SOLAR PANELS:

INSTALLING SOLAR PANELS ON BILTMORE HALL

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FOREWORD

North Carolina State University (NCSU) Biltmore Hall needs a new eco-friendly, reliable, and efficient energy source. Solar panels not only fit all of the criteria, but also evoke a strong message to other publicly-operated businesses that continue to neglect the repercussions of their carbon footprint. Depleting the planet's fossil fuels to power our businesses is an outdated and baleful method. As a mathematics major, I want to work towards optimizing current business operations to run more efficiently and use less nonrenewable resources. This proposal is the byproduct of an assigned final report for course English 331: Technical Writing during the Fall semester 2017. I am recommending the Electrical Engineering Research Department at NCSU install solar panels to power Biltmore Hall. In this persuasion, I discuss, in detail, the problems, solutions, and logistics of implementing solar panel technology in Biltmore Hall.

TABLE OF CONTENTS

LIST OF FIGURES

EXECUTIVE SUMMARY

In approximately 20 years after installing solar panels on Biltmore Hall, you will have saved over two hundred thousand dollars. This large amount of savings is from the electricity cost you would otherwise have to pay as well as a 30% rebate from the federal solar tax credit [1]. So not only will placing solar panels cut down on the University's electricity bill, but will also cut down on the initial cost of installing solar panels.

The planet's non-renewable resources are quickly being depleted. If we as a society continue to use resources as we are today and refuse to switch to more innocuous methods of power, we will run out of both oil and coal by 2056 [2]. Continuing to power businesses with coal and oil is detrimental to the planet and all people living on it. What position will you be in if you rely on resources that no longer exist? As an executive, it is only prudent to invest for the future rather than save for today.

The first photovoltaic cell was invented at Bell labs in 1954 [3]. Since then, advances in modern technology have not only made solar panels more affordable, but also more efficient. Because of this, you are able to take advantage of the newly innovated solar technology to optimize spendings.

METHODS AND MATERIALS

Initial sources to gather background information about the need, subject, and feasibility were gathered independently using the online libraries. Other than the initial sources, the group was focused on obtaining additional information from studies regarding the specific information in each section. Of these sources, peer-reviewed professional journals are preferred because they will contain the relevant and updated information. Many of the sources are journals directly relating to IEEE in some way.

The NC State library online resources are widely available and contain many peer-reviewed journals and articles relating to solar energy. As a widely studied topic, there are many different opinions and findings from professionals that dedicate time to studying solar energy. Lab results from NC State Electrical and Computer Engineering are available to further our knowledge about photovoltaic cell operation and help choose efficient materials for the project.

Another key resource is the representative from Duke Energy. Direct information and opinions from someone working in the professional field will be useful to make accurate assessments of the goals and outcomes of solar energy. Information gathered from the interview will be useful in nearly every section.

INTRODUCTION

History of Solar Energy

According to Silvi, "Renewable solar energy has been, is and will be the principal energy source on our planet" [4]. Solar Energy began to develop after the ending of World War II. However after William Paley submitted a report to President Truman the focus on the development of solar energy technology has changed. In respect to the university, North Carolina State has been a leader since the creation of this technology. In 1981 NC State unveiled it's Solar House and other research has been done by the NC Clean Energy Technology Center on campus [5]. Numerous other solar projects have also been completed around campus in more recent years.

Current Situation

Biltmore Hall was built in 1970, and no major renovations have taken place to address the change in North Carolina State University's perspective towards sustainable energy practices and management. Biltmore Hall houses the College of Natural Resources and specifically sustainable material and technology majors. This major's focus is on the chemical and physical properties of our renewable resources, how we use them in manufacturing processes, and the environmental impacts they have during their "life." Renewable Energy is also discussed numerous times throughout different classes, which is why Biltmore's energy situation is being addressed. It would be contradictory to the lessons that students learn in class to maintain a building that does not meet the energy standards that research shows will help improve our environment. Seeing that the building is mostly in operation from 8 a.m. to 5 p.m. it makes sense to use a readily available energy source during those hours. Other renovations may improve energy efficiency but solar energy does that while simultaneously generating energy with the capability of storage.

