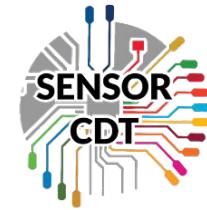


LIFETIME+ Final Presentation

Enabling second-life battery production.



Engineering and
Physical Sciences
Research Council



Image from Nano Magazine - <https://nano-magazine.com/news/2018/6/13/the-technologies-which-are-revolutionizing-batteries>



Phones

Laptops

Tablets

Smart Devices

The iOS family pile (2015) - Blake Patterson via flickr. Licensed under Creative Commons By 2.0 Deed

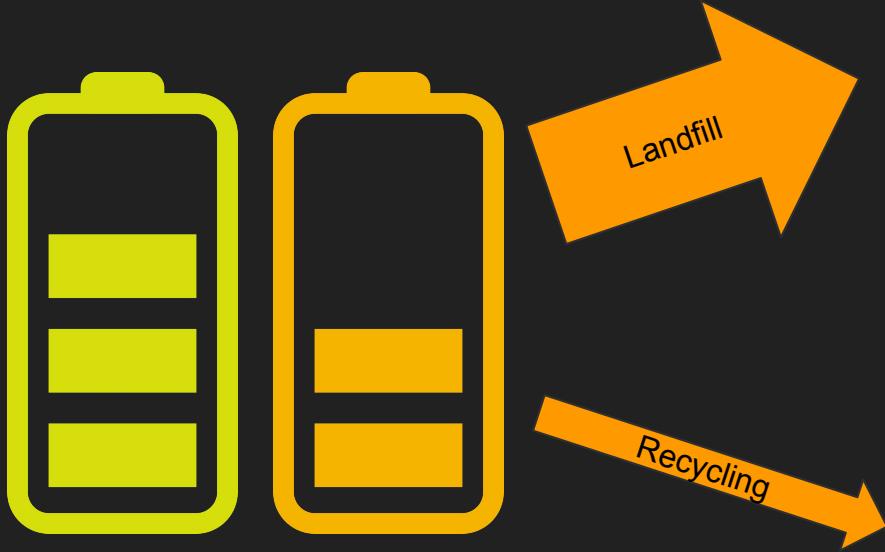


Image by Ashley Felton - Public Domain



Image from National Institute for Occupational Safety and Health (NIOSH) USA - Public Domain



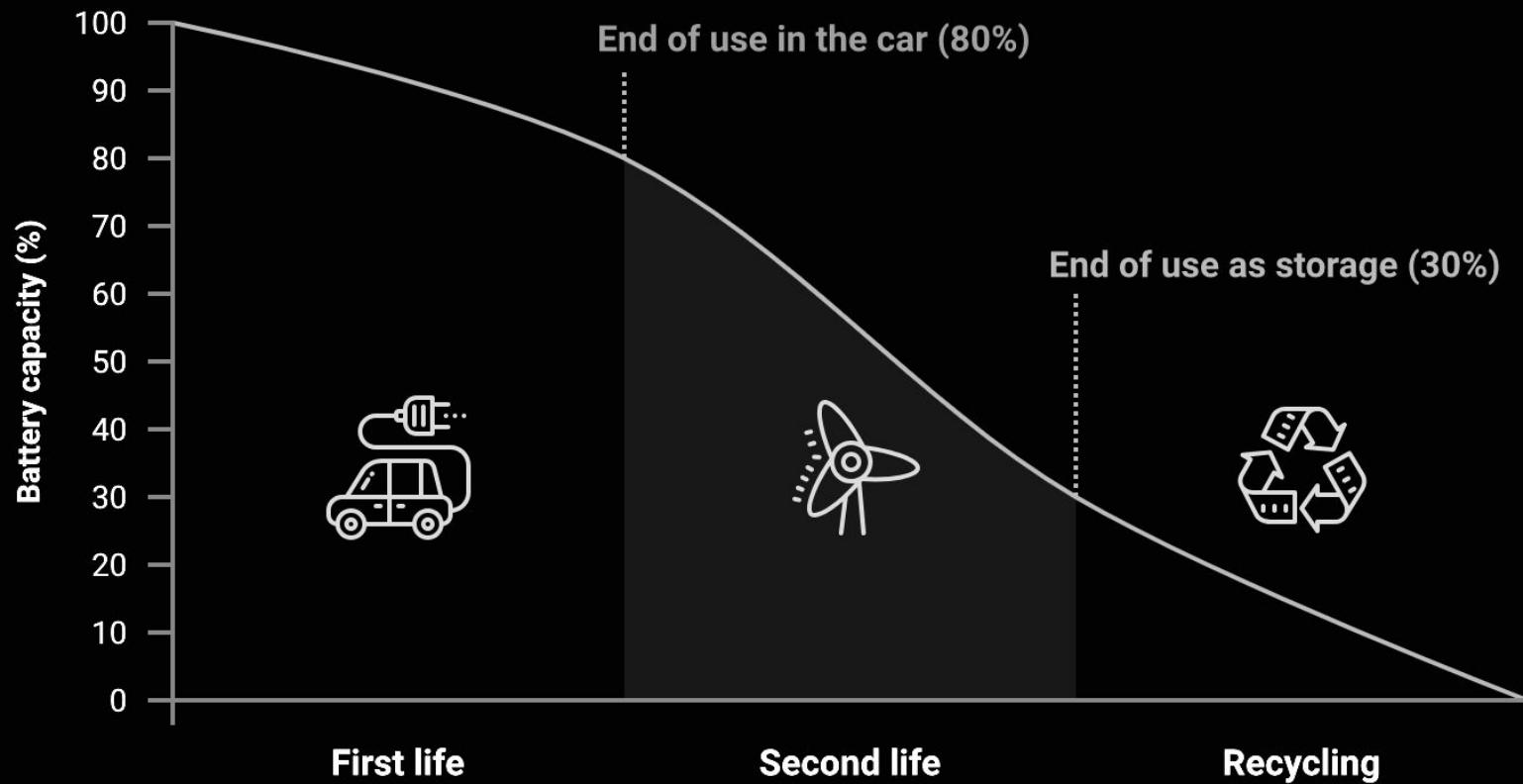
By User:Synth85 - Own work, CC BY-SA 4.0, <https://commons.wikimedia.org/w/index.php?curid=75041978>

Image from The
New Economy:
[Schneider Electric](#)
is helping to bring
reliable electricity
to Africa





By Varistor60 - Own work, CC BY-SA 4.0, <https://commons.wikimedia.org/w/index.php?curid=59368531>



