The Greener Housing Coalition

(Technical Paper)

Carbon Neutral Off-Grounds Housing
(STS Paper)

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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

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Introduction: The Off-Grounds Housing Problem

The University of Virginia has committed to achieve carbon neutrality by the year 2030 (UVA Office for Sustainability). Their plan of action includes significant investment in renewable energy, careful examination of all enterprises located on-grounds, and expanding scientific research and innovation (UVA Office for Sustainability). However, certain areas of the school's footprint remain unaccounted for.

Almost 70 percent of UVA students live in off-grounds housing (Brailsford and Dunlavey) For our purposes, we will define off-grounds housing as the totality of residential space (apartments, houses, etc.) in the city of Charlottesville that is not owned by UVA and in which at least one UVA student is living.

Off-grounds housing is somewhat of a blackhole in the sustainability action plan of UVA. Because the school does not own these spaces, they cannot make upgrades to appliances and infrastructure that would drastically reduce emissions. The burden then falls on individual renters and landlords. However, the average person does not have the means or information to make the necessary changes to their behavior and living situation. And so, a question is posed: how can off-grounds housing become more sustainable despite numerous systemic roadblocks?

In this prospectus, I will envision a framework for further exploration of this topic. The stage will be set for a Design Challenge space, where application of systems engineering concepts will be applied. Furthermore, I propose an outline for STS Research that will identify a strategy to create carbon-neutral off-grounds Housing. These two areas will parallel and build off each other to illustrate the necessity for, and challenges to, sustainable housing in the City of Charlottesville.

Technical Project: The Greener Housing Coalition

I am part of a five-person team that is tackling the problems facing off-grounds housing. In our initial work, we have begun conversations with a network of stakeholders who are invested in this topic. This includes the UVA Office for Sustainability, the City of Charlottesville, and numerous student-led organizations at UVA. Furthermore, we have identified existing resources that can lead to more sustainable living spaces:

- **Low-Cost Retrofits:** There are a variety of minor installations that can be caried out in any living space to improve energy efficiency. Such installations (including LED bulbs, programmable thermostats, low-flow shower heads, etc.) incur a minimal initial expense and generate consistent return-on-investment. (Energy.gov)
- **High-Cost Retrofits:** Some of the most effective sustainable solutions are also the costliest (replacement of water heaters, installation of solar panels, etc.). The high initial expense will eventually pay for itself through gains in energy efficiency, but over a much longer period than low-cost retrofits (Less and Walker, 2015).
- **Outside Infrastructure:** organizations such as the Local Energy Alliance Program (LEAP) exist with the sole purpose of making housing in Charlottesville more sustainable. These are versatile, effective resources that can be utilized across a large-scale.

Resources such as these have yet to see widespread implementation in off-grounds housing due to the following hurdles:

- **Lack of Jurisdiction:** As stated before, UVA does not have the ability to improve the sustainability of off-grounds housing. The most the school can do is provide education and access to resources. The main burden to implement change resides with individual renters and landlords.

- **Split Incentives (Landlords vs. Renters):** College students rarely live in the same unit for longer than one year. This means it is rare to see expensive retrofits to units occupied by students, as they will not occupy the space long enough to have the payback from utility bills make up the initial expense. Furthermore, replacements of broken utilities are usually carried out at the expense of landlords, and landlords will not invest in a more efficient option when they are not seeing the financial benefit.

The purpose of our design team is to discover how to combat these issues. We intend to be a bridge between existing sustainable solutions and the stakeholders that have the power to implement them. As such, we have titled our endeavor the Greener Housing Coalition. The overarching goal of our project is to drastically reduce that number, and therefore work to eliminate one of the largest threats to the sustainability of UVA. As of now, we are working to generate a set of solution concepts that will let us achieve that goal.

I am the only member of my team that is enrolled in the School of Engineering and Applied Sciences. The nature of this project is such that there will not be a rigorous level of engineering applications. That being said, I plan to implement my prior studies in the following ways:

- **Knowledge of Solutions:** Much of my coursework at UVA has focused on sustainable engineering, and specifically on the implementation of renewable energy. It is worth noting that my experience is less technically involved than is traditional of an engineering curriculum. Rather, I have focused on understanding the merits, detractors, and functionality of a wide range of sustainable solutions. As stated earlier, while this project is deeply coupled with said solutions, it does not require the development of any new technology.

- **Systems Thinking:** This project involves the implementation of a variety of solutions in one integrated system (off-grounds housing). To achieve maximum efficiency, the system should be examined holistically, with each component noted, monitored, and analyzed.
- **Modeling:** Computer-based models can be utilized to provide insight into this design challenge. Through software packages such as Excel, we can visualize the footprint of off-grounds housing, compare the effectiveness of different solutions, monitor our impact on carbon emissions, and organize and interpret data to aid in decision-making.

