Automated Solar Panel Cleaning
(Technical Paper)

An Analysis of the Influences Impacting Individuals Understanding of Global Climate Change
(STS Paper)

A Thesis Prospectus
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Bachelor of Science in Mechanical Engineering

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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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Prospectus

Introduction

"Global climate change is not a future problem," states NASA, as glaciers continue to shrink and there are more intense heat waves and natural disaster occurring (Jackson, n.d.). President Biden created the National Climate Task Force in 2021 with goals such as:

- reaching 100% carbon pollution-free electricity by 2035
- achieving a net-zero emissions economy by 2050
- limit global warming to well below 2 degrees Celsius (*National Climate Task Force*, n.d.; *The Paris Agreement | UNFCCC*, n.d.).

As technology continues to develop to reach the carbon neutral goal, there are still disagreements and obstacles on how to create a sustainable society that minimizes impacts to the Earth. An individual's perception and understanding of climate change is influenced by various outside forces such as academia, marketing, social media, political groups, and the government's policies. Understanding the methods information is disseminated to shape an individual's perception of climate change is important when it comes to decision making or consequential actions. While a large amount of pollution is attributed to industrial complexes, individuals do have power and influence as consumers, as voters, or as members of social groups. The STS research paper will use the Wicked Problem Framework to understand and describe the influential powers impacting individual's decisions and opinions of climate change.

The capstone design project will be related to the topic of sustainability. Solar panels are flat plates that collect energy from sunlight and have been used in large agricultural fields or also placed on top of rooftops for households. Solar panels can lose efficiency if they are dirty, and the current commonly employed method to clean solar panels on rooftops is manual labor. The

cost of manual labor can be high. The design project will create a mechanism that will automatically clean a household solar panel and is not expensive.

Automated Solar Panel Cleaning Design

Solar photovoltaic (PV) systems convert sunlight into electricity using solar cells. Solar panels have decreased in cost since 2014 and are becoming a cost competitive energy source. It is projected that more than one in seven U.S. homes will have a rooftop solar PV system by 2030 (*Solar Energy in the United States*, n.d.). Dust and soiling of the solar panel can impact energy loss of up to 7% in parts of the United States or as high as 50% in the Middle East (Hicks, n.d.). Currently, the most common method to clean solar panels is using water, soap, and brushes to remove the dirt which depends on labor and solar panels cleaning experts (*Cleaning Solar Panels*, 2022). Annual solar panel inspection and cleaning costs range from $450 to $780 (*Learn How Much It Costs to Clean and Maintain Solar Panels.*, n.d.). The goal will be to design an automated cleaning mechanism that can stay attached to the solar panel so that climbing on to the roof is not needed. Some of the requirements for the design that will be considered include low cost, safety of the attachment, and good weather durability.

The process of designing an automated solar panel cleaner will include a design phase and an implementation phase. In the Fall 2022 semester, the design phase includes ideation, concept screening, concept selection, and further modification and critique of the final concept design. Ideation will include each individual team member coming up with five unique ideas that are then narrowed down by a concept screening. The concept selection will be done by choosing the top designs and grading them with weighted categories of different requirements. Values will be estimated, and the final design will be chosen. In the current process the final design chosen was a wiper rail system, and the continuation of design will be modifications of Figure 1. In the

fall semester, there will be research into parts and material to purchase to create the mechanism and in the spring semester, the device will be created and tested.

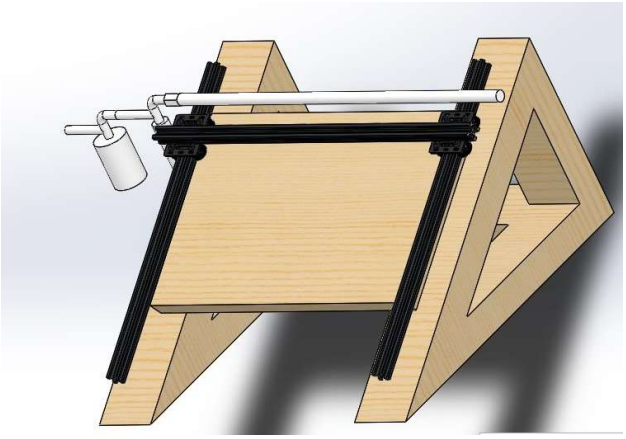

Figure 1: Initial design of wiper rail system mounted on a wooden board test stand.