Data that was gathered from an Energy and Water report done by NC State provided the cost per square foot for utilities ($1.78) and energy ($1.52). Biltmore Hall is a 75,000 square foot building, so the totals for the year for each category respectively is $133,500 and $114,000 per year [6]. According to data provided by Aashe's Star program, Biltmore Hall consumes 9,233.625 MMBtu per year [7]. According to NC State's Sustainability webpage, the main two energy sources NC State uses are natural gas and electricity. However, the university is trying to move away from traditional energy sources and towards cleaner, more environmentally friendly energy sources. There are numerous solar panel projects already implemented on campus from small scale projects like 160 watt charging stations at bus stops and solar umbrellas that allow students to charge their phone to larger scale projects like the 75.6 Kilo-Watt photovoltaic system at Carter Finley [8]. The addition of LEED certified buildings like Hunt Library and the New Talley Student Union highlight this new perspective. However, we can't forget to keep the older buildings up to date as well.

Possible Solutions

The electrical engineering research department should install solar panels to Biltmore Hall. The estimated measurement of the building roof is 15,387 square feet. With the average size of each solar panel having 17.55 square feet, an approximate 876 solar panels can fit on top of the roof of Biltmore Hall [9]. Each panel can generate around 300 watts of energy, allowing for 262,800 watts of electricity which is enough to power a building 5 times the size of Biltmore Hall. Given all these calculations, if we install the minimum amount of solar panels needed to power Biltmore hall, it would cost $10,450 to install 5,000 watts worth of solar energy [10]. In 20 years, according to the average, North Carolina homeowners save $4,035 [11]. Factoring the difference in wattage between a 2,400 square-foot house and Biltmore Hall, NC State would save roughly $207,955 over 20 years. Thus, both financially and ethically, installing solar panels to Biltmore hall is plausible.

Cost Analysis

Large polymer-based solar panels are expensive, and the power savings over time will help balance the costs of panel purchase, construction, and installation. The average price for a single panel is about $400 dollars, which when applied across the 15,387 square feet on top of Biltmore Hall will result in about $10,000 dollars of equipment expenses. In addition to the cost of the panels themselves, equipment is required for power storage and transmission into the campus load for consumption. Labor costs must also be considered a significant portion of the project budget. A total price of no more than $30,000 is significantly low considering the cost savings from renewable power that will begin to accumulate. The interviewee from Duke Energy concurred that NC State would not only save money on their power bill, but will receive compensation for the unused power that is fed back into the grid.

Long-term costs that should be considered include the wear and tear of the solar panels. Luckily, when one panel begins to wear out it can be replaced individually. Silicon-based solar panels with photovoltaic cell operation retain about 80% of initial operation efficiency [9]. Therefore, we can rest assured that there will not be any overwhelming long-term expenses.
The cost analysis concludes that this project will be a small hit to the campus budget. The department of Electrical and Computer Engineering Research will be responsible for covering the cost of installation, equipment, and labor. The funding will be easily obtainable from groups and companies that support renewables, power grid innovation, and green carbon practices.

DISCUSSION

The following document is a technical description for the implementation of solar panels on North Carolina State University's Biltmore Hall. This description further elucidates the information previously discussed in the Proposal and delves into the mechanical specifics of installing solar panels.

- Photovoltaic Panels
- Photovoltaic System
- Solar Panel Maintenance
- Installation

