Thesis Project Portfolio

Design of a Processing Plant for the Extraction of Lithium from Geothermal Brines in the Salton Sea, California

(Technical Report)

Nuclear Energy: Powerful Tool or Imminent Risk? Analyzing the Public Divide on the Nuclear Energy Argument using Cultural Theory.

(STS Research Paper)

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SOCIOTECHNICAL SYNTHESIS

Energy is ever present in our lives and is as fundamental as eating and sleeping. Throughout history, people have progressively needed more and more energy to enable our expansion as a species. From the first fires burnt by man, to first internal combustion engine, we have excelled at technological growth and have shown no signs of slowing down. This growth has brought prosperity to our species, but has also led to dire consequences. The industrial revolution brought with it the wide scale adoption of fossil fuels. Both cheap and plentiful, fossil fuels became the primary source of energy for the world that was becoming filled with advanced technology. Because of this, for perhaps the first time in history, humans gained the ability to affect our environment on a planetary scale by way of mass releases of greenhouse gasses; a byproduct of fossil energy. The accumulation of greenhouse gases in our atmosphere has led to a phenomenon called climate change, which is reflected by increasing global temperatures, rising sea levels, mass extinction, and other ecological disasters. The climate crisis is undeniably bound to our energy needs, and thus it is important to develop new technologies as well as reevaluate older technologies that could prove to be helpful.

This thesis is focused on energy technologies from both an engineering and social perspective. On the engineering side, we explore the importance of lithium: a key component in batteries and other energy storage devices. Demand for lithium is increasing exponentially across the world as renewables and electric vehicles become more viable. However, with current supply of lithium, there will not be enough to meet this demand, thus new processes to extract lithium need to be developed. On the social side, we take a look at nuclear power and its controversial place on the world stage. Nuclear energy is a very powerful and often misunderstood technology. Many people believe it is the key to our independence from fossil fuels; others believe that it is

inherently dangerous and destructive. Where does this distinctive split come from, and how can we best utilize this technology to our advantage?

The technical portion of this thesis focuses on the design of a process to extract, synthesize, and purify lithium hydroxide monohydrate from geothermal brines in the Salton Sea, California. Currently, the United States relies on overseas countries to source their lithium, where environmentally unfriendly practices are utilized to extract the metal. Eyes have turned towards the Salton Sea, as it possesses large, untapped quantities of lithium in underground pools. With existing power plant infrastructure located in the Salton Sea, this process can be readily retrofitted after the geothermal power cycle. Extraction of lithium is done using a novel redox intercalation process, which selectively captures lithium ions over similarly charged cations found in the geothermal brines. By using electrolysis in tandem with the capture process, the deintercalation material can be continuously regenerated, significantly reducing feedstock costs. Economic analysis of the process over a period of 20 years predicts a high internal rate of return, indicating that investment could be favorable; however, this analysis excludes the addition of citrate, a key component that enables the capture of lithium ions. Including the cost of the citrate component reveals to be cost prohibitive enough to make the process economically unviable. Therefore, it was concluded that the process should not be invested in as there are too many uncertainties at this moment and more research needs to be done into using lower cost materials as alternatives.

The sociotechnical portion of this thesis focuses on the cultural influences of risk perceptions of nuclear energy. Unlike renewable energy sources such as wind and solar, which are intermittent and geographically restricted, nuclear energy is more reliable and able to provide base-load power with little to no emissions. However, despite proving to be an effective and safe, an apparent strong risk bias exists against nuclear power. To investigate how the public perceives

nuclear energy, public opinion polls and secondary discourse analysis on social media were Using cultural theory of risk as a framework, it was determined that anti-authority egalitarianism, which originate from 1970's environmentalist and anti-nuclear movements, along with cost-skeptic individualism act as primary sources for nuclear energy opposition. On the other hand, it was found that supporters of nuclear energy tend to come from hierarchicalists, government-based organizations and are seen as dismissive to the negative side effects of nuclear energy. The result is a public who is extremely divided on whether nuclear power is a viable solution to the climate crisis. With these findings, it was suggested that investments in small modular reactors, as well as increase investment in energy science education would appeal to opposing groups and create a less restrictive pathway for the construction and operation of nuclear powerplants.

Through working on these projects, I gained a better understanding of the complexities surrounding energy technologies. Often, it is difficult to grasp how large scale and fundamental the energy problem to our existence as an intelligent species. The cultural ties to energy are especially interesting, and they reveal just how much our society is dependent and at the mercy of the technologies we so rarely consider. I hope through reading these papers, someone else may be inspired to look further into energy technologies.