Undergraduate Thesis Prospectus

Behind the Meter: Strategies for UVA to Contribute to Deep Decarbonization in Virginia

(technical research project in Systems Engineering)

Conservation and Innovation: Protecting the Ogallala Aquifer from Depletion

(sociotechnical research project)

by

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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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General research problem

How may human needs in the U.S. be met more sustainably?

America has always been lauded as a land of plenty, rich in natural resources. Yet more than two million Americans live without access to safe drinking water (Roller et al., 2019). By 2071 nearly half of fresh water basins in the U.S. may not meet water demand (Brown, 2019). Thus, it's prudent to consider how the U.S. can mitigate the effects of climate change. The U.S. consumes about 17 percent of the world's total generated power (USEIA FAQ, 2020), but just 19 percent of it from carbon-free sources (USEIA Statistics, 2020). The U.S. must transition to sustainable practices.

Behind the Meter: Strategies for UVA to Contribute to Deep Decarbonization in Virginia

How can the project team develop low-cost carbon reduction strategies for UVA that can be emulated by institutions across Virginia?

General Information

This technical project is part of the Systems, and Civil Engineering Departments. Advisors for the project are Professor Andres Clarens from the Department of Engineering Systems and Environment, and Senior Research Scientist Arthur Small from the Weldon Cooper Center for Public Service at UVA. The project team has six members, Tommy Anderson, Chloé Fauvel, Harrison Hurst, Nina Mellin, Bailey Thran, and myself.

Project Background

UVA, building on its previous successes, made a commitment with William & Mary in 2019 to reach carbon neutrality by 2030 (UVA, 2019). This paralleled Virginia Governor Ralph Northam's executive order setting a goal for Virginia to produce 100% of its energy from carbon-free sources by 2050 (Northam, 2020). Decarbonizing the energy sector is a vital part of addressing climate change, as globally 25% of greenhouse gas emissions originate from the energy and heating sector (IPCC, 2014). However, the path to renewable energy technology is not clear cut, as its variability creates a new set of challenges as renewables become a larger percentage of the power grid.

Currently, within the UVA Sustainability plan for 2020-2030, there is a section dedicated to the goal of decarbonization by 2030. However, there are no concrete recommendations on how to meet the goal, it mentions decisions being, "guided with this ultimate objective in mind", and also lists some "areas of focus" such as energy and transportation (UVA, 2019). As such, it falls to projects like this one to turn goals and recommendations into actionable plans the University can execute to reach its sustainability goals.

Project Objectives and Methods

The goal of this project is to develop low-cost decarbonization strategies for UVA that other Virginian institutions can emulate. To develop these strategies, we will focus on Fontaine Research Park at UVA, which in 2018 had a road-map for its re-development approved (UVA, 2018). Fontaine makes an ideal location to test these strategies since it will be on its own power meter, and already has historic data about the power usage of its buildings. Strategies will be tested with existing building-level energy models made in Python, as well as grid-level energy

models such as TEMOA. Together, the deliverable of this project will be a proposal to the U.S Department of Energy (DOE) with low-carbon strategies for powering Fontaine, with the goal of getting Fontaine recognized by the DOE as a Connected Community (DOE, 2020). Leading to millions in federal funding for the implementation of low-carbon grid technologies, greatly assisting UVA in reaching its goal of carbon neutrality by 2030.

With or without the federal funding however, the decarbonization strategies we develop will be actionable by UVA for current and future projects, and potentially be implemented by other academic and office campuses across the state of Virginia.

Conservation and Innovation: Protecting the Ogallala Aquifer from Depletion

How have U.S. conservationists strived to slow the depletion of the Ogallala Aquifer?

The Ogallala aquifer underlies 111.4 million acres across eight U.S states (McGuire, 2007). About 27 percent of U.S. farmland depends on the aquifer for irrigation (USDA, 2011), and it provides drinking water for 2 million Americans. (Dennehy, 2000). During the agricultural revolution of the 1950s, farmers drew much more water from the aquifer. Since then, irrigation has lowered the water table by up to 277 feet in some areas (McGuire, 2007). Large agricultural enterprises, independent farmers, conservation nonprofits, and others agree that the depletion of the Ogallala aquifer must be slowed or stopped, but they disagree about how to do so.

Participants include the American Farm Bureau Federation (AFBF), which represents farmers and ranchers across the country; AFBF calls itself the "voice of agricultural producers at all levels", and claims to be "non-partisan, non-sectarian and non-secret in character" (AFBF, 2020). The AFBF represents farmers' interests at all levels of government. Through its state affiliates, National Corn Growers of America (NCGA) represents the interests of U.S. corn

farmers, including many who use water from the aquifer (NCGA, 2020). Their mission is to, "create and increase opportunities for corn growers" and "sustainably feed and fuel a growing world" (NCGA, 2020).

The U.S. Geologic Survey, the Interior Department's sole science agency, monitors the health of the aquifer (e.g. McGuire, 2017). Through technical and financial assistance, the U.S. Department of Agriculture's Ogallala Aquifer Initiative helps farmers adopt less water-intensive irrigation practices (USDA, 2011). Participants also include nonprofits such as Ogallala Commons, which promotes sustainable practices through education and leadership training to plains communities (Birkenfeld, 2017). In their founding document (Birkenfeld, 2017), they describe themselves as "a counterweight to the dominant corporate approach towards economic and social organization" and "structured in a cooperative grassroots pattern."

Apart from organized groups, farmers have also been more directly engaged in efforts to conserve the aquifer without undue hardship to farm families (Bergmeier, 2020).

Researchers have investigated how water conservation can be promoted and how social groups respond to threats of resource depletion. Amosson et al. (2009) found that better irrigation techniques without long-term water use restrictions is ineffective and can increase water consumption. Ward and Pulido-Velazquez (2008) concur, and recommend better water usage accounting. Yang et al. (2003) concluded that optimum water pricing alone is ineffective. They contend that conservation requires specified and legally enforceable water rights and responsibilities. Moon et al. (2012) found that private landholder's desire to follow conservation policies depended on social and personal circumstances, like stress, hours working the land, and their trust of the government. Zhao et al. (2012) likewise found that citizens that owned large tracts of land more often joined conservation programs, and that their age was not a factor.

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