The Wicked Problem of Climate Change

Since the 1800s, the main driver of climate change has been from burning fossil fuels such as coal, oil, and gas used in energy, industry, transport, building and agriculture (Nations, n.d.). Climate change impacts lives in different ways such as sea-level rising and ecosystems being damaged. The United Nations states "The 100 least-emitting countries generate 3 per cent of total emissions. The 10 countries with the largest emissions contribute 68 per cent." Delaying transition towards a more sustainable economy would lead to GDP loss as investing in improving the environment improves health and well-being, and economy ("Investing in Climate, Investing in Growth," n.d.).

There are many outside influences on an individual's perception of climate change. Examples include marketing in grocery stores for choosing something "green", as consumers will feel that green products are healthier and better for the environment compared to traditional products (P. Govender & L. Govender, 2016). Social media influencers and celebrities use private jets to travel, where each flight adds large amounts of carbon dioxide emissions to the

atmosphere (Chiu, n.d.). The manhole covers in Norfolk have an image of a crab and state "dump no waste", "drains to waterways" to be a reminder that any pollutants would drain to the Chesapeake bay and harm the creatures (Vegh, n.d.). In Texas, a volunteer-run organization called Truth in Texas Textbooks pushes for global warming to be taught as an opinion rather than fact in school settings, while the Texas Board of Education votes on what textbooks are approved for public schools (Foran & National Journal, 2014). These influences are examples of how different groups and power dynamics impact an individual's understanding of climate change.

Another influence is the vocabulary and concepts used to describe efforts towards sustainability. Sustainability can be defined as "the balanced integration of economic performance, social inclusiveness, and environmental resilience, to the benefit of current and future generations" (Geissdoerfer et al., 2017). A carbon footprint can be used to describe the amount of carbon dioxide emitted due to consumption from an individual or group, but often it is forgotten that the term carbon footprint was implemented by British Petroleum and the marketing agency Ogilvy & Mather to divert attention from the fossil fuel company and place responsibility on the public (Frank Mitloehner, 2020). Buildings with LEED certification are supposed to be more energy efficient but a study by Carnegie Melon would that there was no effect of LEED certification on average energy consumption in federal buildings (Pittsburgh, n.d.). There has been growing opportunities to recycle plastic bags at shopping centers, libraries, and there has been consistent plastic recycling of water bottles and other plastics throughout the years. However, according to Greenpeace, most plastic put into recycling bins end up in landfills or worse as processing and sorting the different plastics is expensive (Sullivan, 2022). Greenwashing is a term that is used for ads and labels that promise more environmental benefits

than are delivered (Dahl, 2010). The research will include understanding social structures that hold power and influence, and understanding how that power and influence is dissipated to an individual's everyday life.

The framework that will be used to discuss this topic will be the Wicked Problem framework which is a concept introduced by Horst Rittel and Melvin M. Webber. The Wicked Problem is a problem that cannot be definitively described, and that there is no optimal solution or definitive answer to (Rittel & Webber, 1973). Global climate change falls into this category of a Wicked Problem as it is a complex problem with many factors and obstacles to solving it, as well as the fact that number of stakeholders are large, and other societal factors such as policy, and historical injustices are intertwined with the issue. Some academics criticize the Wicked Problem framework because there aren't any clear definitions of wicked problems, or any attempt at defining it. Nancy Roberts created strategies on how to handle wicked problems by describing methods of responsibility between stakeholders as Authoritative, Competitive, or Collaborative (Roberts, 2000). The framework of the discussion will use a strategy of connecting stakeholders and methods of influence on individuals.

Research Question and Methods

The STS research will be: what are the influences that change an individual's perception of climate change? The question will entail understanding the impact of that influence, and where the power of the influence comes from. Documentary research methods and case studies will be the method of research. Topic groups such as policy, marketing, and social media will be made to study interactions between stakeholders and the individual. While there is abundant research and information when examining a Wicked Problem, the goal is to find good examples

that represent and define the challenges an individual faces when given information about global climate change.

Conclusion

The technical capstone will conclude with a final design and creation of an automated solar panel cleaner. The report will include descriptions of testing and the design process of how it was created. The STS deliverable will be a research paper of the topics described above which discuss examples of politics, marketing, and the individual in the context of climate change. The anticipated outcomes of the automated panel cleaner will be a mechanism that meets all the given specifications and functions properly. The outcome of the STS research paper will be an awareness of the influences that change an individual's perception of climate change, and an understanding of how that impacts one's life.

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