Adapted from Drax.com

7 AFFORDABLE AND
CLEAN ENERGY



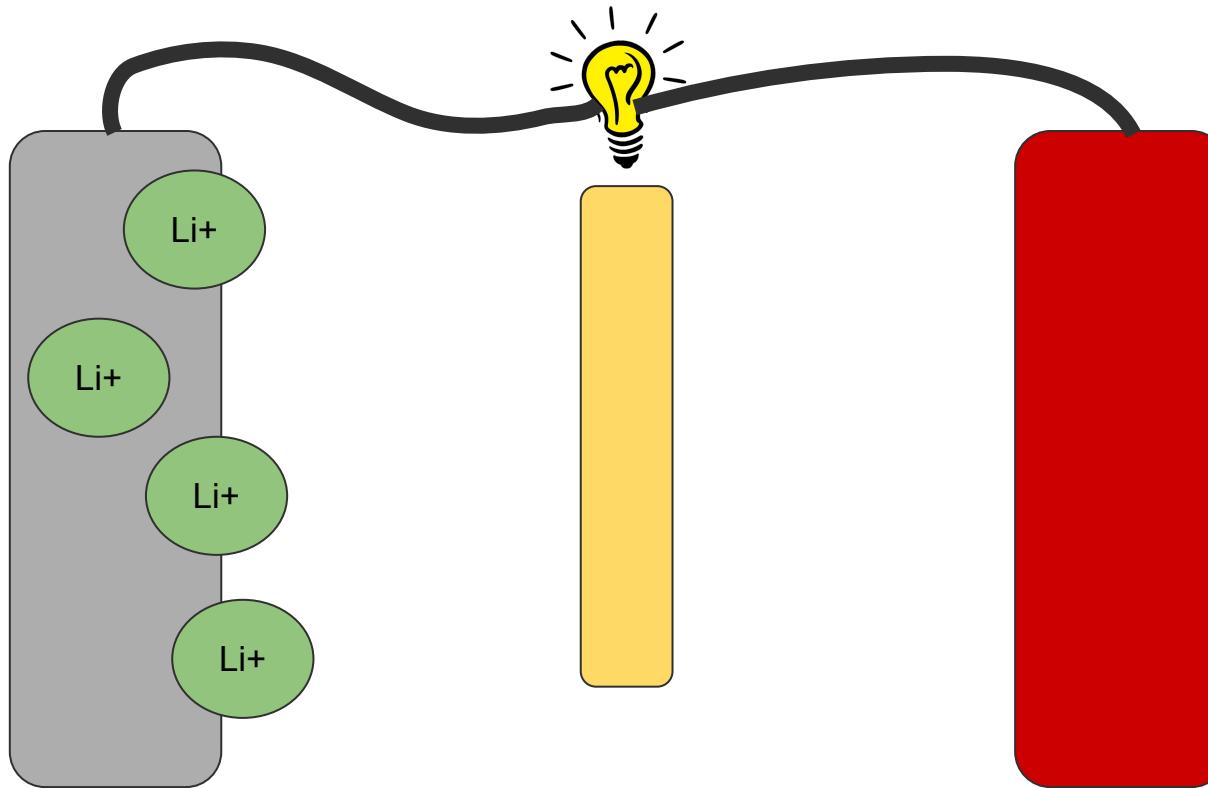
11 SUSTAINABLE CITIES
AND COMMUNITIES



12 RESPONSIBLE
CONSUMPTION
AND PRODUCTION

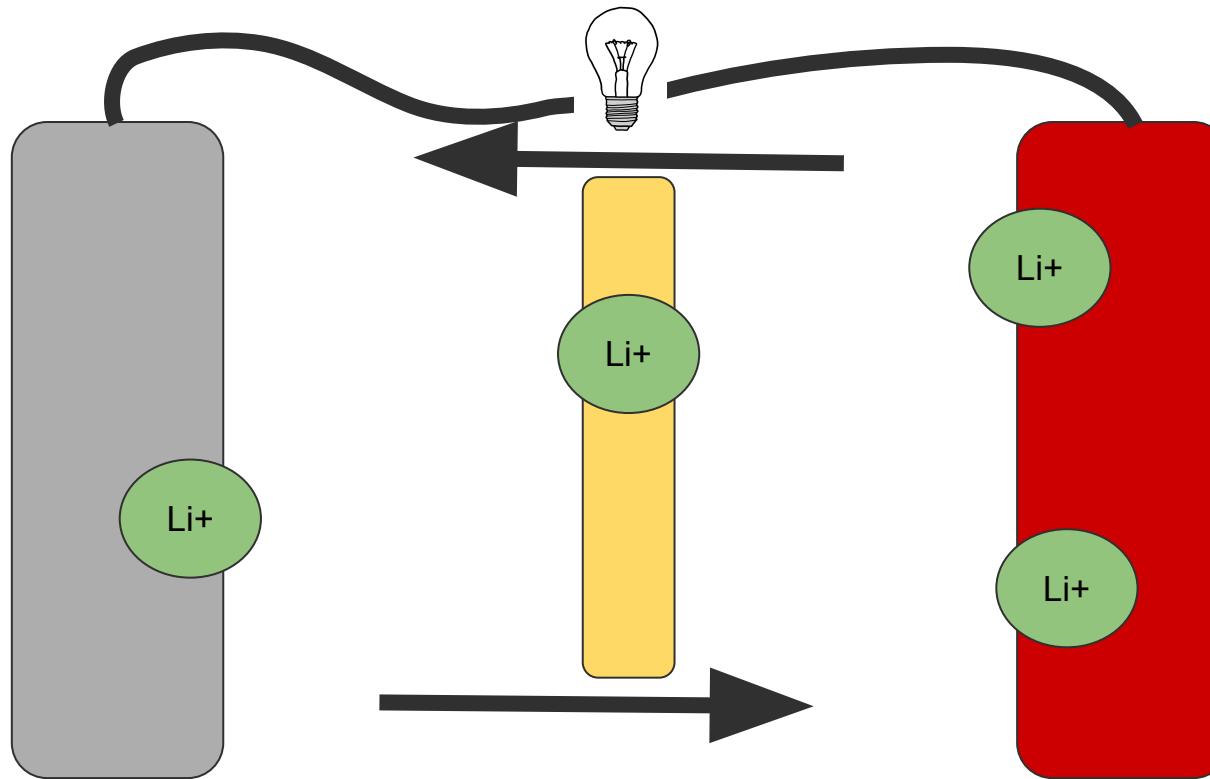


What is a Li-ion Battery?