Photovoltaic Panels

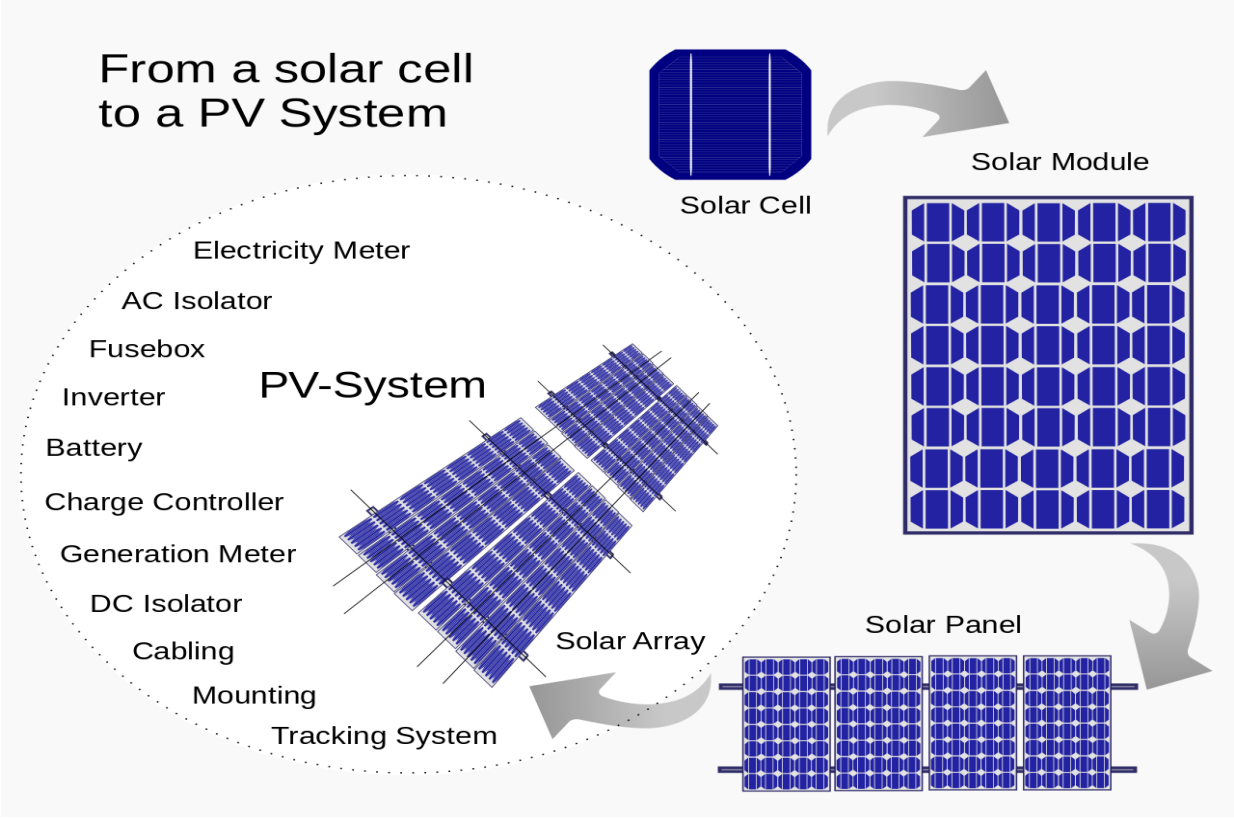

Figure 2. Photovoltaic System (A)

Source: "Photovoltaic system," *Wikipedia*, 02-Dec-2017. [Online]. Available: https://en.wikipedia.org/wiki/Photovoltaic_system. [Accessed: 06-Dec-2017].

As depicted in Figure 2, photovoltaic cells are the most basic components of the PV system. These cells are made from a thin semiconductor wafer that has been treated to form an electric field. Electricity is harnessed from these cells when sunlight strikes the wafer and knocks electrons from the semiconductor wafer [8]. Attached electrical conductors harness this electric energy. These cells are aggregated to form a module, which is then aggregated to form a photovoltaic array. The larger the array is, the more direct-current electricity can be produced. Photovoltaic panels are formed from PV arrays that have been wired together.

Photovoltaic System

The photovoltaic system is the aggregation of cells, modules, arrays, and ultimately PV panels. PV systems can be connected in a variety of ways depending on the application. The energy from each of the panels will be connected to a DC to AC inverter before being connected to Biltmore Hall and ultimately the existing energy infrastructure here at NC State. This process is illustrated in Figure 3.

