The Director of Facilities Planning and Construction; here at Lafayette the administration has a vision as to what the campus will look like many years into the future in terms of the physical layout as well as the aesthetics of the campus. These two aspects combine into a comprehensive plan of the direction of the campus in the near and distant future. In order to be able to implement the solar charging station we must convince the proper parties that this projects fits within the vision of Lafayette College progressing into an era focused on sustainable development and practices. This approval process is laid out very clearly on the Facilities Planning and Construction page on Lafayette College's website. We will briefly explain the process we have gone through that is necessary in order to implement a new capital project on campus.

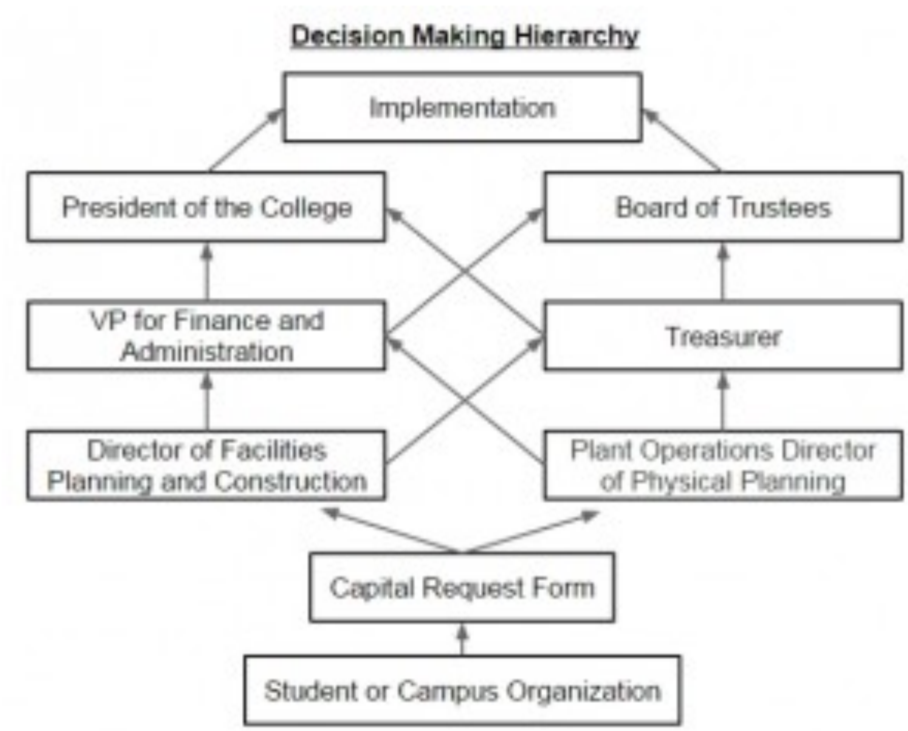


Figure 2: Decision Making Hierarchy at Lafayette College

In order to implement a project such as this there are many different procedures we have followed. Here at Lafayette College we have a very clear and concise process in order to get approval to pursue a capital project here on campus. The first step of the process requires a Dean, Chair, Faculty Member or other College stakeholder to fill out the first section of a request form. They first section required a brief project description, cost estimate, department and division approvals and proposed funding sources. In the case of our project, we would develop the proposal under the guidance of Professor Benjamin Cohen, adviser to Engineering Studies Capstone projects. We have also gained support from the Engineering Division and Sustainability Committee. We have also been in contact with the manufacturer of the charging station and received a complete quote that we included with the request form. In order to further advance our initiative we created a petition for students to sign that are in support of the solar charging station. All but the aforementioned first step of the application process is tasked to administrative actors and those who have great influence on the direction and needs of the campus as a whole.

Figure 3. Markle Hall, location of Lafayette College's administration. Retrieved from www.lafayette.edu.

In the second step of the process, Director of Facilities Planning and Construction and Plant Operations Director of Physical Planning will first go over the proposal to review and then later confirm the scope of the project if deemed feasible. They must also take into consideration the estimated cost of the project and determine whether or not it is in compliance with the college's strategic plan and campus master plan. In the case of our project we have a quote specific to our needs from the company that we have contracted to supply the power station so there is no need for modification. These discretionary decisions are made by administrators high up in Lafayette College's decision making hierarchy. They often take into account the opinions of their colleagues as well as faculty members with greater professional understanding of nature of the proposal at hand. After going through the previous review process, if it is approved, the proposal then moves on to the various division heads such as the VP of Finance and Administration as well as the Treasurer of the College to determine a funding source, as well as total annualized and incremental costs. The only costs associated are the initial purchasing cost, the only maintenance required is that the panels are wiped off once every six weeks, this is a negligible operation and maintenance cost.