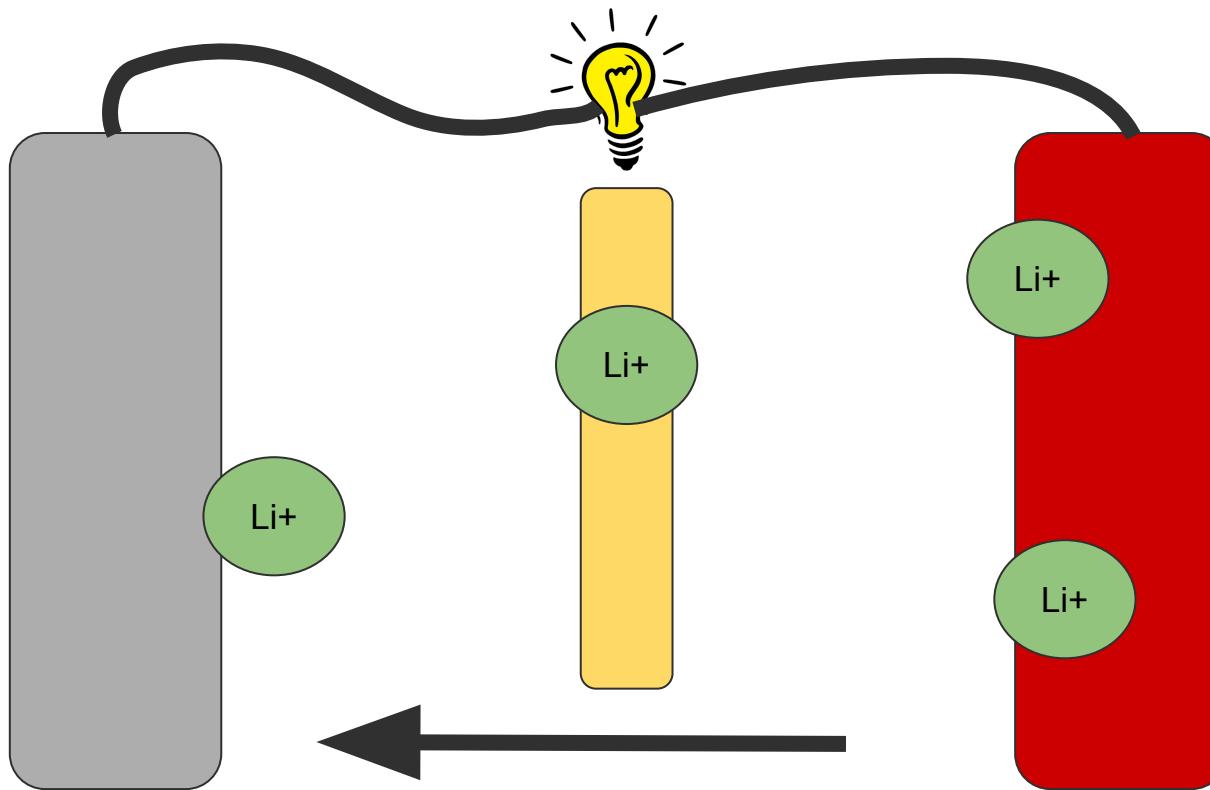
The Strategy of Achieving Flexibility in Materials and Configuration of Flexible Lithium-Ion Batteries - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Schematic-diagram-of-working-mechanism-of-lithium-ion-battery_fig1_356134415 [accessed 3 Jun, 2024]

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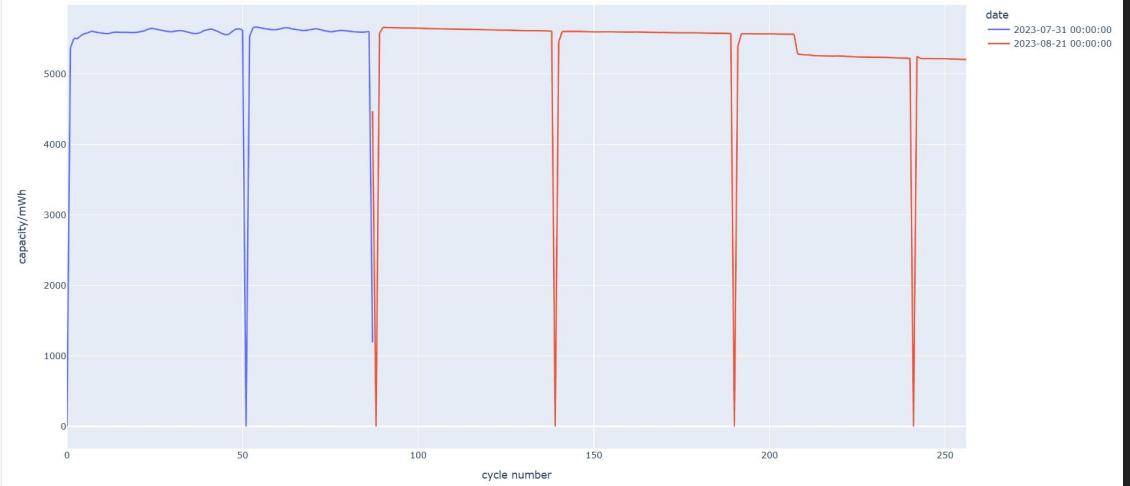
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The Strategy of Achieving Flexibility in Materials and Configuration of Flexible Lithium-Ion Batteries - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Schematic-diagram-of-working-mechanism-of-lithium-ion-battery_fig1_356134415 [accessed 3 Jun, 2024]