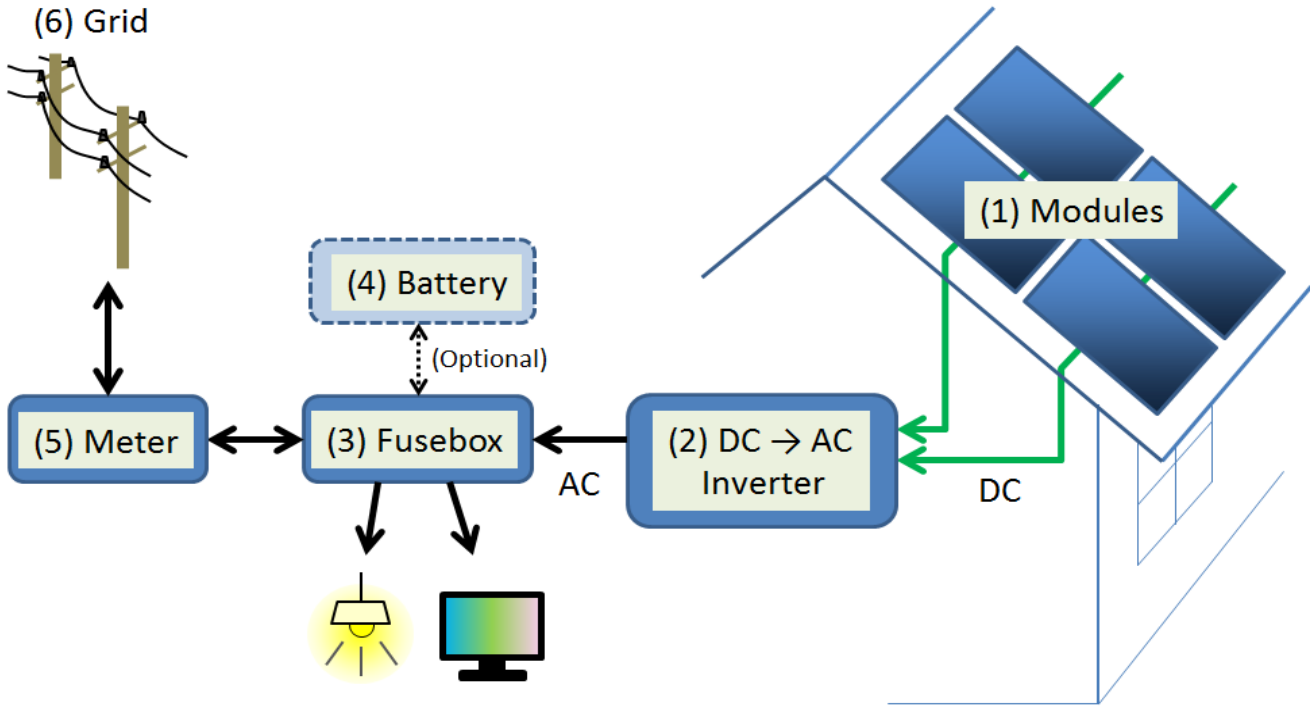

Figure 3. Photovoltaic System (B)

Source: “Photovoltaic system,” *Wikipedia*, 02-Dec-2017. [Online]. Available: https://en.wikipedia.org/wiki/Photovoltaic_system. [Accessed: 06-Dec-2017].

Solar Panel Maintenance

Over time the solar panels will degrade just as any other equipment exposed to weather would. To ensure operational longevity, polymer solar panels with a laminate coating should be used instead of traditional silicon-based solar panels. Studies have shown that the mechanically robust GEN3 polymer solar panels will only degrade to 80% of the original power output when exposed to seasons of snowy conditions followed by humid, hot summers [9].

Repairs may be necessary to keep the panels working at top efficiency. To achieve consistent thermal power conversion, the photovoltaic cells contained behind the layer of insulation and laminate should be visually inspected a few times a year. The flexible barrier of the cells can overheat and cause mechanical stress. Individual PV cells are relatively easy to replace and will not result in significant expenses looking forward [9].

Installation

As stated in previous sections, the total cost to install the minimum amount of solar panels needed to satisfy Biltmore Hall’s power usage is approximated at $10,450. The installation process involves: surveying the rooftop, preparing a fitted frame, installing the panels, and connecting the solar panels to the power output [9]. From start to finish, this process takes only a matter of days.

CONCLUSION

Recommendations

We believe that the installation of a solar energy system on Biltmore Hall would generate immense benefits for North Carolina State University as well as the surrounding community. With such a system, energy costs are reduced and harmful CO2 emissions are reduced. The installation of PV panels is a straightforward process that leads to large benefits. As detailed above, the process takes only a few days once the design is completed. This allows us to minimize the inconvenience created on campus. There are a few recommendations we can provide for future consideration:

- Development of a template for expansion to other structures on campus
- New/Improved version of PV panels as they become available
- Fundraising Campaign via NC State Office Of Annual Giving to offset cost of initial investment in expanded solar energy systems

Benefits

The benefits associated with installation of solar panels in Biltmore Hall would be immense and long-standing. The benefits include a reduction in energy consumption, increased sustainability, and a reduced impact on our environment. This positive environmental impact indicates the installation of solar panels would be socially ethical as well.

Reduced energy consumption is one of the main benefits of the decision to install solar panels. The decision to undertake such a project is made because replacing traditional power with solar energy results in an impactful reduction in traditional energy consumption, which in turn results in real cost savings. The campus here at NC State University provides a practical example of the benefits that can be achieved from the installation of PV solar panels. The project at our Carmichael Gym to install solar panels has generated a reduction of more than $11,000 annually.

As detailed in Nancy Averetts' article, Environment and Ecology, "Solar Power Saves Everyone Money" [10], one couple reduced their electric bill from $200/month to $0/month and even generated power that was fed back to their utility company. This retransmission of power generated more than $100 in credits from September 2015 to April 2016 [10]. This impact, while on a grander scale, is the same type of impact we expect to have upon the implementation of our proposal.

