Triboelectric Energy Harvesting

The Problem with America's Response to COVID

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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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Introduction

Sustainability is often talked about with a focus on the materials we consume and the impact its waste products will have on the environment. While this framing addresses the need to preserve the natural world we depend on, it does not address the broader ambition: to create and maintain healthy societies. This is a two-fold endeavor as it requires both the health of the environment and the many people living in our nations to be prioritized and preserved. In recent years, two problems have come to the foreground in the struggle to maintain health on a societal level: climate change and COVID-19.

Human-caused climate change has been slowly ramping up and destroying our environment since the beginning of industrialization. In 2022, the climate was found by National Aeronautics and Space Administration (NASA) scientists to have increased by 1.1℃ since the beginning of world-wide climate documentation in 1880 (2022). The National Oceanic and Atmospheric Administration (NOAA) predicts that these temperature increases will lead to less food, more heatwaves, more hurricanes, and more wildfires which threaten people's well-being directly (2024). This disastrous change in climate is mainly due to the use of fossil fuels such as coal, oil, and natural gas in producing the power and mechanical motion we utilize daily. These fuel sources release greenhouse gasses that trap heat in our atmosphere with three of the biggest being carbon dioxide, methane, and nitrous oxide (NASA, 2024).

While fossil fuel burning and climate hurt the environment directly, COVID-19 assaults our personal health directly. In 2020 and 2021, COVID-19 killed 343,566 and 475,059 people in the US, respectively (Ortaliza et al., 2022). In 2022, "COVID-19 was the underlying (primary) or contributing cause in the chain of events leading to 244,986 deaths" (Ahmad et al., 2023). While COVID deaths have decreased, it still wreaks havoc through long COVID. The Centers for

Disease Control and Prevention (CDC) defines long COVID as, “a serious illness that can result in chronic conditions requiring comprehensive care and may cause disability.” (2024a) Long Covid symptoms include fatigue, fever, shortness of breath, chest pain, difficulty thinking, headaches, diarrhea, stomach pain, changes in menstrual cycles and much more (CDC, 2024b). Currently, about 17 million Americans are disabled from long COVID (Burns, 2024).

To address these two crises, we must create new renewable energy harvesting methods and better implement solutions to COVID. My technical topic addresses the need for renewable energy while my STS topic address COVID.

Technical Topic: Triboelectric Energy Harvesting

While there are already renewable energy sources that provide an alternative to fossil fuels, they tend to come with major restrictions. This is especially true for wind turbines which do not generate power below a cut-in speed, “typically between 6 and 9 mph” (Office of Energy Efficiency & Renewable Energy, 2024). For a state like Virginia where most regions have average wind speeds less than 4 m/s (less than 9 mph), wind turbines are not viable (AWS Truepower & National Renewable Energy Laboratory, NREL, n.d.).

My technical team hopes to address this problem by creating a triboelectric nanogenerator (TENG) that could generate electricity in low wind speeds. Triboelectricity is generated by two objects rubbing against each other or tapping together. Previous research has set out to analyze the feasibility of TENGs to power devices, specifically small appliances. Simiao Niu and their colleagues set out to analyze this potential use for triboelectricity in 2015. While they did not produce a final product, they did define key concepts in producing a TENG which would be essential for anyone trying to make a viable

product. Tinghai Cheng and their cohorts provided similar research on the topic more recently in 2019. While Niu and co. examined the fundamental aspects of triboelectricity, Cheng and their team investigated how much research is being done on the relatively new form of energy generation. They did this by analyzing how many articles and papers were being written and published on TENGs. Cheng and their coauthors found that while in 2012 there were only 8 articles published on TENGS, in 2018 that number ballooned into 444 (Cheng et al., 2019).

Both of these papers provided my team and I the valuable information we needed to start our own TENG development. Niu and their team's research provided us a better technical foundation on how triboelectricity works and what is currently know in the field. Cheng and co. illustrated to our team that this is a burgeoning field with enough technical research to get a start, but also enough room to make a splash.