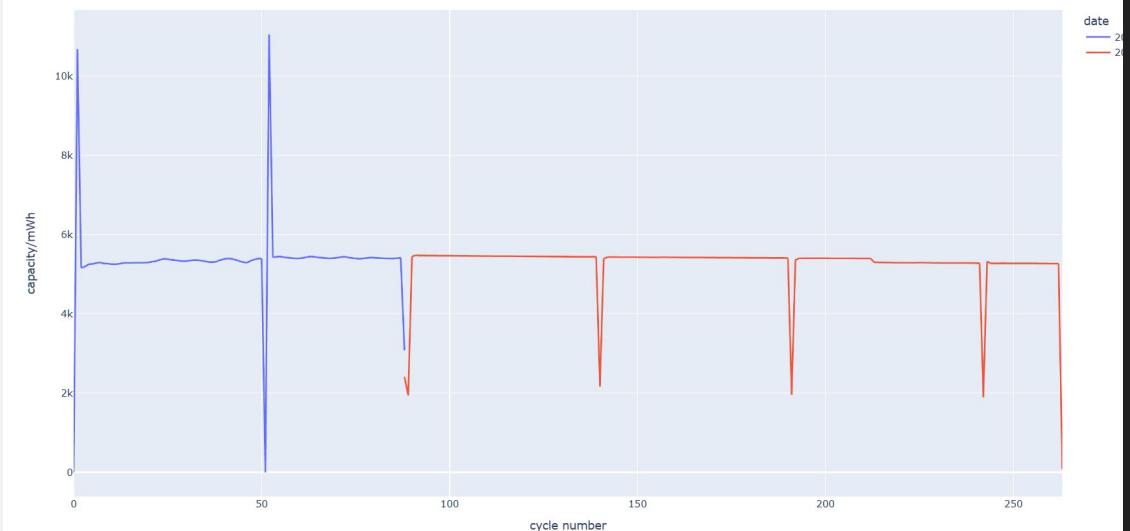


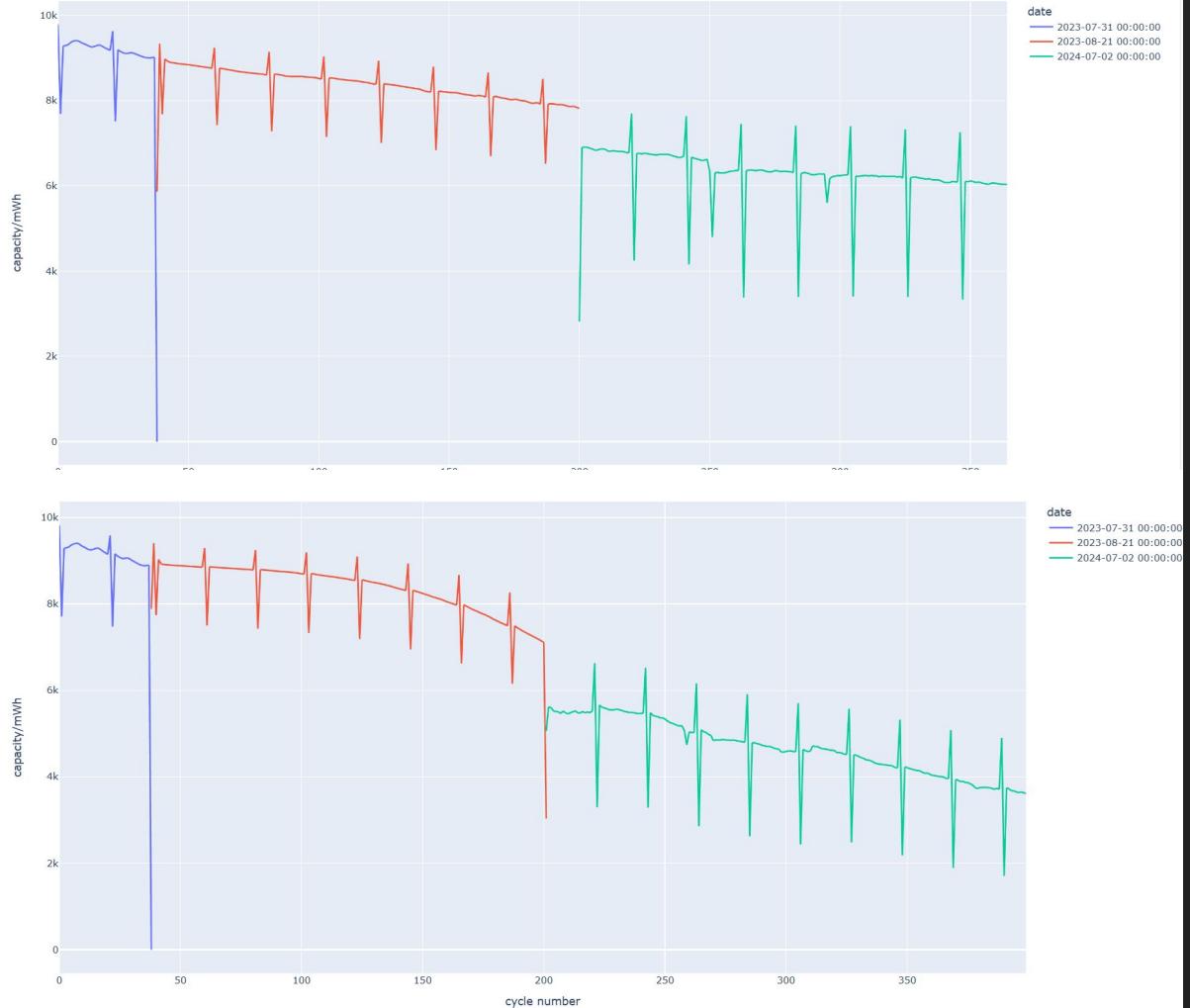
Image from eBay



Lithium-Phosphate

- Used in energy storage and off-grid living.
- Low capacity loss over time.
- Heavier, Larger.

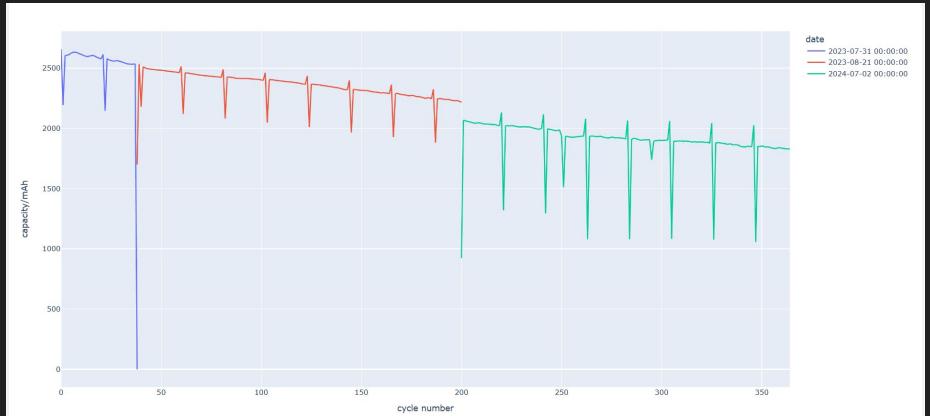




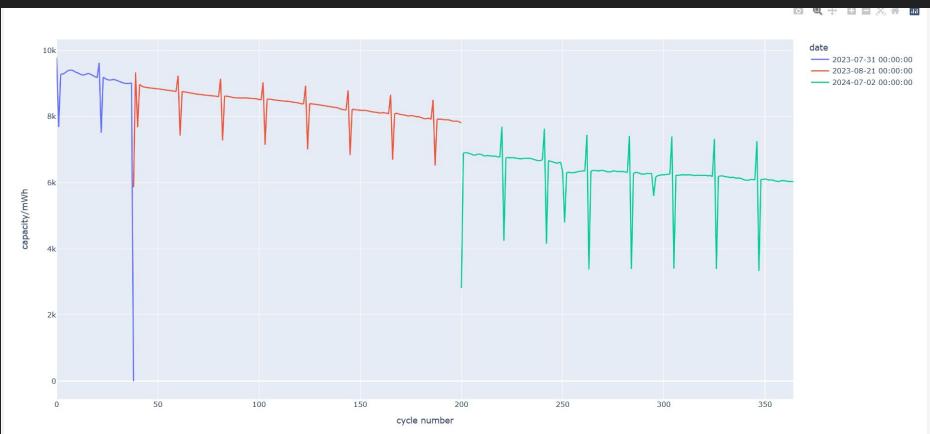
Lithium-Cobalt

- Used in portable applications (phones, tablets, cars)
- High capacity loss.
- Lighter, smaller.

Power = Voltage x Current



Capacity (mWh)



Capacity (mAh)

The problems with predicting battery health.

- Cycling data is expensive
- Degradation depends on:
 - Charging and Discharging (Speed, Depth)
 - Temperature
 - Cell chemistry
 - Time spent charged.
- Future life application depends on the process which degraded.

