Thesis Portfolio

Modular Battery Management System
(Technical Report)

Environmental Impact of Alternative Energy Sources, Batteries, and BMSs
(STS Research Paper)

An Undergraduate Thesis

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Table of Contents

Sociotechnical Synthesis
(Executive Summary)

During my time at the University of Virginia, the largest project I have worked on has been Solar Car. It has definitely been a challenge for me, from learning about the various technical topics I needed in order to contribute to the team, to managing some of the logistics of the team. But when all is said and done, working on the Solar Car Team has been one of the most beneficial experiences I had during my time at the University of Virginia. Most of the components of our Solar Car is made in-house, but there are a few major components that are not. One of these is the Battery Management System, or BMS. This is the main system used to protect the battery pack in the case of a fault, such as over-current, over-heating, over-voltage, etc. Currently, the Solar Car Team uses the Orion BMS, an off-the-shelf BMS we purchased and interface the rest of our system to. While this was a good idea for a new team starting to develop a car from scratch, it could be a better idea to develop the BMS in-house as well. This would give us more customization options for our battery system and it would be a great learning experience for new members on the team. This is what motivated me, along with a few other members of the Solar Car Team at UVa, to develop a Modular BMS, my technical project. Related to that, my STS topic deals with the environmental impact of batteries, since the usage of batteries is quickly increasing mainly due to the rise of Electric Vehicles, or EVs.

The technical portion of my thesis produced a Modular BMS. BMSs today often use a centralized system where a single device monitors all the data and provides all outputs, for both the individual cells and the pack as a whole. This typically ends up becoming rather disorganized and complicated, both within the BMS itself and for the user of the BMS. Therefore, a solution is to move toward a modular design for a BMS, where there are two components: a main node and

multiple cell nodes. The main node handles all inputs/outputs regarding the overall pack while each cell node handles all inputs/outputs regarding one individual cell. The cell nodes then communicate the data they gathered individually to the main node, which can then make decisions regarding the overall pack. This structure greatly simplifies the designs of both the BMS and battery pack layout, as wiring the BMS to the pack can now be done around the pack rather than throughout it.

The STS research question I hope to answer in this paper is two-fold: first, should batteries be used as our primary energy storage devices in the first place? Many new technologies allow energy storage with less negative consequences than batteries, although they are typically more expensive or harder to use. Second, if we continue to use batteries at the current rate, what can BMSs do to reduce the environmental impact of battery usage? Most BMSs today only accurately model the cell's charge levels for first-time use since most batteries are replaced by the time they reach 80% of their original capacity anyway. However, there is some ongoing research into the reuse of cells from EVs as renewable energy storage systems, in which case a new BMS would be required to ensure the safety of those systems.

My technical project is quite useful on its own, however it fails to predict the future effects of the project. With more efficient and scalable BMSs, battery pack sizes and EV sales are increasing dramatically. With all of the extra batteries moving around, there will be severe environmental consequences if used batteries are not disposed of or recycled properly. Thus, in this entire process of using batteries and BMSs to provide safe and efficient forms of energy, it is important to keep in mind the environmental impacts of batteries, from manufacturing and using them to disposing and recycling them.

I want to thank the Solar Car Team at the University of Virginia for their contributions that made the technical project possible. Without the batteries, battery holders, battery charger, power supply, and other miscellaneous components provided by the Solar Car Team, testing the Modular BMS would not have been possible.