If the proposal makes it past these thorough review processes it is then approved to be pursued. If a project requires a large amount of funds or will significantly impact the direction of the College the President or Board of Trustees must approve it. In the case of our request, it would not require that level of administrative involvement. After the approval process, the project must then undergo the implementation process.

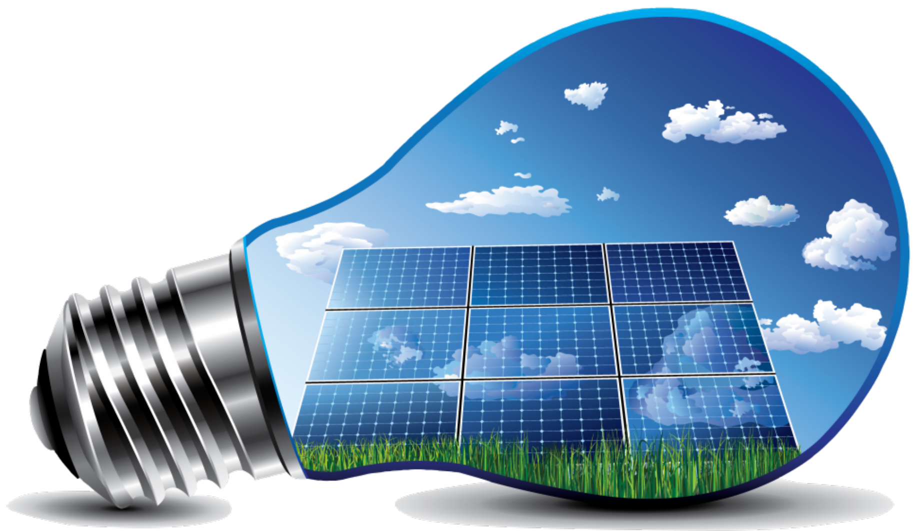
If the project fails the capital request procedure we must have an alternative that would still allow us to still implement our project. To combat a failed request we believe the Engineering Division would be able to take the lead since we have already laid out all of the initial ground work. This would provide a great opportunity for an interdisciplinary senior design project with a student from each engineering discipline to come together to reverse engineer and construct a solar charging station without the monetary limitations of buying a Solar Dok system from EnerFusion Incorporated. This would also allow students from outside of the Engineering discipline to be involved and look at community implications as well as economic restraints.

Retrieved from ideal.lafayette.edu.

We can see a growing number of higher education institutions making progressive efforts to make their campuses more environmentally friendly to foster the idea of sustainable development. Lafayette College is a highly regarded engineering school and is often portrayed as a progressive institution but not nearly enough is being done to push the agenda on renewable energy technologies as well as sustainable development of the physical campus as well as the campus community. There are many stakeholders that would be involved in the decision making process as well as the implementation of our proposed technology. We see great potential in moving this project along from not just a strictly engineering perspective but also incorporating other departments and organizations around campus as an example of interdisciplinary cooperation at work.

Follow this link to explore the Technical Analysis of solar power and the EnerFusion Solar Power-Dok: Technical Analysis

Chapter 4: Technical Analysis



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The technology aspect of this project mainly focuses on the capabilities of the solar umbrella itself. It is relevant to explain how solar panels work in so far as they pertain to renewable energy. Solar panels consist of two layers separated by a junction. Electrons on the top layer move freely and a charge imbalance is intentionally created between the layers. Photons from the suns' rays hit the layers and the electric field that forms across the junction causes electricity to flow. The circuit is closed by the electrons "wanting" to return to the upper layer to balance the charge discrepancy. Please visit this link for more detailed information on how solar panels work (How Solar Panels Work)

Since solar panels require sunlight to produce electricity, how suitable is Lafayette college for the implementation of solar technology?

