**Thesis Portfolio**

**Modular Battery Management System**
(Technical Report)

**The Impact of Battery Systems on Society and the Environment**
(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science
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In Fulfillment of the Requirements for the Degree
Bachelor of Science, School of Engineering

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# Sociotechnical Synthesis

I started this project because of my experience as the Power Lead in the Solar Car Team at the University of Virginia, a student organization whose goal is to provide engineering and business students hands-on learning experience working on a competition-ready solar-powered electric vehicle. As a part of this role, it is my responsibility to ensure the battery pack remains not only safe and functional throughout active driving and charging times, but also in top condition to extend lifetime and increase efficiency. To achieve this, we currently use a fixed-size off-the-shelf battery management system (BMS). However, in the future, we would like to switch over to using a custom-designed modular BMS built by the team in order to give ourselves more flexibility in configuration options and to provide more learning opportunities for our members. Thus, my technical project would serve as the basis for our team to design our future BMS off of. I chose my STS research to allow myself to explore what the effects of designing a modular BMS would have on not only the environment, but also society. Thus, a major component of my STS research would be to evaluate the current state of social and environmental risks involved in the full lifecycle of lithium-ion batteries, from the supply chain to disposal, and analyze how a modular BMS could help alleviate these risks.

My technical work was to design a modular BMS that not only actively works to prevent battery failures but is also configurable for a wide range of application sizes, from electric scooters and bicycles (E-bikes) to electric vehicles (EVs). Many BMSs today are built for a specific battery pack size, such as those built for small E-bike battery packs or those built for a specific number of cells in a large EV. Though modular BMSs have already been designed, they are often too expensive or consume too much space for both boards and complex wiring. This project attempts to overcome these issues by developing a modular BMS that is small enough to use in E-bike and electric scooter applications, while also being expandable to fit the needs of larger battery packs for EVs.

My STS work covers the social and environmental effects of developing such technology for widespread public use in high-powered electric applications. This includes, perhaps most notably,

in the use of EVs. I hope to answer what the implications of designing this modular BMS are not only on the environment, but also society as a whole. This question is important because of the many unseen and hidden risks, both environmental and social, that continue to not only persist but also grow bigger and bigger every day. Even if they may not affect us immediately, these growing problems will come back to haunt us in the near future.

By performing both my STS research and my technical project work, I was able to learn more about how my technical project will affect both the environment and social risks associated with power applications that use batteries. My STS research also allowed me to learn potentially more use cases where my modular BMS may help reduce environmental and social risks, such as in second-use applications. There were also a lot of social risks that I never could have foreseen associated with the production of the lithium-ion batteries I use everyday for the Solar Car project, so my STS research will allow me to make better decisions about where I should source these batteries from to help alleviate these social risks.

This project would not have been possible without the support of my technical advisors Professor Harry Powell and Professor Adam Barnes. I would also like to thank the Solar Car Team at the University of Virginia for providing all of the batteries, battery holders, battery charger, power supply, and other miscellaneous electronic components needed to test our Modular BMS. Additionally, I would like to extend my gratitude to Benjamin Kidd and everyone else at WWW Electronics for providing us with cheap and reliable PCB population services right here in Charlottesville. Finally, I would like to thank my Capstone team members for pushing through a hectic semester to complete this project.