Thesis Project Portfolio

Human-Powered, Illuminated Runner's Vest

(Technical Report)

Empowering New Energy: How Protective Spaces Enable a Renewable Energy Transition

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

Garrett Hanrahan

Spring, 2020

Department of Mechanical Engineering

Table of Contents

Sociotechnical Synthesis

The need for deep decarbonization in all facets our lives strengthens every day. The current global energy consumption would yield a 4-degree Celsius increase in average temperature by the year 2100. To avoid the catastrophic such as flooding, deadly heat waves, agricultural losses, habitat losses, human displacement and much more that would come as a result of this increase in temperature, humans need to develop use more renewable energy sources (Plumer, 2018). Both STS and technical topics seek to attack the task of deep decarbonization from two different realms: industrial and consumer. The technical topic focuses on developing a running vest with embedded energy generation capabilities powered by the running motion of joggers. Battery technologies are an emerging innovation that will unlock an entirely renewable grid, but the current price of batteries obstructs an immediate sociotechnical transition. The STS research analyzes pathways to supporting diffusion of renewable technologies, and it will provide a framework for supporting the industrial battery technology movement through the use of sociotechnical transition strategies.

My technical work aimed to design an energy storage device seamlessly integrated into a running vest. The vest generates energy from the motion of the jogger, and it charges a small battery. That battery then powers LED strips along the vest to alert drivers of the runner's presence. Our goal was to create a small portable energy generation and storage device to power cellular phone. Unfortunately, we realized that the amount of energy needed would require a much larger battery. This compromised our design criteria of comfort and weight of the vest, so we had to opt for only powering LED strips. As you go through your design iterations, the overall goal of your device can easily change. It is important to be flexible in your design strategy, and one must be ready to alter their design to be successful. Still, our device allows an average consumer to use entirely renewable and carbon-emission-free energy while dictating the source of their energy. Consumers have little to no choice in the form of energy that supplies their homes, and they often have no information regarding the source of that

energy. Our device empowers consumers to control the energy that they use. While the device only generates a small amount of energy, future work could yield a much larger portion of consumption that the user can dictate.

The STS topic evaluates protective spaces as a means of supporting disruptive innovations, and it highlights the necessary elements to support the sociotechnical transition to battery technologies. My STS research analyzed cases of protective spaces through two frameworks created by Adrian Smith and Thomas Geels. Protective spaces allow new innovations to develop and mature, without the pressure of competing with existing technologies, so they may be best supported for a large-scale transition and diffusion. Smith defines different levels of protective spaces: shielding, nurturing and empowerment. shielding entails specific actions to initially protect the new innovation or system from pressures of competing with existing the existing system. nurturing entails practices that continue the development of the innovation through actor networks. Smith defines two forms of empowerment: “fit and conform vs stretch and transform.” Fit and conform suggests that this new innovation is able to compete with the other structures once the shielding is removed. The essence of “stretch and transform” empowerment is captured by its title; it “aims *not* at fully removing shielding, but rather institutionalizing parts of it; it seeks to change mainstream selection criteria by incorporating sustainability values” (Verhees et al, 2013, 286). The research yielded an understanding of the complexity of sociotechnical transitions, meaning that window of opportunity for transitions can open or close very quickly depending on the political structure. The cases showed that Shielding and Nurturing are the most important aspects of protective. The research provides key aspects that governments and actor networks should prioritize when implementing socio-technical transitions.

My STS research gave insight about the potential diffusion of my technical topic. In researching strategies to support a sociotechnical innovation, I could imagine the shielding and nurturing required to make my device more successful in its diffusion. While the distribution of my technical work never

gained serious traction in my head, it informed my design processes. For example, actor networks between academia, industry, and policy emerged to be key aspects of sociotechnical transitions and their successes. I understood the value in these actor networks, and it pushed me to establish my own networks. While my networks did not include titans of industry, nor politicians, I sought advice from young professional engineers and many professors outside of my major background. This same concept can be boiled down much more simple thought: ask for as much advice as possible from people across all fields and experience levels.