Solar energy has a large impact on the environment on our campus and around the world. One of the most harmful effects the civilized world has on its surroundings is the emission of greenhouse gasses, particularly carbon dioxide. The emission of carbon dioxide contributes to global warming as well as the erosion of our atmosphere. One 1.5 kW PV (photovoltaic) system could keep more than 100,000 pounds of carbon dioxide out of the atmosphere and prevents the need to burn 60,000lbs of coal [11]. This is of such importance that our local, state, and federal governments offer tax credits to commercial companies and tax subsidies to private citizens that decide to install this alternative energy source. NC State University has also created a Sustainability Fund and awarded grants to students who have designed an efficient project to harness solar energy or to students who choose to take part in Solar Spring Break and install solar panels in California from March 3-March 11, 2018 [7].

Finally, if our proposal is adopted, the benefits realized would be immense. Biltmore Hall would join the large number of projects already adopted and completed here on campus and as such, the implementation would not be as cumbersome as one might think. Our proposal does not attempt to reinvent the wheel, but to extend the progress to another important building on campus. Solar panels would both reduce energy consumption and by extension, reduce the costs associated with running the university. Solar panels would reduce the emission of greenhouse gasses and positively impact our environment. Everybody wins.

Future Developments

The photovoltaic (PV) solar energy system we propose will have long-term benefits. If we are able to successfully implement our solar energy system in Biltmore Hall, this would not only achieve the short-term goal of a reduction in energy costs, but this may also lay the groundwork for expansion to other structures on campus. Biltmore Hall could be the catalyst for installing solar systems in all buildings that house classrooms and might also lead to the installation of such a system in residence halls on campus.

The benefits realized from the solar project on Biltmore Hall could then expand beyond the campus at NC State and could become standard for all universities within the UNC System. Each college and university could apply the same general systems throughout each school's campus. As we look toward a global solution to the problem of global warming and dependence on coal as the primary resource of energy, the practical benefits are endless.

WORKS CITED

[1] “Cost & Savings.” Evergreen Solar, National Council for Solar Growth, evergreensolar.com/cost-savings/.

[2] Collins, Jeremy. “How Much Natural Resources We Have Left?” DoRecycling.com, 29 Jan. 2016, dorecycling.com/how-much-natural-resources-we-have-left/.

[3] Richardson, Luke. “What Is the History of Solar Power and When Were Solar Panels Invented?” Energysage.com, 18 Feb. 2017, news.energysage.com/the-history-and-invention-of-solar-panel-technology/.

[4] C. Silvi, "History and Future of Renewable Solar Energy", Climate Justice and Development, vol. 51, no. 3, pp. 409-414, 2008.

[5] L. Batchelor, "OP-8: Building Energy Consumption | North Carolina State University | Scorecard | Institutions | AASHE STARS", Stars.aashe.org, 2016. [Online]. Available: https://stars.aashe.org/institutions/north-carolina-state-university-nc/report/2016-01-05/OP/energy/OP-8/. [Accessed: 04- Dec- 2017].

[6] NC State Energy Management, "Strategic Energy and Water Annual Report", NC State University, 2016.

[7] “Solar Energy | NC State University.” *Sustainability*, North Carolina State University, sustainability.ncsu.edu/campus/energy-water/solar-energy/. Accessed 18 Oct. 2017.

[8] “Compare Solar Panel Prices in Your Area.” Solar Panel Installation Process & Time, www.theecoexperts.co.uk/how-long-does-it-take-install-solar-panels.

[9] Medford, Andrew J. et al. “Grid-connected polymer solar panels: initial considerations of cost, lifetime, and practicality.” *Optics Express.* vol. 8, no. S3, pp. A272-A285, 2010.

[10] N. Averett, “Environment & Ecology,” *Research Solar Power Saves Everyone Money*. [Online]. Available: https://www.bu.edu/research/articles/solar-energy-advantages/. [Accessed: 18 Oct 2017].

[11] Davison, Alan. “Alternative Energy.” Alternative Energy - Wind, Solar, Hydro and other alt energy sources for commercial and home power, www.altenergy.org/. Accessed 18 Oct. 2017.

[12] “Photovoltaic system,” *Wikipedia*, 02-Dec-2017. [Online]. Available: https://en.wikipedia.org/wiki/Photovoltaic_system. [Accessed: 06-Dec-2017].

INTERVIEW QUESTIONS

The interview conducted with Jon Ramsey at Duke Energy, a stakeholder in solar energy projects, was conducted in-person at the Downtown Raleigh Headquarters.

1. What is the current solar energy budget for Duke Energy?
2. What laws and regulations demand additional renewables?
3. What is an example of a current solar project and the projected outcomes?
4. Is there a downside to converting to solar?
5. How much more expensive is a solar project vs. traditional generation?
6. Do you think NC State could benefit from solar energy?
7. How long would it take for solar panels to pay for themselves?
8. Is there any resistance against solar projects?