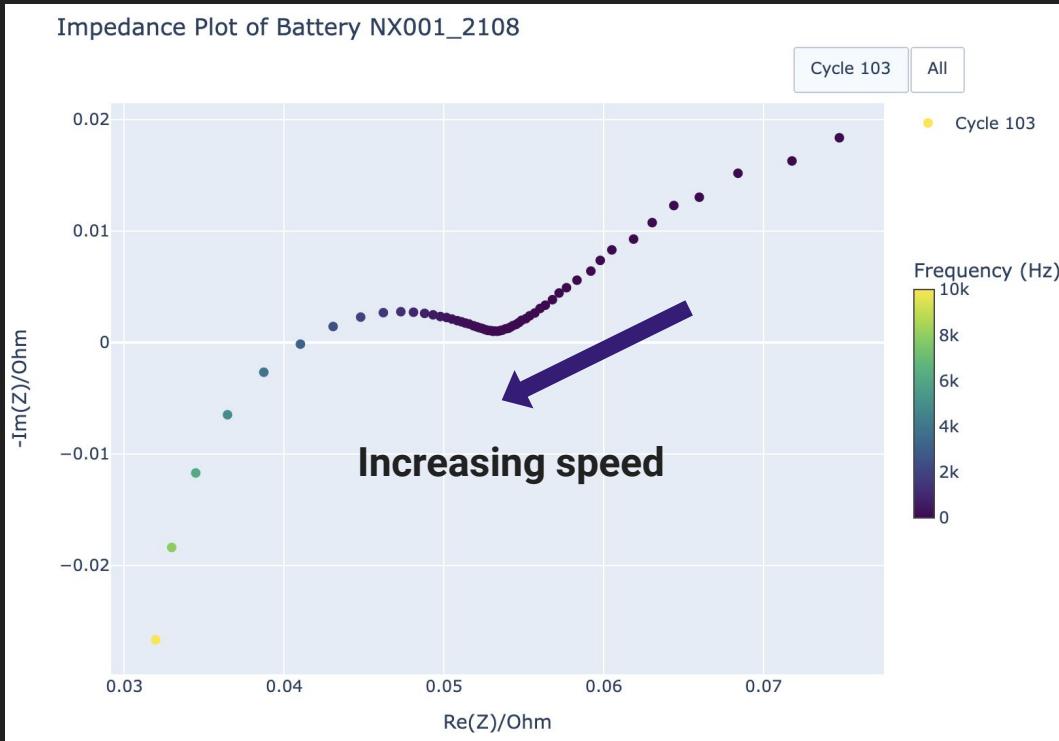
EIS: A different approach

**EIS = Electrochemical
Impedance Spectroscopy**

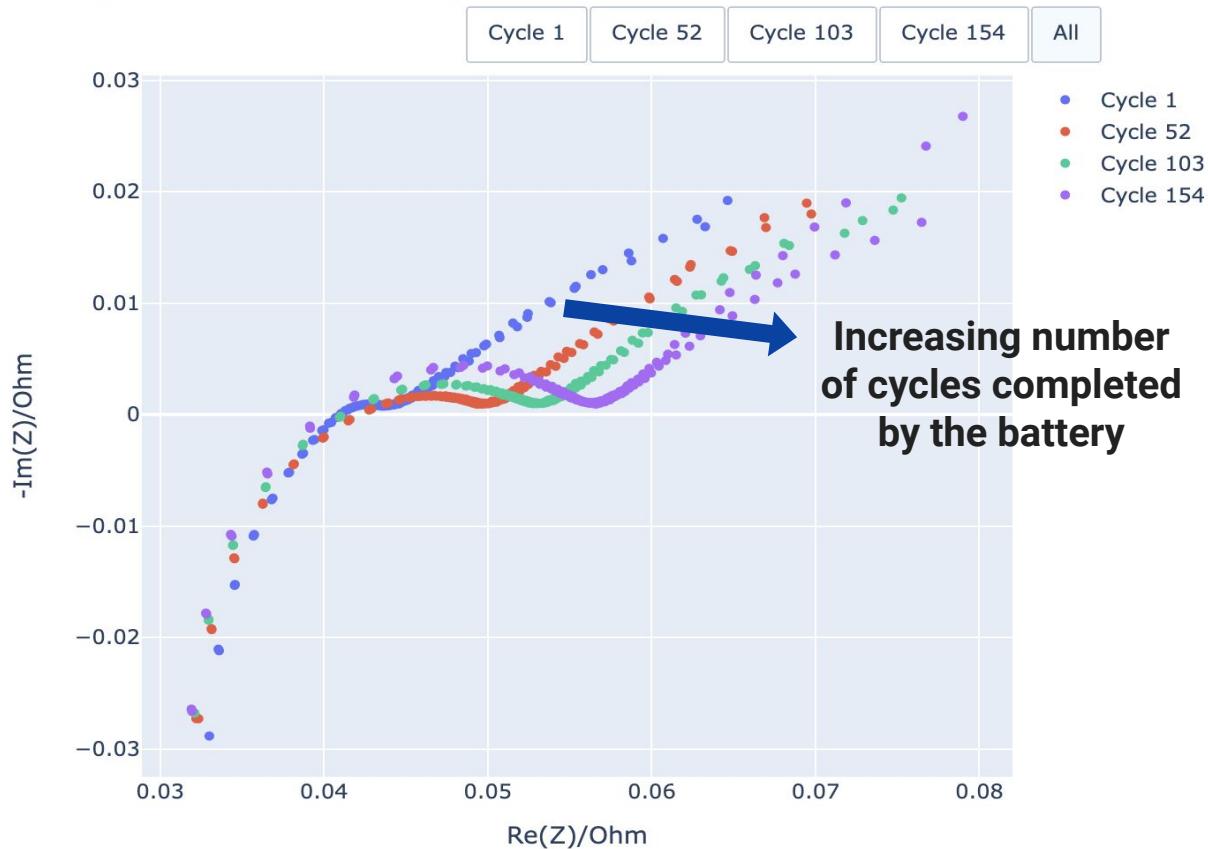


EIS Testing Equipment

An example of an EIS spectrum



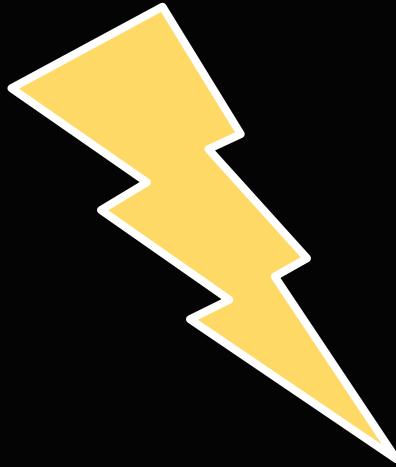
Impedance Plot of Battery NX001_2108



Why is EIS useful?



