

Design and Implementation of a Cost Effective Solar Fan

(Technical Paper)

The University as a Model for Sustainability and Catalyst for Development in the Surrounding Community

(STS Paper)

A Thesis Prospectus Submitted to the
Faculty of the School of Engineering and Applied Science
University of Virginia • Charlottesville, Virginia
In Partial Fulfillment of the Requirements of the Degree
Bachelor of Science, School of Engineering

Thu Tran

Spring, 2020

Technical Project Team Members

Hsing Chun Lin

Kelsi Loudenslager

On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Signature _____ Date _____

Thu Tran

Approved _____ Date _____

Harry Powell, Department of Electrical and Computer Engineering

Approved _____ Date _____

Sean Ferguson, Department of Engineering and Society

Introduction

Environmental concerns have become a forefront issue worldwide as the detrimental consequences of climate change have exacerbated the need for sustainable solutions and efforts. As current trends in resource use and societal behaviors impact the environment in unsustainable ways, there is an increased pressure for communities to find solutions and invoke sustainable development. However, since the first international conference on environmental issues in 1972 (Jovovic, 2017), after four decades of efforts in sustainability, progress has been very unexceptional as climate change, biodiversity loss, deforestation, water quality degradation, and air pollution continue to stir public concern (Stephens 2008). The concept of sustainable development suggests several principles for implementation including, increased significance of sustainable efforts at the local and regional level, public and stakeholder participation, and integrative approaches to regional challenges (Peer, 2012). These principles essentially play on the idea of “think global, act local” in the context of sustainable development. Given the urgency of environmental destruction and the proposed framework, opportunities are emerging for stakeholders and institutions to engage and emerge as catalysts and change agents for sustainable development (Stephens, 2008).

Universities in particular possess pivotal influence regionally as they most notably possess provisions of both human and intellectual capital (Peer, 2012). In addition to educational services and research, their regional impact is expressed through the people they hire as well as how they engage with the community through their financial and physical investments (Jackson, 2018). With this, universities can be recognized to have the capacity to become the core actors in shaping regional socio-economic infrastructure and becoming essential catalysts and models for regional sustainable development. This report will focus on the engagement of universities

within their surrounding communities, and identify their potential roles and opportunities to position themselves as catalysts for inclusive regional sustainable development. In a larger context, this inquiry will be used to further understand the overarching blueprint of creating sustainability awareness within the Charlottesville community by examining the university as a core actor in facilitating an awareness campaign.

In the context of regional sustainability, the technical project will address the necessity of a sustainable cooling solution within communities like Charlottesville through the development and design of a cost efficient self-powered solar fan.

Technical Topic

As the increased levels of greenhouse gases in the atmosphere continue to contribute to the imminent issue of global warming and climate change, the problem of sustainable cooling and ventilation arises as society becomes more reliant on technology to provide adequate living conditions. Often overlooked, heating and cooling systems contribute to over 48% of residential energy with air conditioning releasing over 100 million tons of carbon dioxide yearly within the United States (Schlossberg, 2016). In addition to its carbon dioxide emissions, current cooling technologies rely on human made gases that are almost 10,000 times more potent than carbon dioxide in trapping heat (“Why Cooling”, 2019). Aside from its environmental impact, the lack of adequate cooling systems have serious detrimental effects on health, especially on the elderly, women, and children. Thermal comfort is also essential in productivity and performance as shown in a study done in Denmark, where significant improvements in arithmetic and language tests were seen among students placed in an environment between 20-25 degrees Celsius (“Why Cooling”, 2019).

In addition to being environmentally unsustainable, thermal conditioning has become financially unsustainable as well. In metropolitan areas like Charlottesville, the cost of consistently running an AC in the average household can accrue an electricity bill of over \$245 per month (Ketchum, 2018). This is extremely unsustainable and strenuous on low income families looking to maintain comfortable living conditions within their home. Therefore to tackle this issue, the technical project related to this report will focus on the research and design of a cost effective self powered solar fan whose cost of production is affordable in respect to similar products currently in the market. The current market lacks a low cost solar fan with energy storage, which is an essential feature for allowing operation of the fan when there lacks direct sunlight. The cost for a solar powered fan with energy storage currently is about \$180, and this project aims to reduce this cost by 50%. The main focus for the design will be reducing the production cost in order to increase accessibility to a sustainable cooling option. The design will also allow the fan to have the capability of running completely on renewable energy and without drawing any additional energy from the utility grid. It will also take into account for typical appliance safety standards such as electrical overheat protection. The fan will implement a three blade axial flow fan design with swept tip blade geometry for aerodynamic efficiency. It will incorporate a 12V brushed DC motor because of its reliability and low initial cost, and will include a 12V lead acid battery to implement the energy storage feature. A charge controller will be implemented as well to control the charging state and battery health. Challenges for this design will mainly surround maximizing energy efficiency with a minimal production budget.