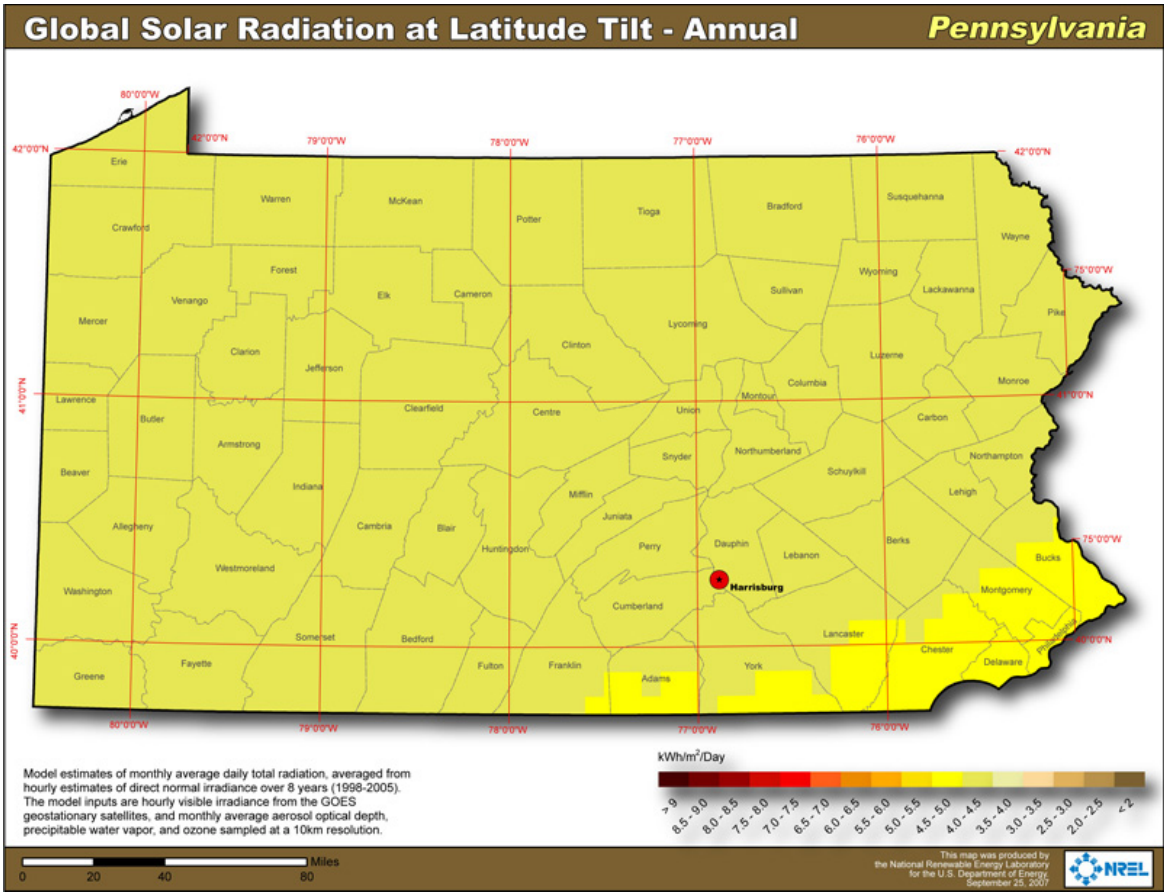

Figure 1. PA Solar Map. PA Solar Capture (apps1.eere.energy.gov,2007)

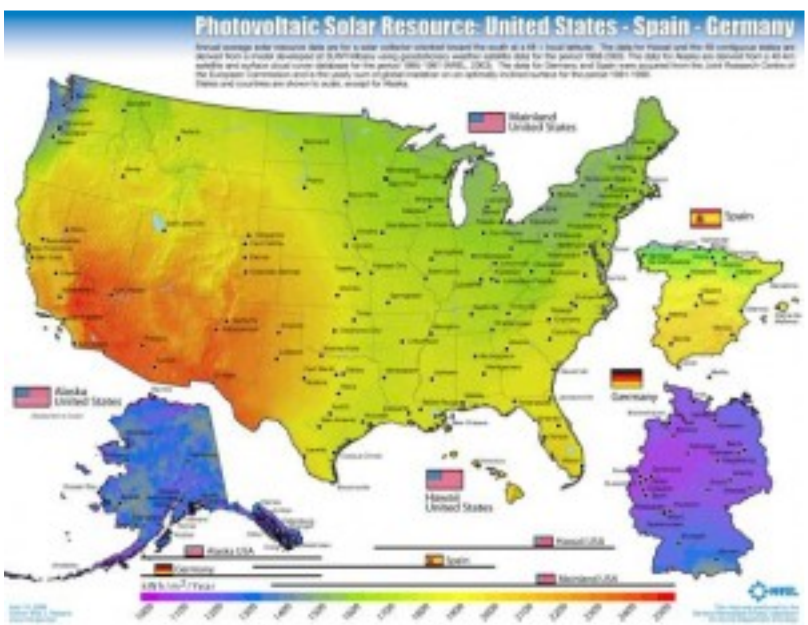

Figure 2. PA vs. Germany Solar Resource. Solar collection map.(washingtonpost.com, 2011)

