AUTOMATED AND REDUCED WATER SOLAR PANEL CLEANING

SOLAR PANEL FEASIBILITY AS THE ENERGY SOURCE OF THE FUTURE

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By
Joshua M. Belisle

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Technical Team Members:
Kyleigh Talomie, Brandon Bonner, and Nick Langer

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

Kent Wayland, Department of Engineering and Society

Michael Momot, Department of Mechanical Engineering

General Research Problem

Why is solar energy not more popular in the United States?

Solar energy has been around for decades and continues to provide a larger portion of electricity each year (Hicks, 2021), and is projected to reach 10% of the worlds electricity output by 2030. However, there are still many factors inhibiting the total turnover from fossil fuels to solar energy within the United States. One main factor is solar panels get dirty from dust, leaves, hair, and animal droppings (commonly referred to as “soiling”). These foreign objects lower efficiency and electric output. Solar panel plants require both vast quantities of sunlight and land, making the most effective locations rural areas, specifically deserts. These locations inherently have more airborne particulates, furthering the issue of solar panel soiling (Panat & Varanasi, 2022). Solar panels are also fragile, needing certain conditions in order to operate. They cannot get too hot or cold, they need to be placed in high sunlight areas, and they need the sunlight to reflect at a certain angle for maximum efficiency (Laseinde & Ramere, 2021) (Mokhtari et al., 2009). While these can be viewed as roadblocks to the future of solar energy, there are new technologies and plans that can help solar energy become an intricate part of the American energy system.

I will be looking into two areas surrounding the idea of solar energy in America. The first is technically, as our team will build a fully automated solar panel cleaning system. This system will remove foreign objects from the surface of the panel to help maximize efficiency while also reducing water waste. The second area will be residential solar panel usage by the American home owner. Beyond the technical issues with solar panels, there are many other considerations a potential new solar system user must consider. Some of these considerations are the economic, social, and political aspects surrounding domestic solar panel usage. I will study these non-

technical aspects of solar panels and place the idea of solar panels within their larger socio-technical system. All of this collectively will provide the full picture on why solar energy is not more popular with America.

Automated and Reduced Water Solar Panel Cleaning

How can a fully automated and reduced water solar panel cleaning system be designed to help improve solar panel efficiency?

In order to help solar panel efficiency, foreign items like dust, bird dropping, leaves, and animal hair need to be constantly removed from the panel surface. The most common current solution to this issue is to use water. However, it is estimated that 10 billion gallons of water is used per year to clean solar panels. It is also very labor intensive and expensive to attempt one of the few waterless solar panel cleaning systems currently available (Chandler, 2022).

To help with this problem, our team will develop a fully automated, minimal water usage system that cleans solar panels. In order to do this, we will use a rolling brush and electrically charged plate that will clean the soiled solar panels whenever solar efficiency drops below a given percentage.

The electrically charged plate was first developed by MIT. Their research has concluded that when a metallic plate has a voltage applied to it, the charged plate can repel dust from the solar panel surface. The charged metallic plate, when close enough to dust particles, utilizes the electromagnetic field to pick up and move the particles. In a lab scale prototype, a fully coated solar cell with various particle sizes could recover 95% of the lost power output just by using the charged plate technology. This technology is limited by the humidity of the environment, but still demonstrates real promise for waterless solar panel cleaning (Panat & Varanasi, 2022).

The charged plate will be attached to a frame that will surround the desired area of cleaning, running along a guide rail system to remove dust from the panel surface. A soft bristle or cloth brush will also be attached to the frame and use a guide rail system, however it's motion will be independent from the charged plate. Further research is needed to determine which brush style will be used, as damaging the surface of the solar panel can also reduce efficiency (Chandler, 2022). As mentioned, other items such as leaves and bird droppings can also reduce efficiency. The brush will be the main way of cleaning these other foreign items from the panel's surface, as the charged plate cannot move these much larger items. This is why it will also be independent from the charged plate, allowing the brush or the charged plate to be used to clean the needed items.