The overall sustainability of the design will also be further evaluated throughout the project as batteries and solar panels themselves have environmental concerns of their own. Waste management for solar panels and batteries become an issue as both are difficult to recycle and

dispose of due to the impurities and chemicals associated with them. Therefore it will be valuable to do a further cost benefit analysis of the design as a sustainable cooling solution within a larger scope.

STS Introduction

The importance of universities and the role they play as catalysts for research and technological advancement is undeniable. As such important institutions with such wide arrays of resources and influence at their disposal, universities could be analyzed to have the capacity to shape regional development on a social level as well. When it comes to sustainability, a city built solely technology will not necessarily lead to a more sustainable society, but requires the behaviors and reactions of the people to guide it. This report will be taking a close examination into the different mechanisms for social influence toward sustainability at the University of Virginia, and how community engagement can be incorporated to induce change within the surrounding region of Charlottesville.

Literature Review

To begin analyzing the social influence of Universities on sustainable development, several pieces of literature have been reviewed that dictate the existing work and theories regarding this topic.

The first area of interest related to this topic, focuses on the role of universities in regional sustainability development through the lens of their educational and research and development programs. Universities as contributors in research in the context of regional development has attracted attention since the 1950s (Peer, 2012). The research piece by Verena Peer and Gernot Stoeglehner, *Universities as change agents for sustainability - framing the role of knowledge transfer and generation in regional development processes* specifically details the role of knowledge within Universities and its impact on sustainability development. This piece

provides insight into the capacity and expectations for universities in strengthening regional innovation through the transfer of knowledge from the university to the community. This piece presents the learning theory and the effectiveness of different methods of transferring knowledge. It shows that with classical paths such as reading a presentations, only 5-10% of knowledge is remembered. For discussions it is 50%, and for self-activity, it is 80%. This suggests that there needs to be bidirectional interaction between the university and the community. From this background, this research project can further elaborate this idea of bidirectional interaction through exploring different avenues for implementing bidirectional interaction within the University. Using this background in developing knowledge transfer for sustainable development, a framework can be created for the process in how universities can effectively induce change toward a more sustainable community.

There have been very few efforts in investigating universities and their capacity for broader integrative community engagement in sustainability. However, one piece that does investigate this topic is *Sustainability Education as a Catalyst for University and Community Partnerships* (Lishawa, 2010). This piece details how an educational curricula that emphasizes community collaboration helps better prepares graduates to develop solutions to environmental problems. It specifically investigates the Biofuels Lab course at Loyola University Chicago. It discusses how the inclusion of such a course can allow for the university to promote more opportunities for students to engage in the community. The ability for universities to promote engagement and awareness marks a social shift for universities from purely educational and research focused institutions into stakeholders in community development. This case study, focuses mainly on how courses with engagement affect the students and their capacity to contribute to sustainability following the course. This project however, can expand upon this

concept by analyzing how these types of courses and programs can allow the university as a whole to increase its influence on sustainability within the community.

Framework

From the above literature review, we can incorporate this background into a framework for developing a process for how the opportunities and resources available by the university can be elevated to induce sustainability awareness and development within the surrounding community. This framework will be designed to evaluate the different avenues for universities to influence sustainability by investigating from the university outwards through the lens of community involvement. This research will first take a look at existing programs related to sustainability within the university and how they are currently transferring their knowledge beyond the university. It will then move on to investigate the potential in elevating these current programs to further emphasize bidirectional interaction between the university and the community. Finally, this project will go over the opportunities beyond the university, within the community, that the university could participate in. Overall this framework shoots to evaluate the capacity for universities to become the lead models for regional sustainable development.

