Thesis Project Portfolio

Romulus I, a 16-bit CPU

(Technical Report)

The Effectiveness of Legislation on the Clean Energy Transition

(STS Research Paper)

An Undergraduate Thesis

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Table of Contents

Executive Summary

Engineers will have a huge impact on the future of our world, and their work on new technologies will affect the lives of many in decades to come. This potential is what inspired these two projects: A desire to empower engineers to leave the world better than they found it. The Romulus I technical capstone project is a 16-bit CPU built from the ground up for the purpose of teaching engineering students how computers work. Its LED status displays, variable and manual clock settings, and easy-to-use machine code are all designed to improve and clarify the curriculum of a computer design course. The sociotechnical thesis delves into clean energy policy and what kinds of laws are most effective in aiding the clean energy transition. With research like this, legislators in favor of clean energy can write bills that are most likely to have a positive impact. Through these two projects, I hope that engineers will be, in some small way, more able to improve our society. With good energy laws, today's engineers might be able to develop and implement new clean energy technologies, and with better classes, future engineers might be better equipped to shape the technologies of the future.

Romulus I is a 16-bit CPU designed for classroom use. We were inspired by classes like UVA's Computer Systems and Organization 1, which teaches students how computers work on a hardware and machine code level. In that course, the lectures and assignments use an online simulator to allow the students to experiment. While this works well enough, we felt that the concepts would be easier to understand if there were a physical system students could use instead, so that they could see the real hardware at work. In addition, we felt that the machine code could have been designed to be easier to program in. To accomplish these goals, we first designed the instruction set architecture we would use, then prepared both a high-level and low-level schematic of the computer. After our theoretical work was complete, we designed circuit boards for each of the components, then tested the completed CPU.

After testing and debugging, our CPU functioned exactly as we had designed it to. It could receive programs written in our machine code and it could run them at the set slow, medium, and fast clock speeds. It could pause a program and run it as a debugger, executing one instruction at a time. Its displays all worked properly, showing the state of various computer components. Its peripheral input/output slots also worked correctly, allowing us to connect other devices we had designed. While we have yet to see this computer used in a real classroom, we hope that it one day could be, or that it could at least provide some inspiration for future students.

For the sociotechnical thesis, I sought to answer two related questions: First, do energy-related laws really cause concrete action on the clean energy transition? Second, if laws do have a noticeable effect, what kinds of laws are the most effective? These questions will be crucial in the coming decades. Clean energy will be critical for improving the lives of people all over the world, so we should be considering how best to promote and implement it. If clean energy policy is a good avenue for this promotion and implementation, we should be putting effort into ensuring that the laws we pass are effective. To answer these two questions, I looked at past clean energy laws and their impacts, and tried to use that knowledge to suggest what kinds of new laws we should be passing today.

After looking at these policies, I determined that laws like the Inflation Reduction Act of 2022, which allocated funds directly to clean energy projects, have a significant impact. Regulatory laws, like the Clean Air Act of 1970, and financial incentives, like the Energy Policy Act of 2005, can also be effective, but their regulations and incentives must meet a certain level of ambition. Otherwise, the regulations will be weakened by lobbyists or outright ignored, and the incentives will not create sufficient economic force to encourage significant investment in clean energy.