Time

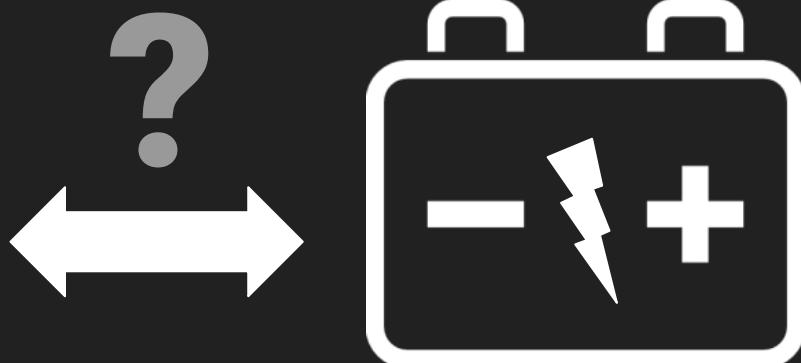
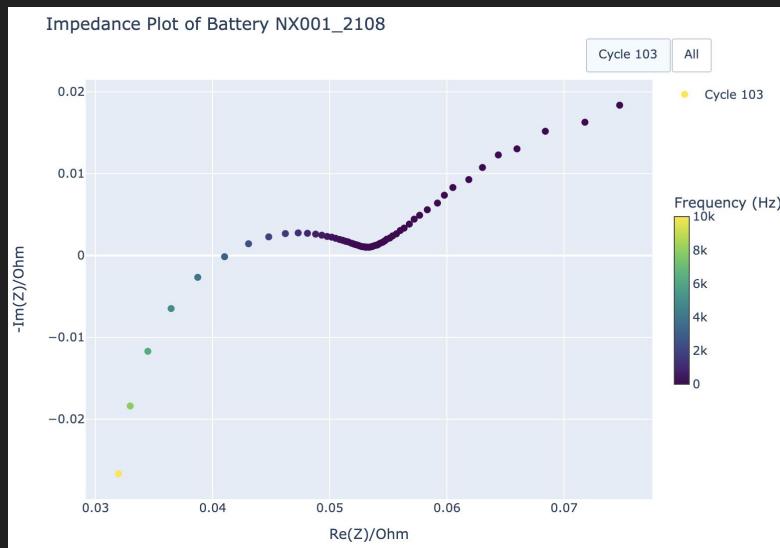


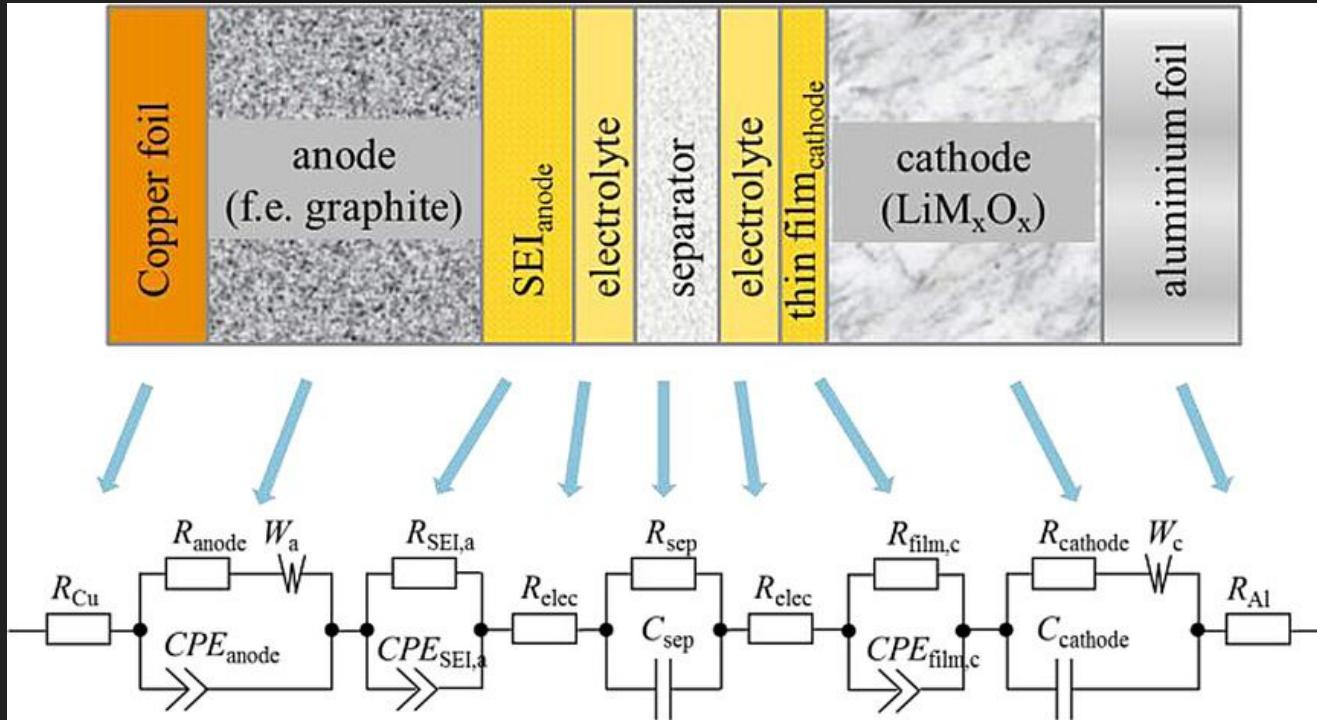
Energy



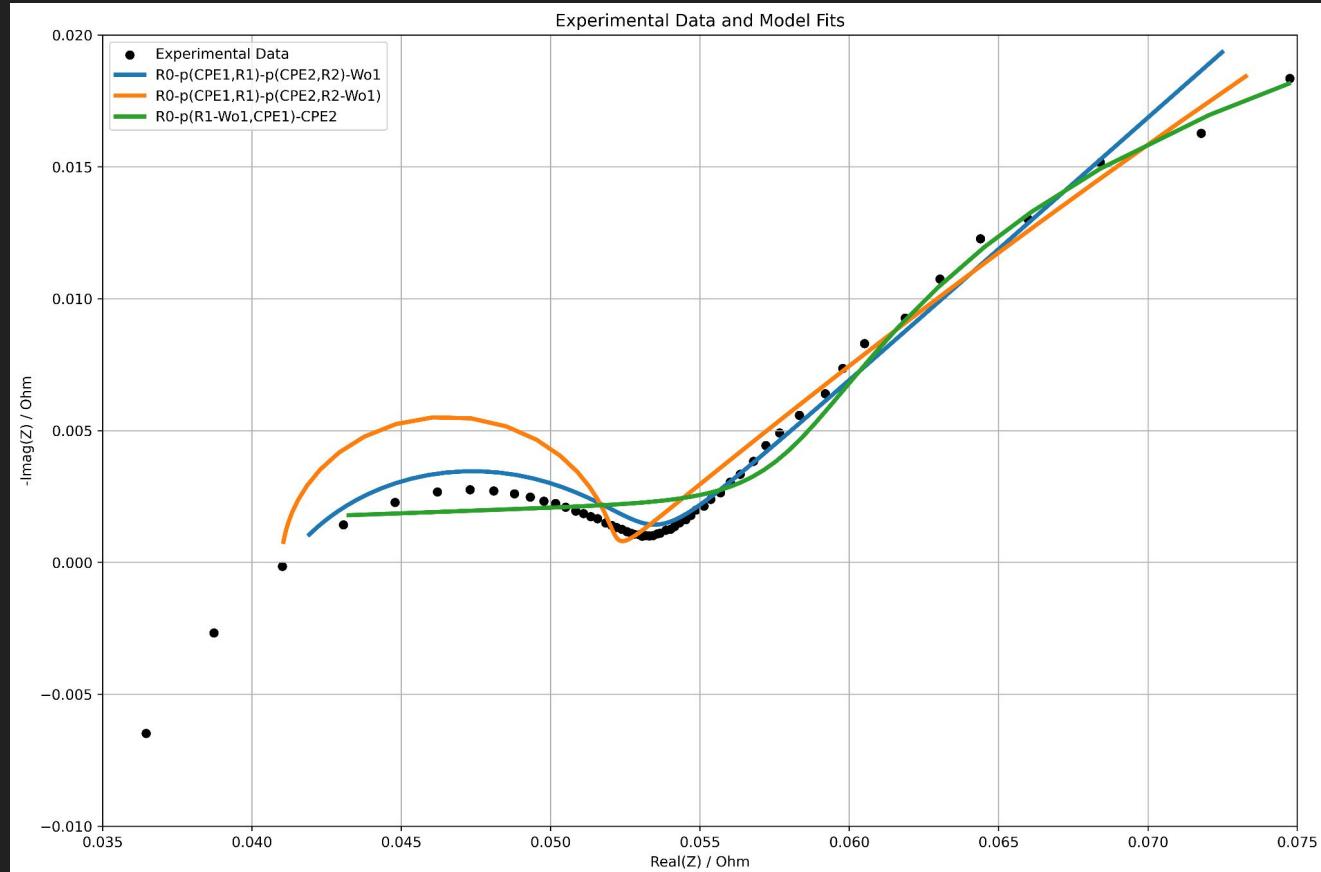
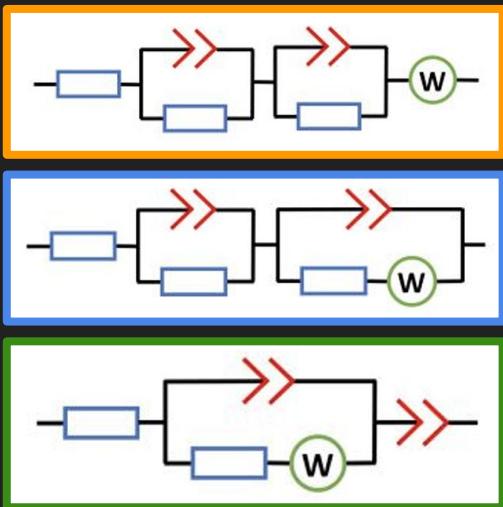
Cost