Easton, Pennsylvania (PA) gets about 4.5-5kWH per meter squared of collected sunlight per day. "The kilowatt-hour (symbolized kWH) is a unit of energy equivalent to one watt (1 W) of power expended for one hour (1 H) of time" (Techtarget.com). In 2013, Pennsylvania installed 38MW worth of solar technology. This ranks Pennsylvania 14th in the country so far as energy production via solar technology is concerned (seiastate.org). Pennsylvania can be compared to Germany, a country that obtains 20% of its energy on any given day from solar technology (Plumer, 2014). PA is much better suited for the implementation of solar panels than is Germany, the world's leading solar technology user as can be seen from figure 2. Germany only gets around 1000 kWH/meter squared of solar energy a year while PA gets around 1900 kWH/meter squared.

Three sites were selected as possible Power-Dok locations. Ideally, this location would be convenient for students as well as optimize sunlight capture for the solar panels. The usefulness of solar panels in these locations as it pertains to building shading and other factors was analyzed. The locations included the outdoor dining facilities at Farinon, Gilbert's, and Simon's. Based on the orientation of these locations in relationship to the daily movement of the sun it was decided that Farinon receives sunlight for the first half of the day, Simon's for the whole day, and Gilbert's for the whole day. Therefore, Simon's and Gilbert's were the two most attractive locations for Solar Power-Dok technology.

Retrieved from hostonnet.com

Furthermore, it was necessary to obtain detailed performance capabilities of the Solar Power-Dok technology. The Solar Power-Dok is capable of generating 600Wh, which is equivalent to the energy needed to power a refrigerator (Saltzman, 2012). Students would mainly use the 6 possible USB and standard outlets available on the Power Dok to charge phones and laptops. The typical iPhone needs 5.45Wh to charge and an average laptop requires 197Wh to charge (Helman, 2013). According to the head of Plant Operations at Lafayette, Bruce Ferretti, Lafayette consumed 26.4 million kWH of energy in 2013. The Power Dok will hardly put a dent into this massive energy usage, but, as has been explained in other sections, the purpose of this project is to raise student awareness in regards to sustainable solutions and not to make Lafayette a 100% solar-powered campus. The charging station produces a readout for students about how much energy is currently being generated by the solar panels. This feature is useful for helping students interact with the Power Dok and to quantify the difference its utilization makes. This technology also has a battery which stores excess energy for use at night or during a cloudy day. This battery must be replaced once every eight years. The Solar Power-Dok is "off the grid" so its usage can only detract from campus electricity usage. For more details on the specifications of the Solar Power Dok, please follow this link.

