Thesis Portfolio

Design and Construction of a Ferrofluid Kinetic Art Clock

(Technical Report)

An Analysis of the Viability of Adoption of Renewable Energy Sources

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

The two projects with which this portfolio is concerned are a capstone project consisting of a mechatronic digital clock functioning as a piece of kinetic artwork, and a thesis research paper considering the feasibility of powering the electric grid with renewable energy sources. The inspiration for the thesis paper came during the capstone project's design process. When deciding how to power the clock, being environmentally friendly was seen as an ideal yet ultimately unattainable goal, and instead the clock was powered by standard wall sockets. This realization caused reflection on how the electricity that comes from wall sockets is generated. The subject of this portfolio's research paper was thus inspired by a desire to make the everyday use of electricity a more environmentally ethical endeavor.

Mechatronics is the symbiotic fusion of mechanical engineering, computer science, and electrical engineering. Mechatronics allows for mechanical systems to be simplified, reducing the need for elaborate mechanisms by replacing them with controls systems and programmable motors. This in combination with the burgeoning technologies of 3D printing and laser cutting allow for rapid iterations of prototypes throughout the design process. Given the predicted widespread adoption of mechatronics and various advanced manufacturing techniques, a capstone project consisting of a mechatronic system created using advanced manufacturing methods was determined to be apt.

While reviewing previous works from which to derive inspiration, the idea of kinetic art was of particular interest. Kinetic art is a piece of artwork that moves and serves a practical function. Often, kinetic art pieces function as analog clocks. Taking this inspiration and adding an element of mechatronics, the project became the development of a kinetic art digital clock. The kinetic art aspect came in the display of the digits, and the mechatronic aspect came in the

mechanisms controlling the clock. Depending on the time to be displayed, various magnets were actuated forwards in a pattern similar to the lights on typical digital clocks. These magnets controlled the display medium, obscured from view of the user. The initial prototypes used ball bearings as the display medium. Following difficulties in implementation of the ball bearings, the display medium was changed to ferrofluid. Ferrofluid consists of iron nanoparticles that are held in suspension by a fluid. The nanoparticles react to magnetic fields, causing the ferrofluid to move closer to magnets. In the context of the clock, the ferrofluid were attracted to the actuated digit segments, displaying the time. The clock was run by a Propeller microcontroller chip, controlling the actuation of the digit segments.

The production of electricity accounts for over a quarter of the United States' carbon emissions. This is because the main method of producing electricity for the electric grid is currently the burning of fossil fuels. Alternate sources of energy already exist, such as solar, wind, and nuclear energy. One of the issues preventing the adoption of these cleaner energy sources is the storage and transportation of energy generated. A benefit of using fossil fuels is that as long as there is a sufficient supply of fossil fuels, electricity can be generated at the rate it is consumed and therefore needed. Solar energy, in comparison, is only generated when the sun is shining. Similarly, wind energy can only be captured when winds of sufficient speed are blowing. Both solar and wind energies can additionally only be implemented in locations with suitable conditions. However, the genesis of advanced battery technology could bridge the gap between production and consumption, allowing for largescale energy storage and transportation. Should an infrastructure of large batteries be successfully integrated, solar and wind power could be transported to communities with climates not suitable to house solar or wind farms. Once

there, the batteries could then be discharged at whatever rate needed, eliminating the other main issue with these energy sources.

Nuclear energy creates no carbon emissions, and nuclear power plants can be built virtually anywhere that has a sufficient water supply. Nuclear power's limitations come from the radioactive waste produced, and the dangers in plant operation historically demonstrated. No sufficient protocols are currently in place, causing several environmental disasters. Plant operation has also proven dangerous in the past, resulting in tragedies such as those at Chernobyl and Fukushima-Daiichi. Bill Gates, Microsoft CEO and Co-Chair and Trustee of the Bill and Melinda Gates Foundation, has developed a new model of nuclear power plant that uses the depleted uranium created by current nuclear power plants as fuel. Gates' model also only requires refueling every 10 years and operates nearly autonomously, reducing the possibility of operator malfunction. A pilot plant was scheduled to be built in China, but progress was halted due to the escalating trade war between the United States and China.

Given sufficient advancements in the fields of battery technology and nuclear power technology, replacing the electric grid with renewable energy sources is a feasible goal which would significantly reduce the amount of carbon emissions created by the United States.