WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

Sahana Upadhya

PhD student
Mechanical Engineering

Office: 1338 ERB
Email: upadhya2@wisc.edu
Hometown: Bangalore, KA, India

Project: Lithium battery SOC estimation and degradation modelling
Advisors: Michael Wagner and Allison Mahvi
Sponsor: Army Research Lab

SCIL

ENERGY SYSTEMS OPTIMIZATION LAB

Background

Goal: Characterize lithium batteries and develop models to efficiently integrate batteries in various applications and increase the life of the battery.

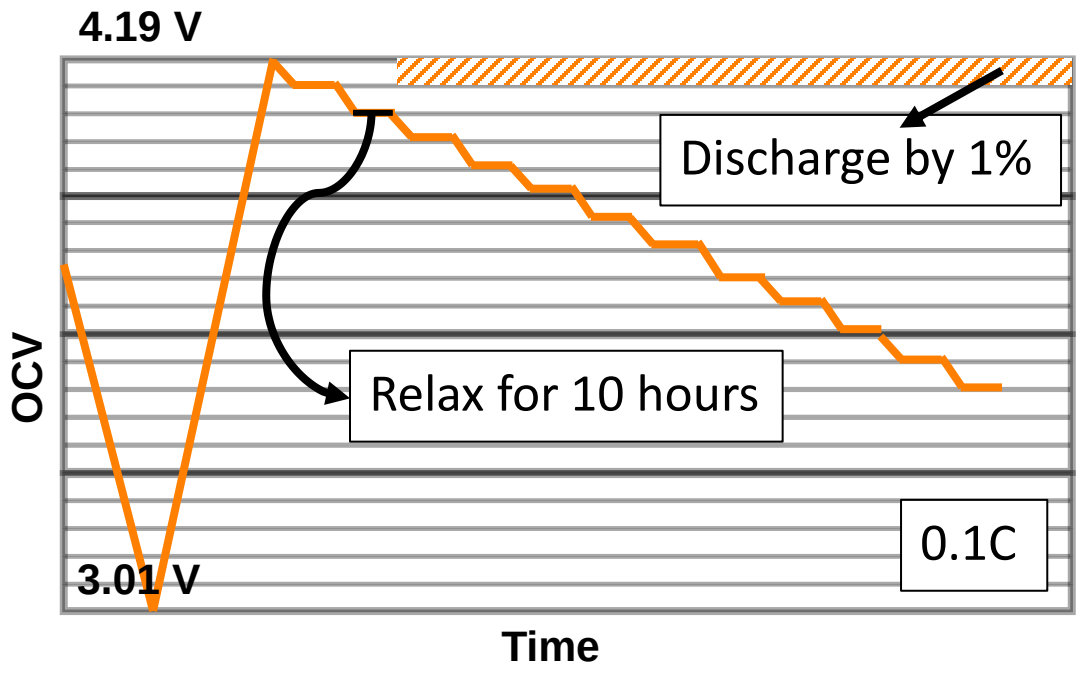
Current Work:

- Perform cyclic, relaxation and degradation tests on batteries to find correlations between physical mechanisms and operational parameters.
- State of Charge (SOC) estimation and degradation analysis.
- Develop a detailed battery model incorporating physical degradation mechanisms to facilitate the integration of batteries in grid applications.

State of Charge Estimation

Cyclic

- Performed cyclic tests on a lithium-polymer cells varying the C-rates.
- This data was used to develop a physics-based model and train a machine learning model to predict the SOC of the battery during operation.