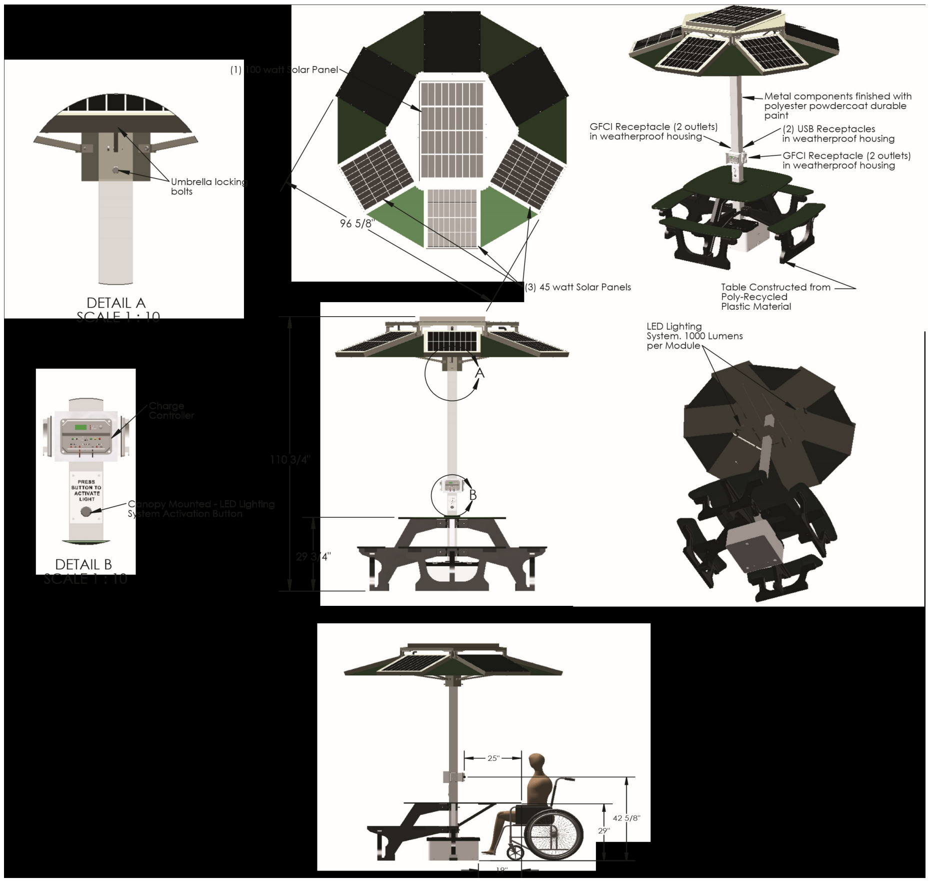

Figure 3 Solar Power Dok Specs. Table images. (Enerfusioninc.com, 2014)

Other technical considerations were made apart from the solar energy components. The Solar Power-Dok unit consists of the solar umbrella, table, and bench. The portability of these parts, or lack thereof, was also important. As the product must be installed by EnerFusion in a permanent location, they can not be considered portable. If the school denies funding for this project, plan B is to pass it on to senior design projects. Engineers could design and build the actual solar panels, economics majors could perform cost analyses on the project, and Gov/Law and EGRS students could tackle social and policy topics. It could become an interdisciplinary project that brings engineering and the liberal arts together to benefit Lafayette College and raise awareness about the importance of sustainable solutions.

To view more about this project, please continue to the economic analysis.

Chapter 5: Economic Analysis

Retrieved from: http://images.wisegeek.com

In order for a solar charging umbrella to be implemented at Lafayette College, a capital request form must be submitted and subsequently approved. The capital request form requires a budget estimate and although our budget is rigid, the positive externalities will not be factored in, failing to give a true picture of the projects "cost." Economic value can be derived from multiple sources, some of which cannot be specifically quantified based solely on monetary value. For those factors we have done our best to accurately convert them to quantifiable values so alternatives can be fairly compared.

Cost of Energy Generation (Easton, PA)	0.12	cents/kW
Cost of Energy Generation (National Rate)	0.083	cents/kW
Energy Produced per day	0.6	kWhr

Savings per Day		**Savings per school year**	
$	0.86	$	181.44
$	0.60	$	125.50

We have identified raising awareness as the primary objective of our proposed solution; however the economic value of this is not easily quantifiable. Therefore, it was crucial that a process for deriving the economic value of intangibles be identified, allowing for standardized adjustments to costs reflecting feasibility given our unique needs. One method we identified was benefit-cost analysis, which determines if an action is advisable based on the output of benefits divided by costs (Laskaris 2013). Given the sunk costs that are typical of the majority of sustainable solutions, having the ability to adjust the price based on the effects of the implemented solution will allow for a more acceptable outcome of a breakeven analysis.

Alternative	Cost	Days Till Breakeven	School Years
Solar Power-Dok	$ 9,500.00	10,995.37	30
Solstice	$ 6,000.00	6,944.44	19
Radiance	$ 8,500.00	9,837.96	27

Conducting the breakeven analysis using adjusted costs will result in a shorter period of time to recoup the costs, which is viewed as a more favorable result. With a well-executed benefit-cost analysis, it will be feasible to determine a process for adjusting the price so that the output is not artificial, it is backed by fact. Imputing the result into a breakeven analysis would yield the amount of time it will take to recoup the cost of the investment (Blank 2012). Without the use of the adjusted cost in the breakeven analysis, the manufacturer price would need to be used, whose result is very discouraging. Our initial result was a duration of over two decades for the college to recoup the cost of implementing a Solar Power-Dok on Lafayette's campus. However the only return on investment considered during the first analysis was the amount of money saved on energy production costs. That factor alone is a major source of potential error, the price of energy will not stay constant throughout the next two decades and therefore unless the average over that span is equivalent to the number we used, then the analysis does not yield a concrete result. Another consideration is inflation, which will undoubtedly fluctuate over the time period.