The last key aspect to the new solar panel cleaner will be its ability to be autonomous. Our new proposed cleaner will incorporate an efficiency calculator, allowing the system to track when the panels efficiency drops. We will have to take into consideration other factors such as weather and the time of day, but we believe that a statistical analysis of the solar panels production can be used to determine when the panel has a foreign object blocking it. We will then try to create a way of determining if the foreign object is a large item that needs the brush, if it is the gradual build up of dust and needs the charged plate, or potentially both. The autonomous aspect of our solar panel cleaner will allow the system to be fully functioning without the need of human monitors. While yearly checkups and maintenance might be required, the desire is for the system to maximize efficiency at all times, potentially down to the hour. This will also reduce the potential dangers of cleaning solar panels, especially for the inexperienced domestic solar panel user.

Preliminary work has already started as the initial concept design has been chosen after and extensive screening and scoring process. Initial calculations for the metal plate in bending have also been performed along with ideas for the movement system and brush design. In the spring, a prototype will be built using a combination of 3D printed and purchased parts. The prototype will be designed for a scaled down 12":20" model solar panel. Before beginning building, we must further design the mode in which the system will secure to the solar panel in order to ensure the cleaner doesn't fall or slip from a 0 to 30-degree tilt (simulating a roof).

Solar Panel Feasibility for the Average American

Why are there not more residential solar panels in the United States?

Solar panels have many advantages as a clean, renewable source of energy. Solar panels are able to provide electricity with 0 greenhouse gas emissions and are far more versatile than other green energy sources, such as nuclear, wind or hydroelectric power (*Environmental Impacts of Solar Photovoltaic Systems*, n.d.). However, only 1.4 % of the worlds energy comes from solar and 8% of US homeowners have installed solar panels (*Environmental Impacts of Solar Photovoltaic Systems*, n.d.) (Leppert & Kennedy, n.d.). This begs the question of why there is not a larger residential solar panel population in the United States.

While the technology of solar panels may be a part of this issue, I would like to focus on the surrounding socio-technical system that solar panels play a part in. The first aspect to consider must be the cost. The average domestic solar panel installation, including the recent tax incentives, costs between $17,500 and $23,500 in 2022. This initial instillation cost is high, but over the course of the 25–30-year life span of a solar cell, can be worth it. This can happen as even small-scale solar installments can greatly decrease or eliminate monthly energy bills. This

does rely on the monthly rate, solar production, and location, but it is possible. Solar panels also typically increase the value of the home (Marsh, 2022). These initial findings would appear to offset the initial installation costs of a residential solar system. Yet, of the 47% of Americans who have given considerable thought to solar, only 8% have actually installed solar systems (Leppert & Kennedy, n.d.).

These findings imply that there is more to the question of solar power than just the cost. Some addition aspects one must consider is the large rental market in the US (roughly 37%), poor credit scores, or the unappealing nature of solar panels on one's roof (Watkins, 2017) (Sami, 2021). While convincing someone solar panels look good on their house maybe be a losing battle, the rental and credit score issue within the US has a major impact on the ability to install solar panels. As Emily Pontecorvo puts it, "[instead] of asking why there isn't more rooftop solar around, you might want to ask a slightly different version of the question: Why is rooftop solar so inaccessible to so many people?" (Pontecorvo, 2021). It has gotten extremely difficult for Americans to install solar systems; despite all the benefits they can provide. There is a much larger complexity around the simple question of whether Americans can or will install a domestic solar system.

In order to more fully understand this issue, I plan to conduct large scale research into residential solar panels. I will look into the current governmental policies in place, both at a national and state level, the developing cost reductions of solar panel installations, and American home owner desires to add solar systems. I will also explore current companies who do residential solar instillation to gain a firmer grasp on all the complexities that must be considered in order to do an installation. Lastly, I plan to organize all of these findings into a research paper that will expound on the socio-technical system that is residential solar panel, explaining how the

economic, political, and social dynamics all come together to answer the question of why residential solar power is not more common in America.

Moving Forward with Solar Energy

Solar energy and specifically solar panels have become more common in society. Yet, with the growing need for energy and the desire to move away from fossil fuels, solar energy could become a leading source of energy in the future. With the small percentage of residential solar systems in the United States, there is an opening for solar to gain more traction. Yet, getting past all the initial issues of solar may be difficult for most home owners. Even beyond the installation, upkeep of the panels must occur to maintain peak efficiency. Hopefully, with our groups new autonomous solar panel cleaning system, the maintenance issues can be diminished and further encourage residential instillation. Hopefully, through the technical and research portions of this thesis, a deeper understanding of solar energy, its limitations, and its place in the broader society will be further expounded and explored.

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