Thesis Project Portfolio

Automated Solar Panel Cleaning

(Technical Report)

Mutual Shaping of Residential Solar Regulations in the Commonwealth of Virginia

(STS Research Paper)

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Executive Summary

To combat climate change, societies must adopt cleaner energy sources like wind, solar, nuclear, etc. to reduce carbon emissions and pollution. Photovoltaic solar technology ("solar panels") is promising through their ability to directly convert sunlight to electricity without an intermediary step like turning a motor or boiling water. Placing solar panels on the roofs of homes and buildings will increase solar energy production on already developed land. Systems like these are collectively called "rooftop solar" or "residential solar." Due to innovation and policy, solar panels costs have fallen over 97% since 1980 while doubling in efficiency in the same period. Despite residential solar system costs having dropped by 64% since 2010, "soft costs" like overhead and installation can still account for up to 65% of the total system's costs. Technical challenges around maintenance and cleaning also remain. This overall project addresses how to increase residential rooftop solar technology adoption in the US through improved technical and regulatory efficiencies.

The technical project aimed to address challenges in residential solar system maintenance. In the United States, solar panels can lose up to 7% of their energy generation annually if not cleaned. Current solutions for cleaning residential solar (RS) consist of laborious manual cleanings occurring at semi-regular intervals. An affordable and automated system that can regularly clean panels would provide greater system efficiencies and reduce "soft costs." The technical project aimed to address the gap in automated cleaning solutions for this market. The HoosWiping group built an automated wiper blade system that can be installed around a pre-existing solar panel and keep it free of debris and particulate. The system was built around a custom-made wiper blade on vertical tracks that moves up and down via a motor. A mix of off-the-shelf and 3D printed parts was used. A lightweight Arduino circuit board was used for

system automation and regulation. The group constructed a working model with the ability to further iterate for larger solar panels.

The sociotechnical question revolved around analyzing the local and state regulatory environment for RS in Virginia and seeing how they interact and influence each other. This paper intentionally excluded other stakeholder groups such as the utility companies, activists, homeowners (as a social group), and the federal government to maintain an actionable scope. This covered selected local, state, and homeowner's associations (HOAs) in the Commonwealth of Virginia. Research in these areas attempted to answer the question: how might these stakeholder groups better promote RS adoption? To answer this, various state and local regulations were analyzed; HOA rules and media observations were added where possible. How these groups acted and influenced the others and collectively were analyzed. Generally, the research found that as the levels of authority from the Virginia state government to HOAs goes downwards, the explicit political power decreases but there is more discretion in RS approvals. The state has great power and can promote these systems, but it is ultimately left to the local governments and HOAs to greenlight them. With RS, more so than larger utility or community renewable projects, promoting broader system adoption ultimately comes down to a motivated household's personal interactions with the solar market, the overall economy, and the "cumulative" regulatory environment in that locale. Since Residential Solar ownership is strongly tied to single-family homeownership and socioeconomic affluence within the broader housing market, the relevant authorities should consider how actively to promote RS within the context of a broader energy and environmental strategy.

Overall, the coupled project yielded mixed results. The technical project was fruitful within its understood limits, but the sociotechnical work's scope was too limited. Although the

HoosWiping team had to shift project goals slightly, the shift involved cutting nonessential subsystems to focus on core functionality. The goal was modest but was fully realized. In contrast the sociotechnical paper's scope was cut too much too soon. The paper only analyzed a few groups along a narrow basis and excluded integral stakeholder groups like Virginia utilities and the federal government. Even in the case of national stakeholders like the federal government and its agencies, the paper could have included ways as to how national regulations both are influenced by and inform the actions of other stakeholders within the state. On the technical side, future research should be done to iterate on the solar panel wiper design and harden it for consumer use. Future research on the socio-political landscape of residential solar in Virginia should include more stakeholders and be more all-encompassing in its analysis.