How do we use the EIS graph to simulate what's going on inside the battery?





Fitting a circuit to EIS

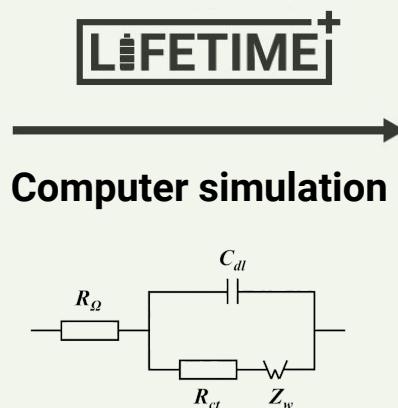


How does this help LiFETIME reach their goal?

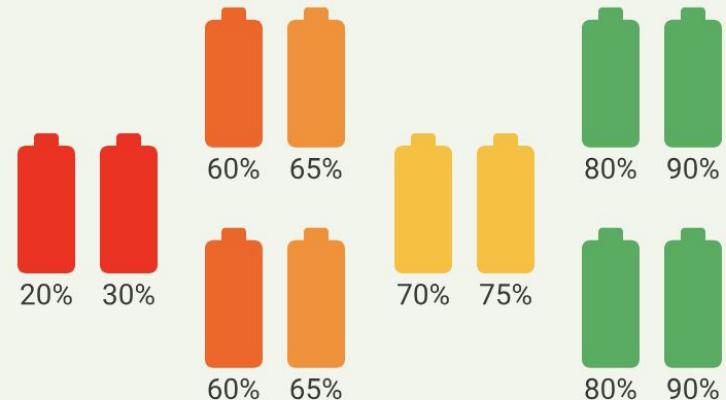
Collect EIS data
from batteries
10-15 minutes



Aged first-life pack



Device outputs
remaining capacity

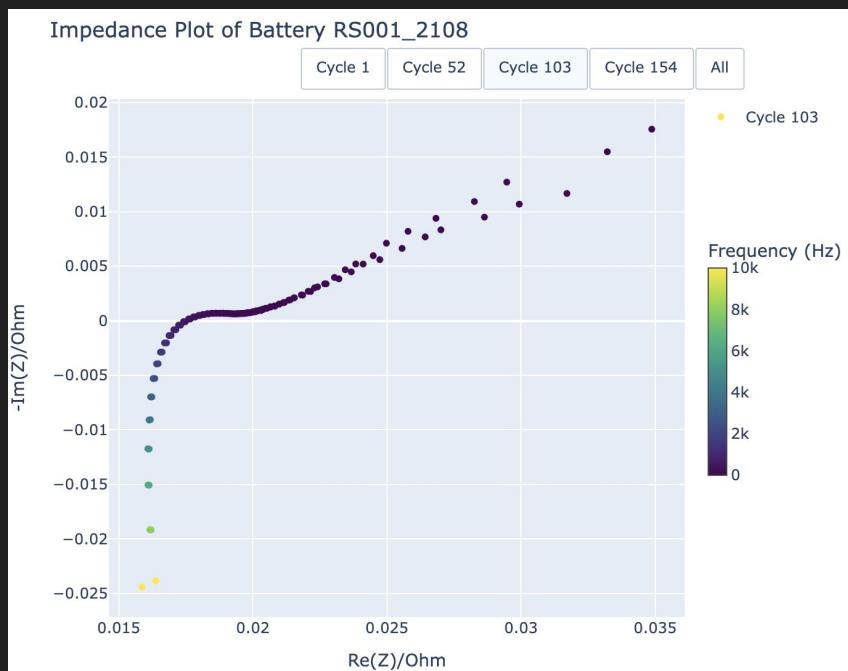
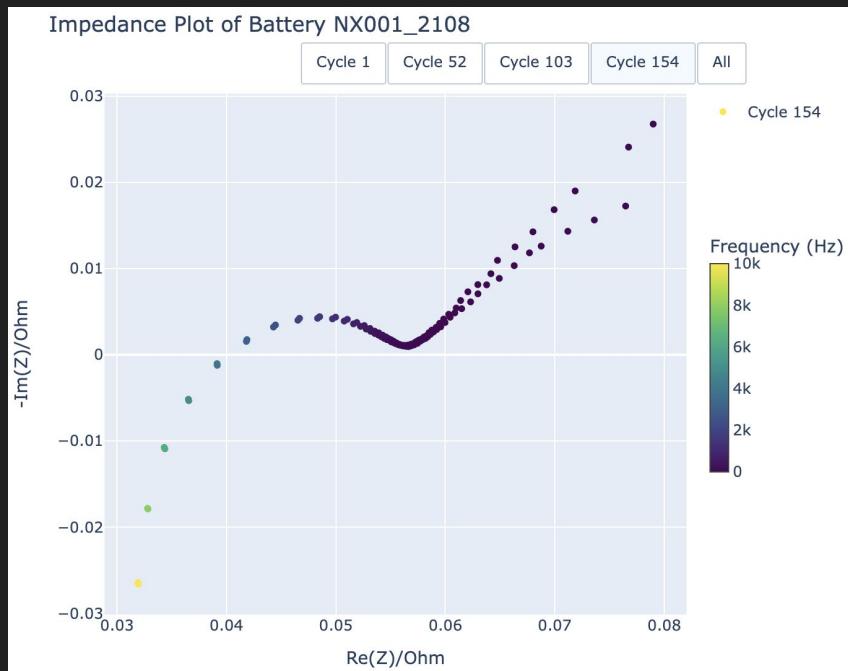