The error resulting from the use of certain factors can be mitigated to a certain degree, which would increase the accuracy of our breakeven analysis. In order to adjust these factors, we had to first determine the best process for forecasting the price. Present Worth Analysis was utilized to determine the net present value of the cash flows for the monetary savings generated by the Solar Power-Dok. Finding appropriate rates of change for inflation and the cost of energy generation is crucial because an incorrect factor would corrupt our results. We determined that appropriate rates should be more conservative than neutral, to build an additional cushion into the number, protecting our result from new sources of error.

Ultimately the breakeven analysis and the benefit-cost analysis will yield the two most important indicators of the attractiveness of implementation, through a purely economic lens. However the two analyses' results offer very different conclusions. The benefit-cost analysis result is viewed as a binary value; if it is less than 1 then the project is too expensive to justify undertaking. If the resultant is greater than 1, the project should be undertaken because the benefits outweigh the costs (Blank 2012). With a breakeven analysis, the output number represents the number of, in our case, school years until the return on invested capital matches the cost. We decided that the Solar Power-Dok will get most of its use during the school year, while students are on campus, so in the breakeven analysis we used school years (35 weeks per calendar year) as the unit of time. This will further ensure the accuracy of the result of the analysis due to the increased accuracy of the input values (El Alimi 2014). Together these two powerful analyses will offer a good picture of the economic value of the Solar Power-Dok relative to the needs of Lafayette College.

Alternatives	Maximum Number of Users	Energy Produced / Day	Number of Outlets	Number of USB ports	Ability to Raise Awareness (Rank 1-3)
Solar Power-Dok	8	0.6	4	4	1
Solstice	4	0.2	2	2	3
Radiance	7	0.4	0	7	2
Adjustment Weight	2.5%	5%	5%	5%	10.0%

(For the price adjustments, the number one ranked alternative received a negative adjustment to reflect savings from a positive characteristic. If the alternative was in the middle, no price adjustment was used. For the least desirable alternative a positive increase was used to reflect an increase in price. The magnitude of the adjustments was determined based on the significance of the category, a more important factor received a greater weight.)

Alternatives	Total Adjustment (%)	Price	Adjusted Price	Breakeven Point (Years)
Solar Power-Dok	-22.5	$ 9,500.00	$ 7,362.50	23.35
Solstice	22.5	$ 6,000.00	$ 7,350.00	23.31
Radiance	0	$ 8,500.00	$ 8,500.00	26.95

Comparing the output of each analysis between different alternatives is possible with breakeven analysis but not benefit-cost analysis. With breakeven analysis, whichever alternative returns the smaller time period would be the more favorable solution to pick for implementation. This is due to the more attractive economic value; being able to recoup the sunk costs more quickly is much more desirable for Lafayette College when solely considering the economic effects. We are in favor of this for other reasons; if the capital is recovered faster, then a new sustainability project can be started sooner or at the very least our project can be categorized as "complete" in terms of economic obligations. The greater the sustainability efforts on campus, the greater awareness will be among the student body, and that was the main source of motivation for undertaking the project. (El Alimi 2014)

Another economic facet which required our attention was going through the bureaucratic process of requesting the funds for the project from Lafayette College. The college will need to be responsible for paying the initial costs, as well as maintenance costs. Given the relative immaturity of this technology, little is known about the maintenance costs. The region in which the Solar Power-Dok would be implemented will play a role in the cost of maintaining the solution because inclement weather could damage the device or require man hours to take precautions to ensure it will not be damaged. All of this needed to be articulated on the capital request form.

Once we chose the Solar Power-Dok as the product of our efforts, we received an official quote from Enerfusion Inc. to get shipping and installment costs for the specific unit. The cost of the Solar Power-Dok is $9,495.00, with shipping and installation cost of $1,875.00, totaling $11,370.00. This is the amount of capital requested on the capital request form we submitted.

