Thesis Project Portfolio

Active Control of Wind Turbine Blades to Increase Efficiency

(Technical Report)

Analyzing Public Opinion on Wind Energy in the United States

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

This capstone technical project and STS research paper both address the technology behind wind power. While the technical work focuses on wind turbines and power generation specifically, the research paper focuses on the social, political, and economic status of wind energy. These two topics are intertwined beyond just being about wind energy, since the technical efficacy of wind turbines bears influence over the social, political, and economic status of wind power. Researching wind power for the research paper revealed that wind power has notable space for technical improvement. The technical project seeks to address this problem by trying to improve wind turbines in an innovative way. Together, the technical project and research paper provide an analysis of the current state of wind power and a technical concept showing one potential route to improve wind turbine technology.

The goal of the capstone technical project was to develop an active mechanical system that could be embedded within wind turbine blades to improve blade efficiency. In the current wind power industry, energy production is generally increased by improving generator efficiency, making larger wind turbines, and building more, better sited, turbines. Actively changing the shape of the blades during operation is not currently used in the industry, but holds considerable potential. Changing the shape of the blades adds additional control over how quickly the blades are spinning, allowing for more power production at lower wind speeds and safer operation at higher wind speeds. These ideas were validated theoretically using computational flow dynamics in the 3D modeling software SolidWorks. The technical team designed a mechanical system that implemented extendable flaps within each blade with a motor driving the system in the turbine's central hub. The turbine blades and hub were modeled and 3D printed, with space inside for the mechanical system to be installed. This flap system worked in

isolation outside of the turbine blades. However, due to manufacturing issues and time constraints the system was not able to be fully installed within the turbine. Regardless, the concept of extending flaps from the blades at low wind speeds was validated. How far extended the flaps were was manually adjusted and power production at a single wind speed was recorded. It was found that at low wind speeds the flaps increased power production, although the effect does have a limit and will begin to decrease power production beyond a certain point. The technical project demonstrated the potential of blade profile adjustment for improving turbine performance. Improved technical capabilities will be essential as renewable energy continues to grow in the US.

The subject of the research paper is public opinion on wind energy and the social groups most influential to it. More specifically, this research aims to address the following question: what are the dominant sociotechnical relationships informing public opinion on wind power, and how do they affect its development and expansion in the United States? To guide this research, the Social Construction of Technology analytical framework will be used as a foundation, as originally developed by Trevor Pinch and Wiebe Bijker (1984). A wide variety of factors will be analyzed regarding their effect on wind energy public opinion. Among them: the impact of political party affiliation, political leanings, and news source preferences. Economic factors will also be considered, including economic status, perceptions of wind power profitability, and beliefs surrounding jobs. Regarding jobs specifically, the perceptions regarding elimination of fossil fuels jobs alongside creation of clean energy jobs will be researched. Cultural considerations will also be looked at, including encroachment upon religious and cultural landmarks and forms of aesthetic pollution. A brief analysis of the technological efficacy and general feasibility of widespread wind power adoption will be performed too. As the Federation

of American Scientists states (2021), accelerating the growth of clean energy is essential in slowing climate change. This research illuminates what factors best facilitate shifting from fossil fuels to clean energy. Furthermore, misconceptions can then be corrected and investments can be made to improve legitimate perceived shortcomings. Altogether, this research should provide information that could accelerate wind power adoption in the United States, an urgent and necessary step in addressing global climate change.

By completing these projects simultaneously, both projects benefited from additional depth and insights that crossed over between the projects. The STS research paper exposed weaknesses in the technical ability and general reputation of wind power, providing inspiration for the technical project. The time, logistics, and complexity of creating a prototype for the technical project demonstrated the difficulty and time scale of improving technologies. This time scale and pace must be considered when discussing technologies in society, as the changes that will need to be made take time, and in the context of climate change, time is very limited. This fact highlights just how urgent transitioning to renewable energy is, and how important research into renewable energy will increasingly become.

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