Thesis Portfolio

Modeling the Implications of Fugitive Gas Emissions on Building Heat Upgrade Decisions
(Technical Report)

Climate Change as a Driving Force of Social and Technical Innovation
(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

Jackson Sompayrac
Spring, 2022

Department of Systems and Information Engineering

Table of Contents

Sociotechnical Synthesis

In the technical report, a cost-emissions accounting model is conceptualized and produced in an effort to provide building managers a tool to make more economical and sustainable decisions regarding their buildings and processes. Given the current state of the built-environment, one of the largest producers of greenhouse gas emissions in the United States, activities and decisions must be made to slow the current acceleration of climate change while simultaneously ensuring that buildings are still efficient and effective. Several aspects of building energy consumption were analyzed, including: what methods of space heating are available to building owners/managers, what effect does fugitive methane emissions have on the lifecycle impact of natural gas heaters, and what improvements can be made with alternatives to traditional natural gas (such as Certified Natural Gas and Renewable Natural Gas). Several market cost and emission and lifecycle cost accounting tools were researched and technical gaps were discovered, such as lack of geographical explicitness and omission of fugitive emission methane in the calculations. The model created allows business managers to model the implications of a switch in space heating infrastructure, such as from a natural gas furnace to an electrified heat pump. It incorporates upstream fugitive methane emissions to deliver a more accurate lifecycle estimate of carbon emissions. Several scenarios are drawn out to give meaning to the model, such as putting a cost on carbon emissions. The overall intention for the model is to be able to serve building managers in their attempts to obtain accurate lifecycle cost and emissions predictions for space-heating infrastructure with the ability to subscribe and not to a variety of possible future scenarios. This gives a holistic prediction capability and allows users to specify a range of events they think are probable.

In the STS Research Paper, the US electric grid system and its response to the threat of climate changed are analyzed. Previous models and predictions of the future of our climate have proven to be far from accurate time and time again, however, even some of the most conservative predictions are a warning of the dangers that could proliferate. As one of the largest consumers of fossil fuels in the world, the United States is in a position to incorporate strategies for mitigating the risks of climate changing activities; the electric grid system, especially, could prove to be a pivotal vehicle for cutting emissions and manipulating societal consumption of electricity (especially electricity produced from fossil fuels). One such strategy is by incorporating sustainable measures into our electric grid system, such as increased renewable resources, increased nuclear resources, as well as infrastructure and technologies that are more efficient consumers of that electric power. By incorporating STS Frameworks Technological Determinism, Actor-Network Theory, and Paradigm Shift Theory, conclusions were made about the directives and incentives responsible for previous regulation and action, and then predictions for the future were drawn out using similar frameworks of analysis. Given the current level of human reliance on electricity consuming technology, the decisions made in this industry could have enormous impact on the future of society.

Together, these two papers form a very general outlook on the contemporary landscape of the United States utility system, both in terms of electricity generation and distribution, as well as natural gas production and distribution. While both systems have discrepancies in the operational structure, economic structure, and overall impact on the climate, it is vastly important to connect the two systems as they form the general bulk of energy resources. While space heating is the most common use of natural gas, there are many others, and often people forget that the vast majority of electricity generation is done through natural gas combustion. Therefore,

occurrences in the natural gas system and electric system are directly connected and can have huge systematic impacts on one another. It is also very interesting to bring these two systems together because it is extremely likely that they will have to work together in order to promote sustainability goals and achieve a rollback of human climate change impacts.