Prospectus

Getting to Neutral
(Technical Topic)

What potential does renewable energy have to reduce energy poverty and promote the development of an equitable energy grid?
(STS Topic)

By

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Fall 2020

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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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I. Introduction

Companies including Apple, Amazon, and Tesla are amongst the growing number of companies, countries, and institutions that have pledged carbon neutrality by 2030. This trend will increase the demand for renewable energy. The growth of a renewably supplied energy grid will increase the diversification of energy sources such as wind turbines, hydropower, geothermal, and photovoltaics. The transition to a renewably sourced electrical grid will require a complete restructuring of the current electricity grid that exists today.

Currently the majority of the electricity in the United States is controlled by geographic utility monopolies that supply commercial, industrial, and residential electricity (Burke and Stephens 2018). The structure of electrical utilities' distribution traditionally consists of a centralized power plant and distribution center. The electricity supply monopolies dominate at the expense of the residential consumer. The issue of 'energy poverty' has become significant globally. Currently, 1.1 billion people do not have adequate access to electricity (Lee 2020). It occurs when a household spends more than 10% of their household income on electricity (Lee 2020).

With the diversification that arises from distributed energy resources, there will be many sources supplying electricity to the grid. Ideally, this shift will increase competition between electricity supplies and drive down the rates for consumers. The potential for customers to generate their own electricity and sell excess back to the grid would allow for increased customer choice and autonomy.

II. Technical Topic

Similarly to many of the large corporations and countries, the University of Virginia has set steep decarbonization goals to be carbon neutral by 2030 and consume no fossil fuels by 2050

(Kelly 2019). The intent of the Getting to Neutral project is to model a potential microgrid at Fontaine Research Park that utilizes distributed energy resources. The main technologies included in the analysis are rooftop solar, cogeneration plant, geothermal energy storage, data center heat trapping, and an electrical bus fleet station.

The University of Virginia has three electrical substations that take in energy supplied by Dominion Energy and distribute it out to the facilities at the University. Fontaine Research Park is about a mile off of central grounds and so it has its own metered substation that is Sherwood Substation. There are currently office and medical research buildings at Fontaine, but the plans for development are extensive. Proposals for development include more medical research buildings, academic buildings, office buildings, and clinical buildings.

The capstone project team will be modelling the future build out of Fontaine to simulate the energy loads and determine how best to reduce these loads. The ultimate goal of this modelling is to determine how the Fontaine Research Park can operate while maintaining carbon neutrality. The team has taken the approach of using distributed energy in order to do this.

Distributed energy resources are decentralized microgrids that are capable of generating and storing their own energy, while being connected to the larger energy grid. For UVA this would include generation from sources such as rooftop solar and harvesting excess heat from the proposed on-site data center. Storing energy within the microgrid allows for reduction of peak loads during the day. The energy storage systems will take in energy during low demand times (typically at night for this kind of development), and the energy would then be used during peak load times to level out the energy demand curve. The reason that the energy demand curve needs to be leveled out is because when the supply of renewable sourced energy is unable to meet the demand, fossil fuel electrical generation is then used. Since the university has pledged carbon neutrality, avoiding the consumption of fossil fuel-based energy is highly important.

At the Fontaine site, there is little building level data on energy consumption. In order to conduct the analysis and predict future load values, comparable data from the University of Virginia's main campus will be extrapolated and applied to the situation. The modelling tools being used are TEMOA and a script in Python developed by Jeffery Bennet and Jay Fuhrman, graduate researchers at the University of Virginia (Bennett and Fuhrman 2019).

The case study at Fontaine will then be used later on in the project in order to model the entire University of Virginia. Since Fontaine Research Park is currently being developed, implementing distributed energy resources is relatively easier because there are no energy systems already in place. Additionally, these results will be used to model a scenario in which large scale institutions, similar to the University of Virginia, are actively using distributed energy resources.

III. STS Research

The development of distributed energy resources and a renewable-based grid will have a large societal significance. The lens that will be used to analyze the resulting implications of this will be the Actor Network Theory and the Social Construction of Technology. The Actor Network Theory posits that both living and nonliving elements act and affect a socio-technical situation (Sage, Vitry, and Dainty 2019). Meanwhile, Social Construction of Technology Theory suggests that rather than technology influencing humans, the social ideas of the time are manifested in the technology. These two theories will be the main structure in the analysis of energy equity and how or if it will change with the transition to renewably sourced electricity and distributed energy microgrids.

There are many physical and nonphysical actors within this situational network. The main ones are electrical utility companies, federal and state governments who set regulations and standards, institutional electricity buyers, the technology of cogeneration plants and energy generation, and the residential buyers of electricity. The residential buyers are a large group of people who have varying motivations within the group. Thus I will split them into two groups, the people who are considered energy stable and those who are considered energy poor. The definition of energy poverty being used in this analysis is a household that spends more than 10% of their household income on electricity (Lee 2020) or a household that does not have adequate access to electricity (Betto, Garenga, Lorenzoni 2020).

The importance of determining how a shift to renewables and a distributed energy grid will change the situation for the energy impoverished people is that it will help guide how these technologies should be implemented. Within the context of the past decade there has been a large trend in equal rights and treatment activism. The concept of energy equality is undeniably linked to the solution to this problem. Frequently, poorer communities are charged higher rates for electricity, leading to exorbitant electrical bills which creates a cyclical pattern of poverty (Ingber 2019).

I will research the potential for the growing renewable energy market to affect the issue of global energy poverty. This will include both the positive and negative ramifications of renewable energy systems and the politics associated with these solutions. Ultimately the question is: what potential does renewable energy have to reduce energy poverty and promote the development of an equitable energy grid? I will limit my research to within the United States, and will focus primarily on the effect this shift will have on the people who are in energy poverty.

I will research the current rate structures for electricity and will look at how those have changed in areas that have implemented large scale renewable energy. Additionally, I will study the structure of the Texas competitive power market and how that idea could be applied to the renewable energy market (Zarnikau 2011). The lens of this will all be focusing on the people who can least afford their energy bills and therefore are the group most affected by the energy rates. Another important consideration that will be researched is the potential for autonomous household energy generation (Campos 2020). This will be researched with the main technological solution being photovoltaics. The implications of people generating their own electricity will also be considered through a cash flow analysis compared to a traditional electricity rate structure. This will be conducted by comparing the initial and maintenance cost of at home solar generation to the current price that people are paying for their electricity. There is a study conducted in Seoul, Korea that looked into implementing this in low-income neighborhoods (Lee 2020). The trial was successful, but I will build off this research and look deeper into the economic drivers behind the situation.

IV. Conclusion

The final deliverable of the STS portion of the research will be a scholarly article that presents my findings. The deliverable to the Technical portion will be a grant application to the DoE and University of Virginia to promote the development of distributed energy resources at Fontaine Research Park. The DoE is awarding grant money to institutions that are building distributed energy resource infrastructure. Ultimately, I hope to create a succinct argument on how the distributed energy market will affect people in energy poverty and the deployment of these resources can be altered to ameliorate the burden on the impoverished communities.

Task	**Estimated Days To Work**	**Start Date**	**End Date**
Research	52	11/9/2020	2/1/2021
Analyze and Organize Research	10	2/2/2021	2/12/2021
Writing Process	21	2/13/2021	3/6/2021
Review	21	3/7/2021	3/28/2021

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