**Thesis Project Portfolio**

# Portative Pipe Organ

(Technical Report)

# The Legal Fight for HVAC Sustainability

(STS Research Paper)

An Undergraduate Thesis

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**Sociotechnical Synthesis**

Introduction:

At the start of the semester, our team of mechanical engineering students sought out to create a portative pipe organ as a way to better understand airflow in closed systems. In buildings all throughout the U.S, the implementation of airflow systems allows buildings to remain temperature controlled and comfortable for building occupants. These airflow systems function under a broader system known as a building's heating, cooling, and air conditioning system, or "HVAC" for short. At the helm of this massive infrastructure, mechanical engineers work to build airflow designs that suit the needs of the building and adhere to building codes.

Though mechanical engineers have a relatively comprehensive understanding of HVAC, climate change and society's push for sustainable design calls upon mechanical engineers to draw up new or modified HVAC systems. In response to this, the goal of our capstone project was to better understand the fluid dynamics of airflow within a closed, hermetic system, optimizing energy expenditure along the way. This capstone project motivated my subsequent STS research in which I discussed the political and social obstacles of sustainable HVAC design.

Capstone Project:

The pipe organ is a combination of a piano and a flute. The keyboard keys activate valves that allow air to escape from the wind box; resonance ensues, and a euphonic pitch sounds off. While older pipe organs rely on someone to manually push a bellow to get the pipe organ to play, our group wanted to try to build a 21st century pipe organ—one that would play automatically without the help of a person. To do this, we would need to incorporate a new subfield of mechanical engineering: mechatronics.

Mechatronics has burgeoned over the last few decades. While strictly mechanical systems still exist, the coupling of mechanical engineering and electrical engineering is becoming more and more common. Mechanical designs incorporating transistors, solenoids, and other electronics prove to be more precise and less prone to failure. With this in mind, the group believed that a mechatronic application would work well as the basis for the pipe organ's airflow system.

We designed the pipe organ's exterior with acrylic—cut and processed with sophisticated machining tools. For the pipes themselves, we modeled their design in SOLIDWORKS after extensive computational fluid analysis. Afterward, we 3D-printed the pipes out of ABS plastic. For the mechatronic bellow system, we used a mechatronic scotch yoke to oscillate the bellows and provide airflow to the wind chambers. All in all, the organ worked as intended and showed that mechatronic systems can be a vital tool in the construction of airflow systems.

STS Research:

In my STS research, I contextualize the exigency of climate change and HVAC's current role in it. However, I show that HVAC need not be a perpetuator of climate change, given that newer HVAC designs have little to no carbon emissions. However, despite these great advancements, old HVAC systems continue to be built. In trying to understand this dissonance, I argue that a lack of legislation is responsible for the slow adoption of sustainable HVAC systems, and corporations and other societal actors hinder the progress.

The research aims to understand why there has not been more legal movement for sustainable HVAC implementation and to identify the social motivations that have led to this situation. I examine state and federal legislation and track the attitudes of major actors to

understand the obstacles to progress. The research sheds light on the societal structures and views that have shaped the current HVAC engineering reality and provides a framework for a more sustainable future.

Conclusion:

Throughout the capstone project, I gained a better understanding of mechatronics and its utility in bettering airflow systems. Mechatronic systems can be turned off and on easily, which means that they are generally easier to maintain. The mechatronic pipe organ saved enormous amounts of energy and performed very well in moving air during prototyping. As airflow is the foundation of HVAC, I began to wonder to what extent mechatronic applications have a place in HVAC design. My work on the portative pipe organ spurred questions and new ideas about the implementation of mechatronic systems in sustainable HVAC design. Given I had come to this epiphany myself, I thought that surely others have as well.

Sure enough, many new HVAC systems and modifications had been introduced that were reported to save energy and increase efficiency. Even so, my further research revealed that these promising systems were not at the prevalence they could be. I wanted to know, from an STS perspective, why this was the case and what we can do about it.