THESIS PROJECT PORTFOLIO

SOLAR INSTALLATION ON IVY LANDFILL

(Technical Report)

THE ROLE OF ELECTRIC UTILITY MONOPOLIES IN US RENEWABLE ENERGY TRANSITION

(STS Research Paper)

An Undergraduate Thesis

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EXECUTIVE SUMMARY

With a quarter of U.S. greenhouse gas (GHG) emissions in 2022 linked to electricity generation, decarbonizing the energy sector is a central challenge in addressing climate change. This capstone combines a technical design project with a sociotechnical research thesis to explore the multifaceted barriers and opportunities in transitioning U.S. energy production to renewable sources. The technical component involves designing a small-scale solar farm on a capped landfill for potential acquisition by Dominion Energy, Virginia's largest utility, in alignment with the Virginia Clean Economy Act. In parallel, the STS thesis analyzes the role of regulated electric utility monopolies, like Dominion, through the lens of actor-network theory (ANT). Together, these projects highlight the importance of understanding both technical feasibility and systemic power dynamics in accelerating renewable energy adoption.

The technical capstone focused on designing a three-megawatt solar facility on a capped cell at the Ivy Landfill. The site and size were chosen to comply with thresholds established by the Virginia Clean Economy Act, which incentivizes renewable generation under specific conditions. Designing on a capped landfill presented unique constraints, as disturbing the protective cap through digging or grading is prohibited. Despite these challenges, such landfills offer untapped potential as they are otherwise unusable for development and do not contribute to deforestation or farmland loss. The project showcases how sustainable design can transform constrained spaces into productive, community-aligned assets for clean energy.

The design process began with a site assessment to evaluate grading, solar access, and visibility from nearby parcels. A prefabricated concrete ballast system was selected to support the solar arrays without penetrating the landfill cap, limiting placement to areas with slopes under 7%. Key design decisions included module layout, row spacing, inverter count, and system orientation. Erosion and sediment control plans were developed to manage runoff, and cost estimates were produced to assess project feasibility. A community engagement strategy was also included to build local support and transparency. The final outcome was a fully developed solar farm design that balances environmental, technical, and social factors.

The sociotechnical research investigated a critical yet underexplored barrier to the renewable energy transition in regions of the United States using a traditional utility model: the entrenched power of regulated electric utility monopolies. While technological advances and public support for clean energy have surged in recent years, the pace of adoption remains stymied. The significance of this inquiry lies in understanding not only what progress must be made to decarbonize energy production, but also how existing networks must change to allow for this transition. By applying actor-network theory (ANT)

as a sociotechnical framework, this study analyzed academic literature and contemporary critiques of electric utility monopolies to determine how they are entangled within regulatory, political, and technological networks.

Analysis revealed that utility monopolies function as dominant actors within a self-reinforcing network, leveraging lobbying efforts, policy manipulation, and public messaging to maintain control over the energy system. This networked power structure inhibits the widespread adoption of renewable technologies, not due to technical limitations, but because of asymmetrical influence over key decision-making bodies. ANT illuminates how these monopolies use their guaranteed profits for lobbying to uphold their dominant position, even as renewable technologies offer decentralized, cost-effective alternatives. However, renewables technologies also wield power, creating new feedback loops of affordability, access, and public support. The findings suggest that to embrace energy transition there must be disruption to existing power networks through regulatory reform, civic advocacy, and a reconfiguration of institutional relationships. Only by dismantling these systemic barriers can clean energy reach its full potential as a public good.