With these two papers in mind, my peers, advisors, and I are working on creating a TENG that can be installed on the roof of homes similar to solar panels. To do this, we will utilize the materials other scientists found to create very negative or positive charges, have two opposite-charged materials interact, and measure the charge produced. After establishing a material combination that is effective, we will move on to creating a device that oscillates in low wind speeds (about 5 to 10 mph) and produces the friction needed to create power.

STS Topic: The Problem with America's Response to COVID

COVID-19 has done an immense amount of harm internationally and domestically and continues to harm people en masse. Though this harm is well documented, there is a disconnect in how researchers and public-facing institutions examine the issue. While

researchers have analyzed COVID as a sociotechnical problem, covered the virus as if the only solution necessary is a vaccine. This disconnect in problem framing is allowing COVID to further rampage through our communities as an acute illness and chronic disability all while reinforcing systems of oppression.

Researchers have been sounding the alarm of COVID's societal impact throughout the pandemic. One way COVID impacted our society is by revealing holes in our healthcare system. When COVID initially struck America and other countries, hospitals were flooded with people as people came down with the virus. This flooding of hospitals happened routinely as COVID mutated and generated new waves of infections. On the surface, this appears to be a technical problem. But in reality, a lack of political and economic willpower is what made hospitals unable to address health crises. Owain David Williams addresses this in his 2020 paper where he pointed out that the US is dependent on private hospitals who value profit over well-being didn't take initiative in aiding patients as it was not profitable. In 2021, Williams and a team of scientists goes further in his analysis by pointing out exact reasons for private hospitals poor performance in the early years of the pandemic: Less operations decreased revenue, an increase in personal protective equipment (PPE) purchases increased costs, and politicians were bribed to allow hospitals to skirt responsibilities. This assessment is further reinforced by Nason Maani and Sandro Galea who found in 2020 that the US government tends to underinvest in healthcare due to "a lack of political will, a focus on reactionary interventions instead of strategic capacity building, and a general focus on health care provision over prevention" (p. 256). All of these papers build off each other to show that there is a societal and economic incentive in the US that allows for COVID to do harm.

Another way COVID's societal harm materialized is by the rhetoric and action taken by politicians. When Trump served his first term as president, Charles F. Parker and Eric K. Stern found that his administration's psychological delusions, bureaucratic ineffectiveness, and political leanings inhibited the US from being as effective against COVID (2022). Molly A. Sauer and their coresearchers also reinforce this point by showing Trump's administration did not follow the 2002 Crisis and Emergency Risk Communication (CERC) manual made by the CDC when addressing COVID (2021). Instead, the executive branch delayed its response, downplayed the virus, and changed guidelines so frequently that it confused medical professionals as well as regular citizens (Sauer et al., 2021). Biden's administration has also fallen victim to thee failures outlined by Sauer and co. On the point of downplaying the virus, Biden infamously said in 2022 "the pandemic is over. If you notice, no one's wearing masks. Everybody seems to be in pretty good shape" (Archie, 2022). That assessment blatantly ignored the millions of immunocompromised or long Covid-ridden Americans still struggling. These stances from both parties not only allowed COVID to cause more harm than it should, but also disenfranchised disabled and immunocompromised who are being hit the hardest by COVID.

While COVID still affects millions of Americans either in the acute or chronic long COVID forms, there has been a decrease in coverage of COVID. My research wishes to further analyze the way politicians cover COVID and how it inhibits our collective ability to deal with the virus. I plan on doing this by researching how prominent states like New York, Texas, California, and Florida went about dealing with COVID socially and further analyzing how federal actors portray the pandemic. This can be done by looking at school shutdown policies, analyzing the speeches made about the pandemic, looking into how

frequently policies changed, and if officials generally followed CDC and CERC guidelines. I will also apply Social construction theory (SCOT) as defined by Wiebe E. Bijker Trevor Pinch to analyze how societal indifference to COVID created gaps in technical solutions and how they could be applied.

Conclusion

The health of our people and environment cannot be neglected. By creating a TENG for low wind speeds, the environment will be made better off. By illustrating the problem in our COVID response, we can build a better public health strategy and root out systemic injustice. Both of these initiatives will help in correcting course and increasing the well-being of our community.

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