Thesis Project Portfolio

River Water Treatment in Chennai: Producing Drinking Water by Reverse Osmosis and Biocrude Oil by Hydrothermal Liquefaction

(Technical Report)

Evaluating the Role of Government in Establishing Sustainable Energy Infrastructure in Massachusetts

(STS Research Paper)

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Katarina Liddell

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Department of Chemical Engineering

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Sociotechnical Synthesis

Centuries of pollution have devastated the Earth, and have made it increasingly difficult for individuals to access the resources they need to thrive. Chemical engineering, as an industry, has a long history of disregarding the health and safety of individuals in order to increase profits. As such, the true future of chemical engineering is changing existing practices, and remedying the problems caused by decades of neglect. At one end of the spectrum, water scarce countries like India are in desperate need of engineered solutions to slow an ongoing crisis. At the other, industrialized countries like the United States are battling legislature to prevent a future crisis caused by decaying energy infrastructure. Though these issues appear dramatically different at the surface, both stem from an imbalance of ethics, economics, and politics. This imbalance permeates global society as an unfortunate connecting factor in the human experience.

Chennai, India has faced extreme water scarcity in recent years. Though three large rivers run through the city, the water is undrinkable. Decades of industrial and agricultural effluents have been dumped into once clean waters. As a result, Chennai has relied on the monsoon rains to provide enough water for the entire year. However, these rains have become increasingly unstable and reservoirs are completely dry. With no safe natural resources, residents must buy expensive bottled water, or risk acquiring enteric diseases from river water. This capstone project aims to design a water treatment plant, using river water as a source, to produce cheap potable water to the people of Chennai. Water will be sent through bar screening, two rounds of sedimentation, microfiltration, reverse osmosis, and ultraviolet disinfection. The large debris accumulated during initial screening and the sludge collected from sedimentation will be transported to a hydrothermal liquefaction reactor. This reactor will use the aforementioned waste, as well as supplemental municipal sewage, to produce biocrude oil, biochar, aqueous coproduct, and various gases. The oil, char, and gas will then be sent to a furnace to produce power to operate the reverse osmosis system. Because reverse osmosis is power intensive, the fuel produced by waste products will help offset the annual operating costs, allowing the water to be sold for as little as possible. This design both provides clean drinking water to Chennai, and reduces further pollution of the Cooum River.

Burdened by the effects of climate change, the decaying energy infrastructure in the United States both fails at providing citizens with reliable power and further contributes to greenhouse gas production, creating a spiraling cycle that will catastrophically fail if left unchecked. The state of Massachusetts is a frontrunner in addressing the corroding natural gas lines, initiating a multi-billion dollar replacement plan in 2014 (Shankman, 2021). However, because of the unsustainable nature of fossil fuels, an additional legislature was recently signed that would end all natural gas use in Massachusetts by 2050. These contrasting initiatives will inevitably create large public health and economic burdens if both plans are allowed to continue. This paper seeks to determine the role that government entities play in the continued mediation of negative environmental impacts due to decaying energy infrastructure in Massachusetts as scientific opinion continues to evolve. A historical case study involving governmental response to initial reports of excessive methane leakage, along with current government policies and discourse between scientists and politicians, is used to understand the source of conflict regarding infrastructure change and how this conflict has been previously mediated. This research is interpreted using the co-production framework to better define the ever-evolving relationship between science and government, specifically when public health and prosperity are at risk. Results should encourage policy makers and researchers to use an evidence-based approach for future negotiations regarding climate and energy infrastructure in order to more effectively and efficiently make crucial environmental decisions.

The simultaneous undertaking of both the STS research paper and the capstone project has illustrated the worldwide importance of chemical engineering solutions in relation to climate science. In researching both current and future problems, one can see that the solutions are not vastly different. The difference lies in communicating the importance of said problem to other parties. To successfully prevent a future climate crisis, one must be able to effectively communicate, especially to individuals with non aligning interests, the severity of a problem that is yet to exist. Therefore, engineering is not purely technical. It is not calculating formulas for a sedimentation treatment process or geothermal power lines. These projects have proven that to be an effective engineer, one must solve technical problems, communicate effectively to potentially hostile audiences, advocate for underrepresented communities, and remain willing to change and develop over time.