Retrieved from: http://mavensnotebook.com

Another part of the economic analysis our group felt was necessary to include was the economic justification proposing the implementation of such an expensive piece of equipment. Again, the expected outcome of implementing a Solar Power-Dok on campus is not to turn Lafayette into a campus generating power exclusively from renewable and sustainable sources(although that would be nice). Our goal is to raise awareness, given the college's lack of any tangible commitment to sustainable energy practices. One tactic for raising awareness utilized by Lafayette College is hiring guest lecturers to speak on an important issue. At this time in history sustainable energy practices are arguable the single most important issue the entire world is currently facing.

A guest speaker can cost thousands of dollars for a lecture lasting less than two hours, and Lafayette College is able to justify the expense. The Solar Power-Dok would be on campus raising awareness for many years. Adjusting the cost of the Solar Power-Dok to reflect its value over the lifespan of the equipment makes it more attractive than the popular alternative of hiring a speaker. The advantages of the Solar Power-Dok over a guest lecturer are a constant presence on campus and the ease it affords students to use and understand the technology, at their discretion, with limited interruptions. (Ahi P 2014)

The Solar Power-Dok would be available to the campus community all the time, whereas a guest lecturer's time on campus is far more limited. The Solar Power-Dok would serve as a constant reminder of the issue of global warming and its link to energy production and consumption. Effectively, it would have the ability to provoke thought on the issue for the entire time it is on our campus. Compared to, at most, the few hours a speaker has the ability to provoke thought on an issue while on campus. The availability of a lecturer is almost exclusively limited to the set time they have to deliver their speech. The Solar Power-Dok would be available to the entire campus community always. Another positive externality resulting from the implementation of the Solar Power-Dok is the opportunity it gives users to interact with and gain intuition about the technology utilized (Ahi P 2014). The importance of this should not be downplayed because a relationship with the technology and awareness of the issue such as this cannot be fostered exclusively by a guest lecturer.

Solar Power-Dok Cost	$ 11,370.00				
Guest Lecturer	$ 1,000.00	$ 2,000.00	$ 3,000.00	$4,000	$ 5,000.00
Lectures Needed to Breakeven	11	6	4	3	2

This table displays the number of lectures required to equal the cost of implementing the Solar Power-Dok. A range of $1,000 – $5,000 was considered for the price Lafayette College pays for an average guest lecturer. It is important to remember that the guest lecturer is only speaking for a short period of time and not a campus-wide resource like the Solar Power-Dok would be. That was a consideration that could not be accounted for in the analysis however with the results we obtained it is possible to make realistic estimates. From these numbers if we assume an average of two guest lecturers per year on an important topic (such as campus sustainability), the result is the number of years before the Solar Power-Dok becomes a more economically attractive alternative to hiring guest lecturers to raise awareness.

Please continue to the conclusion.

Chapter 6: Conclusion

We have submitted the capital request form, in hopes of of approval for the implementation of the Solar Power-Dok on campus before the start of the Spring 2015 semester. The amount requested on our submission was $11,370.00, which is the total cost as per the official price quote we received from Tom Davis, Vice President at EnerFusion, Inc. Our outlook is optimistic, given the extremely positive feedback we have received from many members of the engineering faculty and student body. The process our request will go through in order for a decision to be made was outlined in the policy section of our report, and although daunting, we believe Lafayette will view this project as an opportunity to make a commitment to sustainability on campus and approve the request.

As previously stated, the main goal of our project is to increase awareness of sustainable energy practices across the entire campus community. Our first step in doing this was demonstrating the technology we hope to implement to members of the campus. We set up in the student center, under a skylight so we could use the solar panels, and allowed students to use the solar panel we had to charge their mobile phones. During our demonstration we had a petition for members of the community to sign, giving them a voice in the issue as well as further raising awareness about a proposed solution for the campus.

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We are only able to initiate a relatively slight degree of change to the Lafayette campus. However, the importance of getting started and fostering the necessary institutions to enact future change is vital to our goal of promoting a sustainable campus. Achieving a sustainable campus is not a task that is completed in one semester, and it requires a commitment from campus administrators as well as students. We have started an early dialogue on campus with our demonstration and petition. By submitting the capital request form we have gone a step further and proposed to enact real, tangible change to campus. This is where the college needs to show a commitment to us as students, and the campus community as a whole seeking sustainability on campus. The action of the college will be a major determinant in the relative success of our project. If the request is granted, we were truly able to enact positive change on campus and the project will successful in raising awareness and implementing change.