# SOH Analysis for LFP Truck Batteries

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## Background

Greenhouse gases emitted by vehicles like trucks are detrimental to the environment. PACCAR has begun manufacturing EV trucks using lithium iron phosphate (LFP) batteries to reduce the emissions of these harmful gases. However, not much research has been done on the batteries used in PACCAR's trucks to determine their performance and degradation impacted by the truck routes. To further understand these batteries, PACCAR has tasked the team to **define the "end-of-life" (EOL)** of these batteries, **analyze state-of-health (SOH)** and **identify degradation parameters** of these batteries based on how the batteries are used in PACCAR's trucks.

### Experimental Motivation

> Current research uses 80% SOH as a general cutoff point for battery EOL.

> Specific capacity definitions for EOL can vary depending on application, but performance past the 80% standard has not been well-explored for EV trucks.

Therefore, further experiments should **explore battery degradation rates for truck loads past 80% SOH**.

## Existing Research

- Research currently cites battery cycling and temperature as the two main degradation mechanisms in lithium-ion batteries.
- Also notable are depth of discharge, charge and discharge rates, and battery state of charge.
- As a battery degrades, the total amount of charge it can store decreases. Thus, battery SOH is commonly measured as remaining battery capacity over the nominal battery capacity.
- SOH is often estimated using differential capacity analysis (dQ/dV) to identify extent of battery degradation.

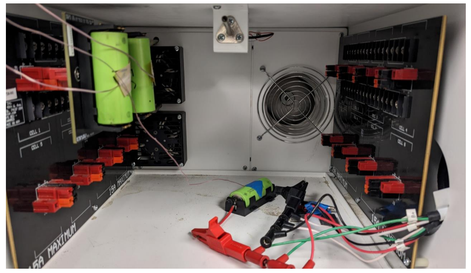
## Methods

LFP Batteries previously cycled to 80% SOH under heavy duty EV applications were chosen for testing.

| Load | Cycle |
|---|---|
| 20 W (Scaled from near max truck power load) | Constant charge/discharge |
| 1 W (Scaled from average load during truck drive cycle) | Discharge 4.5 hrs<br>Charge at 2.3 A for 0.5 hrs<br>Discharge 4.5 hrs<br>Fully charged |

Experimental setups for each cell run at the Clean Energy Testbeds

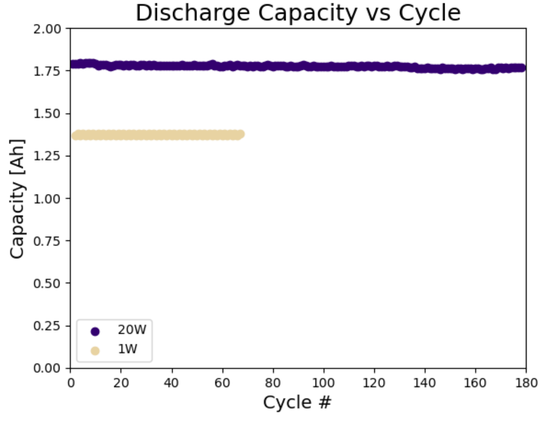
Experiments collected data on degradation rate, capacity, voltage, current, and time in order to better understand when the batteries can no longer safely perform.



Batteries placed in a temperature control chamber to be cycled using a MACCOR Battery Tester

## Results

The discharge capacity vs cycle graphs for the tested batteries had a minimal slope: at 1W the slope is 0.00036, at 20 W the slope is -0.0014.




Discharge capacity with increasing cycle # for 20W and 1W load

## Conclusions & Next Steps

*Truck batteries can operate safely past their standard EOL according to drive cycle needs or second life applications without sudden, rapid degradation.*

### Project Takeaways

- Slow degradation even at 80% SOH
- Degradation parameters from literature
- End of Life estimation from average power load and time requirements

### Next Steps

- Further testing with more parameters:
  - Time
  - Representative Drive Cycles w/ Variable Power
  - Defined End of Life criteria
  - Manipulated Degradation Factors
- Battery pack testing with cell balancing

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