These strategies are meant to aid in the design process, but they are not the focus of our challenge. Instead we will devote our efforts to the development of infrastructure and relationships between stakeholders. Our intention is to create a resource that envelops as many solutions as possible, and that is easily accessible to the average student or landlord in Charlottesville. This resource will be known as the Greener Housing Coalition.

STS Research: Carbon Neutral Off-Grounds Housing

My STS Research will focus on developing a theoretical model of carbon-neutral off-grounds housing. This model will be intended as a benchmark goal for The Greener Housing Coalition and should be utilized as a tool to compare my team's applied efforts with the best possible outcome.

Just as with my technical project, my research will involve application of systems thinking. This approach to sustainable housing practices is supported by Davidson and Venning (2011), who assert the need for a wide variety of solutions to address all aspects of the footprint of residential living spaces. Furthermore, Gilkinson and Sexton (2010) suggest application of the triple-bottom-line approach to residential living spaces, dictating the need to consider ecological, social, and environmental ramifications of a system.

Just as the components of off-grounds housing are varied and wide-ranging, so too are the stakeholders connected to this research. As stated above, close to 70% of the student body of UVA lives in off-grounds housing at any given time (Brailsford and Dunlavey, 2016). These students interact with numerous renting companies in Charlottesville to form a network of individuals and organizations seeking and providing living space. Similarly, the administration of UVA is committed to achieving carbon neutrality (UVA Office for Sustainability). While off-grounds housing does not fall under their jurisdiction, the system is motivated by the existence of the school, and therefore the school is responsible for the impacts of the system. Finally, Dominion Energy supplies the electricity for the City of Charlottesville (Dominion Energy). The large population of students in off-grounds housing creates the need for higher energy production by Dominion.

The supporting theory for this research is the application of systems thinking (Davidson and Venning, 2011) and the triple-bottom-line approach to sustainability (Gilkinson and Sexton, 2010) to residential living spaces. Such spaces represent both a hurdle and opportunity in the transition to a clean energy future, as much of the built environment has yet to see widespread integration with renewable energy systems (Dunphy et al., 2016).

The research question for my thesis is as follows: how can off-grounds housing at UVA achieve carbon neutrality?

The answer to the research question will be supported both by my work with The Greener Housing Coalition and through my STS research. These components combine to form the following methodology to provide an answer:

- Qualitative and quantitative analysis of the footprint of off-grounds housing, with attention paid to the triple-bottom line theory of sustainability

- Research on the integration of renewable energy solutions into the built environment
- Application of strategies through efforts with The Greener Housing Coalition
- Compilation of findings from my technical project and STS research

While the purpose of the STS research is to develop a theoretical model for carbon-neutral off-grounds housing, The Greener Housing Coalition will provide real-world illustration of the difficulty of the problem. Together, these efforts will create a complete picture of the hurdles and opportunities surrounding my proposed research question.

Conclusion

Ideally, the two endeavors discussed in this prospectus will build off each other. The technical project will provide insight into the most effective means of implementing solutions, and the research will propose a benchmark to strive for. Furthermore, the projects should set up a framework that can be applied to any system of housing, whether connected to a university or otherwise.

From this prospectus, it should be clear that my efforts, both this semester and next, will be less technically focused than my peers in STS 4500. Rather, I will emphasize the need for cooperation amongst individuals and organizations to combat large-scale challenges. This cooperation will be supported by renewable energy solutions and systems engineering concepts, but the overall focus of the project will be organization and collaboration of existing resources.

Citations

- Plans & Progress. (n.d.). Retrieved October 16, 2020, from https://sustainability.virginia.edu/about-us/plans-progress

- Brailsford, & Dunlavey. (2013, May). Student Housing Analysis Survey. Retrieved October 16, 2020, from https://officearchitect.virginia.edu/pdfs/UVAPhase_I_Documentation-BriefingMemo.pdf
- Gilkinson, & Sexton. (2010). Delivering Sustainable Homes. *Int. Journal for Housing Science, 34*(3).
- Davidson, K., & Venning, J. (2011). Sustainability decision-making frameworks and the application of systems thinking: An urban context. *16*(3).
- Dunphy, N., Boo, E., & Dallamaggiore, E. (2016). DEVELOPING A SUSTAINABLE HOUSING MARKETPLACE: NEW BUSINESS MODELS TO OPTIMIZE VALUE GENERATION FROM RETROFIT. *Int. Journal for Housing Science, 40*(3).
- Home - LEAP: The Local Energy Alliance Program. (n.d.). Retrieved November 02, 2020, from https://leap-va.org/
- Plans & Progress. (n.d.). Retrieved October 16, 2020, from https://sustainability.virginia.edu/about-us/plans-progress
- Less, B., & Walker, I. (2015). Deep Energy Retrofits - Reducing Cost and Increasing Cost Effectiveness. Retrieved November 02, 2020.
- Why Energy Efficiency Upgrades. (n.d.). Retrieved November 02, 2020, from https://www.energy.gov/eere/why-energy-efficiency-upgrades
- Home. (n.d.). Retrieved October 16, 2020, from https://www.dominionenergy.com/