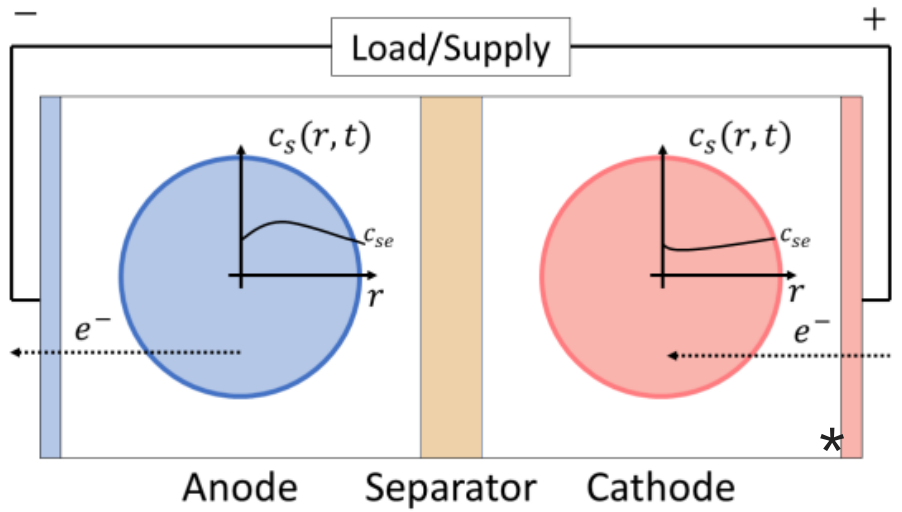


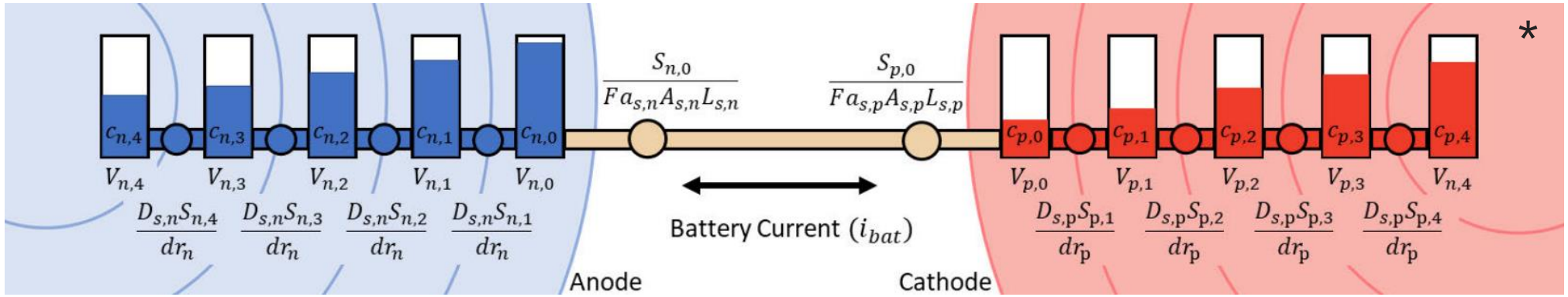
Rest

- Relaxation tests were performed varying C-rate and depth of discharge to develop a correlation between SOC and open-circuit voltage (OCV) for SOC prediction.
- Similar tests to be performed at varying temperatures.

Battery Modelling

- Developing a single particle battery optimization model that represents the two electrodes of the battery as single particles to characterizes the diffusion of lithium ions and capture the concentration gradients in the electrode.

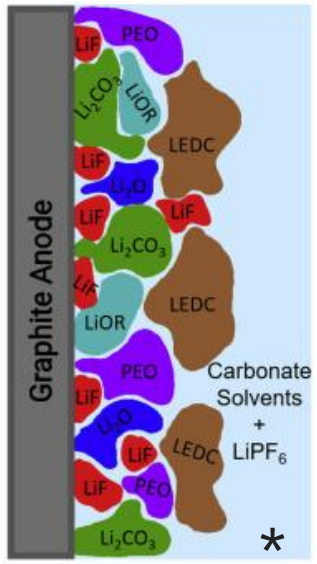


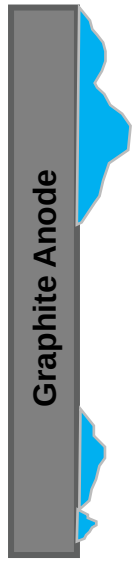


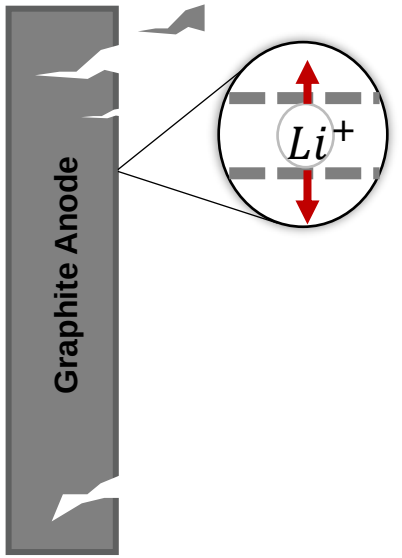
*Rosewater, David M., et al. "Battery energy storage models for optimal control." *IEEE Access* 7 (2019): 178357-178391.

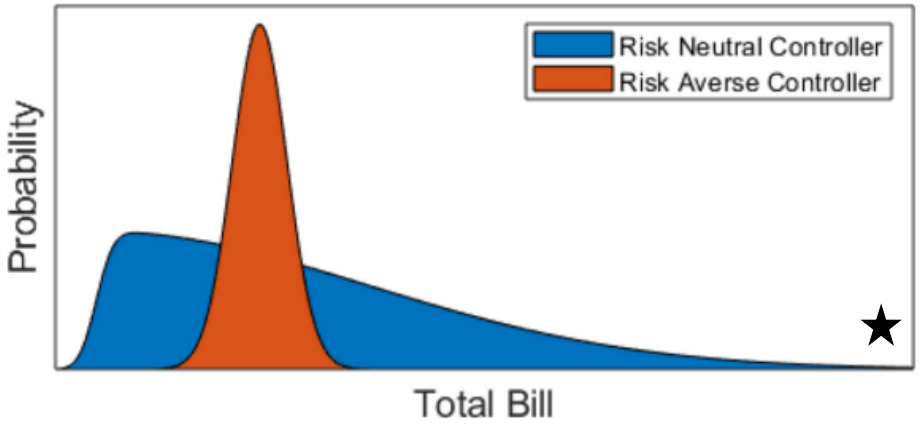
Battery Degradation and Risk Averse Controller

- Include physical degradation mechanisms in the model → SEI growth, lithium plating and intercalation stress.









- Include a risk averse controller to reduce risk during peak demand management by underestimating battery capacity

*Heiskanen, Satu Kristiina, Jongjung Kim, and Brett L. Lucht. "Generation and evolution of the solid electrolyte interphase of lithium-ion batteries." *Joule* 3.10 (2019): 2322-2333.

★Rosewater, David, Ross Baldick, and Surya Santoso. "Risk-averse model predictive control design for battery energy storage systems." *IEEE Transactions on Smart Grid* 11.3 (2019): 2014-2022.