Thesis Project Portfolio

Modeling the Implications of Fugitive Gas Emissions on Building Heat Upgrade Decisions

(Technical Report)

Electrification of American Homes and Businesses: The Way Forward

(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

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Spring, 2022

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Sociotechnical Synthesis

(Executive Summary)

Identifying Problems and Assisting in The Transition to Electric Heating

Even though converting fossil fuel heating sources to electric alternatives is an unavoidable step on the road to a zero-carbon emission future, less than 1% of all buildings in America use modern efficient heat pumps as their main source of heating and cooling. Building operation accounts for over a quarter of all global emissions and in most cases the HVAC system is responsible for anywhere from 40%-70% of a buildings carbon emissions. Logically, it follows that decarbonizing HVAC systems would be an effective way to reduce overall emissions, but there has not been any overwhelming effort to make the switch. For the technical project, my team developed a model to help building owners or property managers to model what it would look like from both a financial and emissions perspective to convert to different heating alternatives for the next 20 years. My STS research was centered on figuring out why the public is not eager to upgrade to the more efficient system.

The life cycle cost calculator that my team developed for the technical project should serve as a tool that could help individuals or organizations achieve some clarity on just how much the savings (both environmental and financial) resulting from installing a new HVAC system would be. There are many factors that go into this calculation including the age and measurements of the building, the age and efficiency of the unit being replaced, the cost of natural gas and electricity, and more. The most notable aspect of our calculator (as other life cycle calculators do already exist) is the fact that it includes the fugitive emissions, or natural gas pipe leakages, that would occur as a result of a certain building's usage. We recognized that not everyone would be willing to fully convert their HVAC system but may still want to reduce emissions so we also included options to switch to a number of different sources of natural gas which produce less emissions, but at a higher price.

While the model is intended to help property owners potentially switch to greener HVAC systems, my STS research was focused around figuring out why the help is necessary. Given the fact that in the long run this upgrade pays for itself through savings and helps the environment at the same time, it seems like anyone who can afford the upfront cost would looking to make the switch, but that is not the case. Geels' "Multi-Level Perspective on Sustainability Transitions" (2011) describes how society can push off the adoption of superior products because of the 'lock-in mechanisms' the current technological regime has put in place and how there must be a landscape movement in order to overcome these barriers. Applying this framework to the energy and HVAC situation in America now it is clear that the fossil fuel industry is opposed to every building in America going electric because demand for their primary product will decline. The simple fact that fossil fuel furnaces and boilers were built to last a long time before they must be replaced is a lock-in mechanism and my research was aimed toward revealing more of these mechanisms, both ones the fossil fuel giants were responsible as well any that were simply products of our society.

My STS research was an effort to determine where the problem in upgrading existed, and the technical project developed a tool that may help people decide to upgrade. Approaching this issue from both sides gave me a more complete understanding of the issue and how different actors within the network affect each other. The research completed for both projects demonstrate the value of electric heat pumps and the potential emissions savings they could bring about. Identifying the problem does not necessarily solve it and this research shows moves taken by the energy industry to maintain its dominance that could be considered unethical. Moving forward, the information gathered has to be used to make the best data driven decisions possible.