Methods

As outlined in the framework, the existing programs related to sustainability within the university will first be explored. From prior fieldwork, the core programs to be interviewed will be the Green Labs program at UVA, the ecoMOD program at the School of Architecture at UVA, the Sustainability UVA CIO, the Office for Sustainability, and Environments and Sustainability Global Studies program. The civil engineering department heads will also be a valuable program to interview, as much of their designs must incorporate sustainability. I will be meeting one on one with either core players or highly involved individuals within the program

and will be investigating their opinions on the role that their program is playing in how the university is influencing the greater Charlottesville. From these interviews, I will then be using this data to evaluate the actual degree of effectiveness by speaking to members of the Charlottesville community regarding the above programs within the University. Interviewing the members of the community will then allow me to evaluate how these programs can further engage with the local community and increase their presence and influence. Finally, I would like to investigate a few of the many sustainability programs available outside of UVA, but within Charlottesville. These include Quality Community Council's Urban Farm program, Piedmont Environmental Council's Buy Local Initiative, and the Better World Betty Campaign. These methods will be used to thoroughly understand how community engagement and directly be related to the capacity for the university to create a more sustainable Charlottesville.

Discussion and Next Steps

Looking forward with this research project, the methods involve investigation in three stages, which will be conducted in three week time intervals beginning at the start of the following semester. Both the ideas of knowledge transfer and engagement within education, as drawn from the literature review, will be used as a basis as I go through the investigation of the proposed framework of the capacity of universities as a model in sustainability development . The data collected through the proposed method will allow insight into how the university is currently influencing the surrounding community. It will also allow us to contrast the intended influence of these existing programs, with the actual influence on the community and evaluate its shortcomings and needed improvements. This will allow us to holistically develop a process for shifting the university from merely an educational institution, into a model for sustainability and catalyst for regional development.

Conclusion

The technical work and STS research of this report both address sustainability, and the need for change through innovation and social development within regional infrastructure.

The technical work for this report offers a design for a cost efficient self powered solar fan in order to address the lack of sustainable low cost cooling solutions. The design will be used as a baseline iteration for future endeavors into the development of similar sustainable cooling options as the different design features of the fan will be evaluated against the current understanding for sustainability.

The STS research will explore more on the side of how developments in sustainability can be catalyzed regionally in a social context with universities as the main drivers. This study will be used to gain further insight into how universities can shape development through research, education and community engagement. Both the technical and STS research will be used to further understand the synergy between technological innovation and social development and their roles within the larger blueprint of creating a more sustainable and aware community.

Bibliography

- Jovovic, R., Draskovic, M., Delibasic, M., & Jovovic, M. (2017). The concept of sustainable regional development – institutional aspects, policies and prospects. *Journal of International Studies*, 255–266. Retrieved from <https://pdfs.semanticscholar.org/777a/9989abdbbd1d6c23b05cbb5426274dd64510.pdf>
- Jackson, E. T. (2018). *Catalyst for Sustainability: The Achievements, Challenges, Lessons and Prospects of the University of Winnipeg Community Renewal Corporation Full Report*. *Catalyst for Sustainability: The Achievements, Challenges, Lessons and Prospects of the University of Winnipeg Community Renewal Corporation Full Report* (pp. 1–88). Montreal: University of Winnipeg Community Renewal Corporation .
- Ketchum, D. (2018, November 1). How Much Will It Cost Me to Run an Air Conditioner? Retrieved November 8, 2019, from <https://budgeting.thenest.com/much-cost-run-air-conditioner-23306.html>.
- Lishawa, S., Schubel, A., Varty, A., & Tuchman , N. (2010). Sustainability Education as a Catalyst for University and Community Partnerships . *Greening the Curriculum* , 58–72.
- Peer, V., & Stoeglehner, G. (2012). Universities as change agents for sustainability – framing the role of knowledge transfer and generation in regional development processes. *Journal of Cleaner Production*, 85–95. Retrieved from https://www.researchgate.net/publication/271636174_Universities_as_change_agents_for_sustainability_-_framing_the_role_of_knowledge_transfer_and_generation_in_regional_development_processes

Schlossberg, T. (2016, August 9). How Bad Is Your Air-Conditioner for the Planet? *The New York Times*. Retrieved from <https://www.nytimes.com/2016/08/10/science/air-conditioner-global-warming.html>

Stephens, J. C., Hernandez, M. E., Roman, M., & Graham, A. C. (2008). Higher education as a change agent for sustainability in different cultures and contexts. *International Journal of Sustainability in Higher Education*, 317–338. Retrieved from [https://www.uvm.edu/giee/pubpdfs/Stephens_2008_International Journal of Sustainability.pdf](https://www.uvm.edu/giee/pubpdfs/Stephens_2008_International%20Journal%20of%20Sustainability.pdf)

Why Cooling. (2019). Retrieved November 8, 2019, from <https://www.k-cep.org/why-cooling/>.