SOLAR INSTALLATION ON IVY LANDFILL

THE ROLE OF ELECTRIC UTILITY MONOPOLIES IN US RENEWABLE ENERGY TRANSITION

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By
Mina S. Gorani

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Technical Team Members: Maggie Collins, Erik Hammerquist, Anusha Jain, Demari Jackson, & Caroline Maher

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.

ADVISORS

Prof. Pedro Augusto P. Francisco, Department of Engineering and Society

Prof. Zhen "Leo" Liu, Department of Civil & Environmental Engineering

INTRODUCTION

With a quarter of US greenhouse gas (GHG) emissions in 2022 associated with electricity generation, finding routes to decarbonize energy production is a key challenge in addressing human-caused climate change (US EPA, 2024). The US energy crisis of the 1970s led to a notable increase in renewable energy research; however, since 1970, renewable energy production has only increased from 3.7% to 8.2% of US primary energy production while energy production as a whole has almost doubled (National Grid, 2024; US EIA, 2024b). This thesis explores both technical and socio-technical challenges involved in the implementation of renewable energy transition.

Solar panels are a technology at the forefront of renewable energy production. What makes this energy generation source particularly unique is its ability to be installed on a variety of scales from residential rooftops to grid-connected photovoltaic power systems; however, solar energy production faces challenges with space constraints, shading, and upfront installation costs (Crail, 2024). While both small- and large-scale solar installations serve as sources of renewable energy, small-scale residential projects have the added benefit of directly providing households with below market-rate energy and the opportunity to sell excess energy back to the energy utility company operating the grid. Conversely, large-scale solar farms are typically owned and operated by energy utility companies and distribute solar energy at the same pricing rate as other energy sources.

In most of the US, energy utilities operate as regulated monopolies, holding exclusive rights to generate, transmit, and distribute electricity within specific service areas (Cleary & Palmer, 2022). This structure grants them monopolistic status to ensure stable energy access and pricing; however, this status also prevents typical free market competition that promotes the use of newer, more efficient technologies like those used for renewable energy generation (Farrell, 2024).

In combination, this socio-technical thesis and design capstone seek to examine different dimensions of transitioning the US's energy production to renewable sources. The design capstone explores the process of developing a capped landfill into a small-scale solar farm with the goal of selling it to Dominion Energy, Virginia's largest energy utility company, who is working to meet the renewable energy requirements passed by the state. Alongside this, the STS thesis examines how placing energy production in the hands of regulated monopolies, like Dominion Energy, influences the US's renewable energy transition. Together, understanding the technical and socio-technical complexities involved in carrying out this shift is crucial to the ability to efficiently transition to renewable energy sources, reduce the emission of greenhouse gases, and provide communities with long-term low-cost power.

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The goal of this design capstone is to create a design-based proposal for the installation of a solar power facility on the closed and capped Ivy Landfill site. The capstone group will be playing the role of a solar development company that will then sell the completed solar farm to Dominion Energy for them to connect it to the power grid. This project is

based on a real-world design solicitation from Dominion Energy that was motivated by the 2020 Virginia Clean Economy Act (VCEA).

The VCEA established a mandatory renewable portfolio standard program for Dominion Energy, requiring the company to deliver energy from fully renewable sources by 2045. As a part of the act, Dominion Energy is required to provide 200 megawatts of solar capacity through the development of small projects on previously developed sites, such as landfills or coal mines. The VCEA defines small projects as those producing less than three megawatts of alternating-current power. These restrictions are to promote the reuse of land that otherwise has limited development potential and to add renewable energy sources to the grid at loads small enough that significant improvements to transformers, substations, and transmission lines are not required (Tioga Contractors, 2024).

The primary objective of this design is to create a solar arrangement on top of one of the closed cells of the landfill. To accomplish this, appropriate solar panels must be selected based on the photovoltaic modules' energy conversion rate, durability, size, and cost (EPA, 2022). Once the solar panels are selected, they are arranged on the site to optimize energy capture based on their orientation and subsequent shading.

As this solar farm is on top of a closed landfill, additional considerations are necessary for the solar panel installation. Capped landfills, like the Ivy Landfill, tend to be sloped. Solar installation on sloped surfaces, such as rooftops, is common; however, in these cases solar panels can be secured to the sloped surface they are attached to by penetrating the surface with bolts (Mooney, 2024). Conversely, landfills are capped with

layers of different cover materials to prevent the waste materials they contain from leaching into the surrounding environment (Joyce Engineering, 2002). Because of this cover, the surface of the landfill should be minimally disturbed, and a concrete ballast system can be employed that sits on top of the landfill and secures the panels using the ballast system's weight (EPA, 2022).

