

Thesis Project Portfolio

Distributed Smart Solar Charge Controller for UVA Solar Car

(Technical Report)

Investigating Data Center Development in Northern Virginia

(STS Research Paper)

An Undergraduate Thesis

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Bachelor of Science, School of Engineering

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Executive Summary

Global power demand is growing more than forecasted with electricity consumption by data centers, artificial intelligence, and cryptocurrency sectors expected to double by 2026 (Eren et al., 2024). This is important because demand could overpass supply in the mid to long-term, leading to power shortages. My capstone's technical and socio technical components address power demand, a local-level solution and a state-level problem. At the local level, I aim to make power generation systems more efficient, and at the state level, I investigate data center (DC) development to support fair and equitable development through spreading awareness among Virginia residents.

For my technical capstone, my team worked with the UVA Solar Car team to design a solar charge controller (SCC) that will draw more power from the car's solar panels so that the car can drive further and win the Formula Sun Grand Prix. However, we hope our project can be applied to much more than racing. Solar charge controllers are vital to the longevity and efficiency of all solar systems including systems for homes, IOT devices in remote areas, agriculture, and more (Yellowlite, 2024). To design the SCC, my team carried out a semester-long project, working closely with the UVA Solar Car team to determine specifications and following a Waterfall methodology.

We delivered a proof of concept with documentation to help Solar Car implement the charging system. We implement the SCC with controllers at each panel, with the output in series called module cascaded converter (MCC) architecture (Al-Smadi et al., 2020). This allows each controller to optimize for a single panel power output. The SCCs feed into Solar Car's current SCC, extending the current system. Along with the architecture, we created a metrics dashboard to track Solar Car charging. We unfortunately did not deliver a fully functioning plug-and-play

prototype to Solar Car. Due to current sensing constraints of our test environment, we were not able to test the charging algorithm, just validate the charging process. Overall, while there is more work to do, we believe an SCC with MCC architecture is the future for Solar Car's charging system and have laid the initial groundwork for its integration.

My goal for the STS research paper is to investigate the state of DC development in Northern Virginia, if it is being carried out in an ethical and sustainable manner, and provide some direction for future growth. This is important because Virginians should have a say on some of the largest infrastructure developments in the state and should be informed as soon as possible as it is easier to influence development projects ideally before they begin. I conduct a literature review, reviewing sources ranging from market analysis reports, sustainability models, county interviews with stakeholders, news articles, noise pollution medical journals, and environmental impact analyses. Through the information collected in the literature review, I analyze DC development with a sustainability framework (Lykou et al., 2017) and comment on the state of DC development considering that a DC is 1 actor in a network of people and infrastructure.

It is clear that DCs are here to stay and that development in NoVA will continue. The benefits of DC development are substantial, catalyzing employment and further infrastructure development as well as being a major tax contributor to the county. DCs have shaped NoVA's socio-economic landscape as these developments are large and long-term, but they may come with direct negative externalities to people and the environment. As a key stakeholder, residents should reach out to local county officials on their planning and development boards to express concerns and ideas for reforms. Residents should specifically advocate for proper zoning

ordinances to reduce the possibility of noise complaints and stay up to date with bills passed by the Virginia General Assembly.