Alongside the solar arrangement design, erosion and sediment control (ESC) measures must be taken in two phases. Phase I ESC involves capturing the current state of waterflow on the site and is modeled using elevation and surface material data in Civil3D. Then, once the solar arrangement design is finalized, the panels will be drawn into Civil3D and the modeling process will be conducted again for Phase II. Depending on the level of runoff waterflow after development, additional control measures may be necessary such as placing silt fences around the perimeter of the site (Altomonte, 2024). These solar and ESC design components will be delivered through plan sheets in addition to a written report.

Once the major technical design components are complete, attention will be shifted to two other elements that address the solar farm's development. As with the introduction of any new technology to a community, it is important that the surrounding community in Albemarle County is properly educated on the functions of the solar farm. Our capstone group will prepare slideshows and resources for an information table at community events to promote acceptance and dispute misconceptions about the solar panels. Furthermore, once all the design components have been determined, online resources will be references to capture an accurate cost estimation for the material and labor costs of building the solar farm.

THE ROLE OF REGULATED MONOPOLIES IN RENEWABLE ENERGY TRANSITION

Playing off the many actors involved in the production of this thesis's design capstone, the sociotechnological research will focus on answering the following: How does the regulated monopoly status of energy utility companies in the US influence renewable energy transition?

Renewable energy sources are simply power sources that do not come from a finite or exhaustible source, like fossil fuels, and are instead derived from natural processes that are continuously replenished. These include solar, wind, hydro, geothermal, and biomass energy, each of which leverages naturally occurring energy cycles to generate power sustainably. Unlike fossil fuels, renewable sources have lower environmental impacts and transitioning to their use is crucial to addressing climate change. (United Nations, n.d.)

Beyond the environmental benefits of renewable energy, there are also a plethora of economic benefits to their use: renewable energy sources tend to be local, allowing communities and countries to be independent from the unpredictable price swings of fossil fuels; renewable energy is cheaper; and renewable energy creates three times as many jobs as the fossil fuel industry per dollar of investment. (United Nations, n.d.)

Despite those environmental and economic benefits, transition to renewable energy in the United States continues to lag with non-renewable energy sources comprising 91% of energy consumption in 2023 (US EIA, 2024b). One reason many attribute for this lag is that across the US, investor-owned power utility companies hold a unique

monopolistic position granted to them by the states they operate within (Stein, 2024). Although they comprised only 6% of utility companies in 2017, 72% of US electricity customers received their power from an investor-owned utility (U.S. Energy Information Administration, 2019). These statistics speak to the dominance these companies have over electricity sourcing within the country. One major opponent to this monopoly structure went as far as to say corporate utility monopolies have begun “a long-term divergence from the public interest that continues today, opposing climate action, eroding trust in oversight and faith in government, and pursuing unjustified profits” (Farrell, 2024).

The regulated or “natural monopoly” status of energy utilities emerged in the US during the early twentieth century. This regulatory status was widely adopted by state governments as regulators recognized that a single electric grid was more efficient than multiple competing sets with overlaying infrastructure. This designation also meant that the utility companies could operate on a larger scale within a legally stated jurisdiction, lowering the cost of electricity given the technology at the time. This structure has widely continued into the present day, providing electric utilities with guaranteed profits and almost no competition, providing little motivation for change (Farrell, 2024; Stokes, 2020). To combat this, over half of US states have launched renewable portfolio standards (RPS) or clean energy standards (CES) that require energy suppliers to provide energy with a minimum share sourced from renewables (US EIA, 2024a). That said, many feel that these programs are not radical enough and larger changes must be made to the electricity utility market (Farrell, 2024).

To further explore how the regulated monopoly status of energy utilities influences renewable energy transition, state and federal policies along with insights from scholarly and non-scholarly sources will be analyzed through the lens of technological determinism. Technological determinism is the theory that technology is the primary driver of societal change and development, shaping social structures and cultural values in ways that are seen as inevitable or autonomous. Although reductive, this lens will refine the complex issue of energy transition to a simplified technological actor and societal response between policy and the status of energy transition. This exploration will then provide insights on how this regulatory status affects energy transition, and what changes may need to be made to better promote the use of cleaner, greener, and more sustainable energy sources. (US EIA, 2024a)

CONCLUSION

This thesis will explore issues related to renewable energy transition in both a technical and sociotechnical sphere. The technical design will culminate in solar arrangement and ESC design plans as well as community engagement plans and cost estimation for a solar farm development on top of a capped landfill local to Albemarle County. The sociotechnical research will explore how the role of regulated energy utility monopolies affects renewable energy transition in the US through the lens of technological determinism. Through this sociotechnical research, I anticipate to conclude that the regulated monopoly status of electrical utilities is hindering renewable energy transition.

Exploring these challenges is critical to unpacking and addressing renewable energy transition. Moving away from fossil fuels to renewables not only reduces the emission of

greenhouse gases, but also provides the cheapest form of power long-term, job growth, and air quality improvement to communities that otherwise must house fossil-fuel power plants.

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