Suitable
for recycling

Suitable
for energy storage
if grouped $\pm 5\%$

Suitable
for EVs

Challenges of fitting circuit models



Software packages for circuit fitting

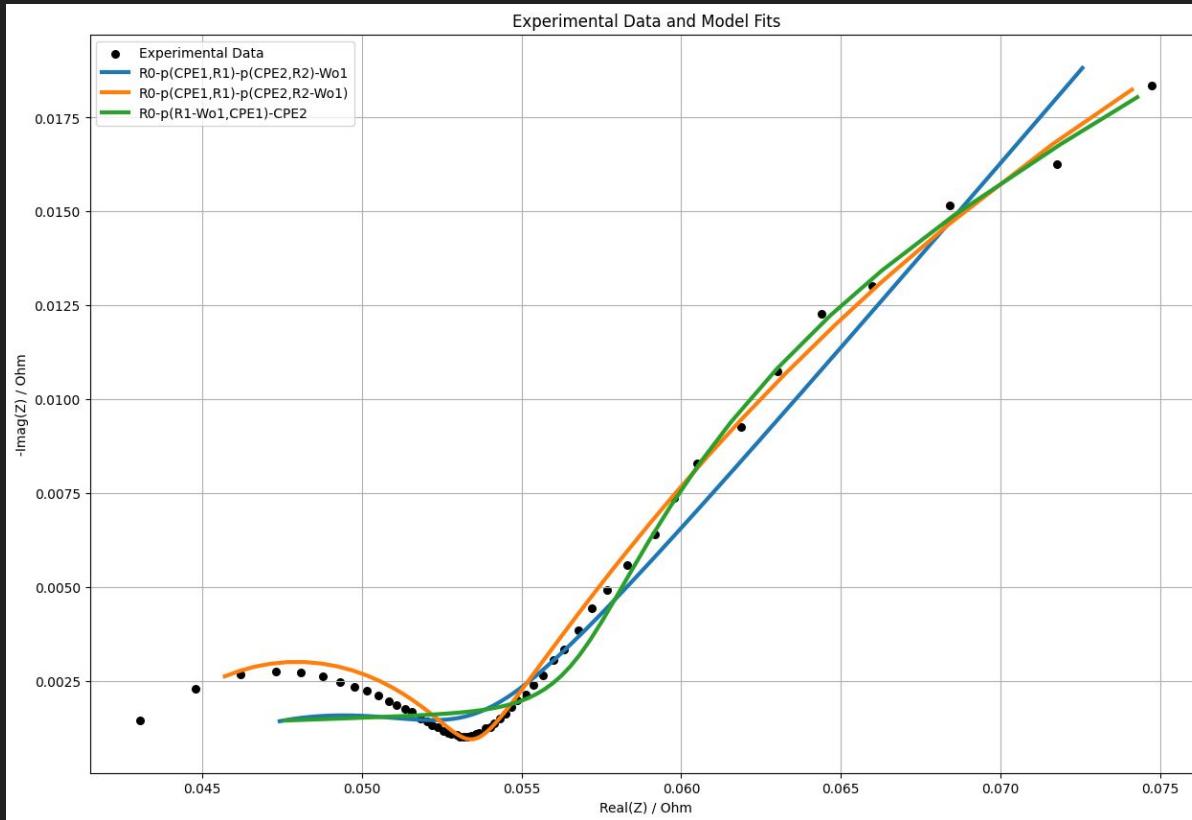


SciPy

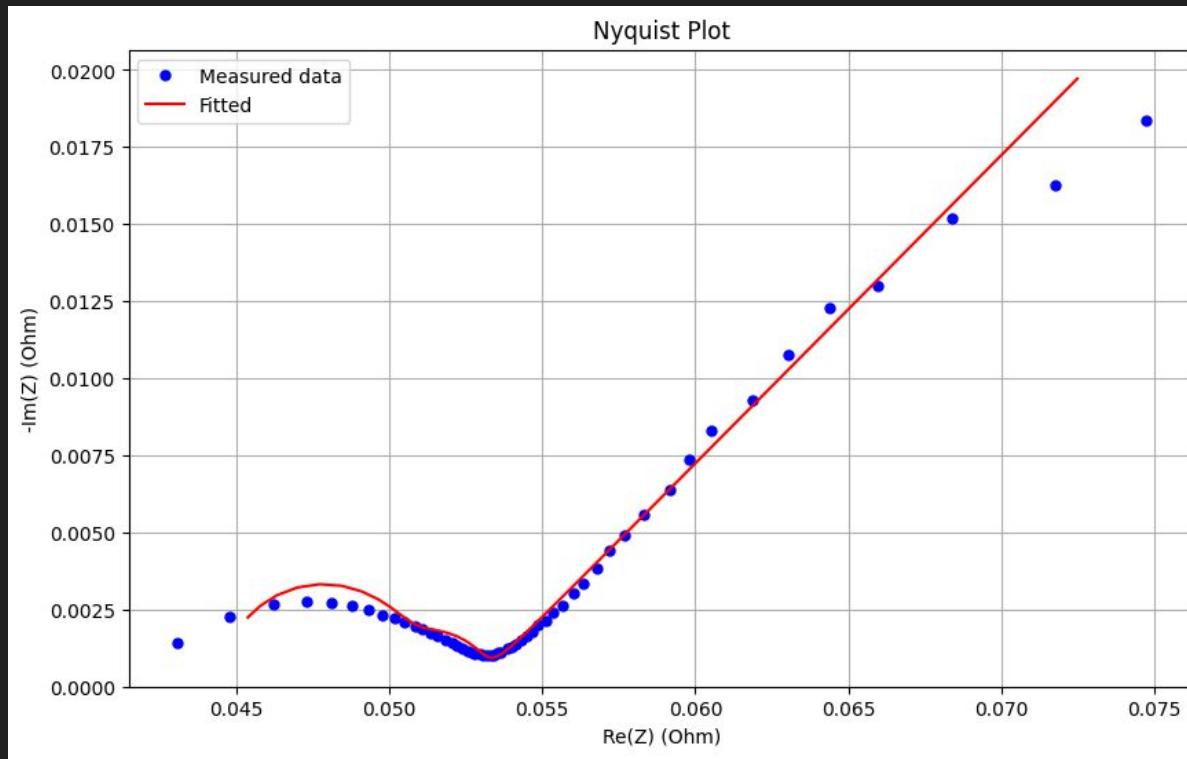
impedance.py

PyEIS

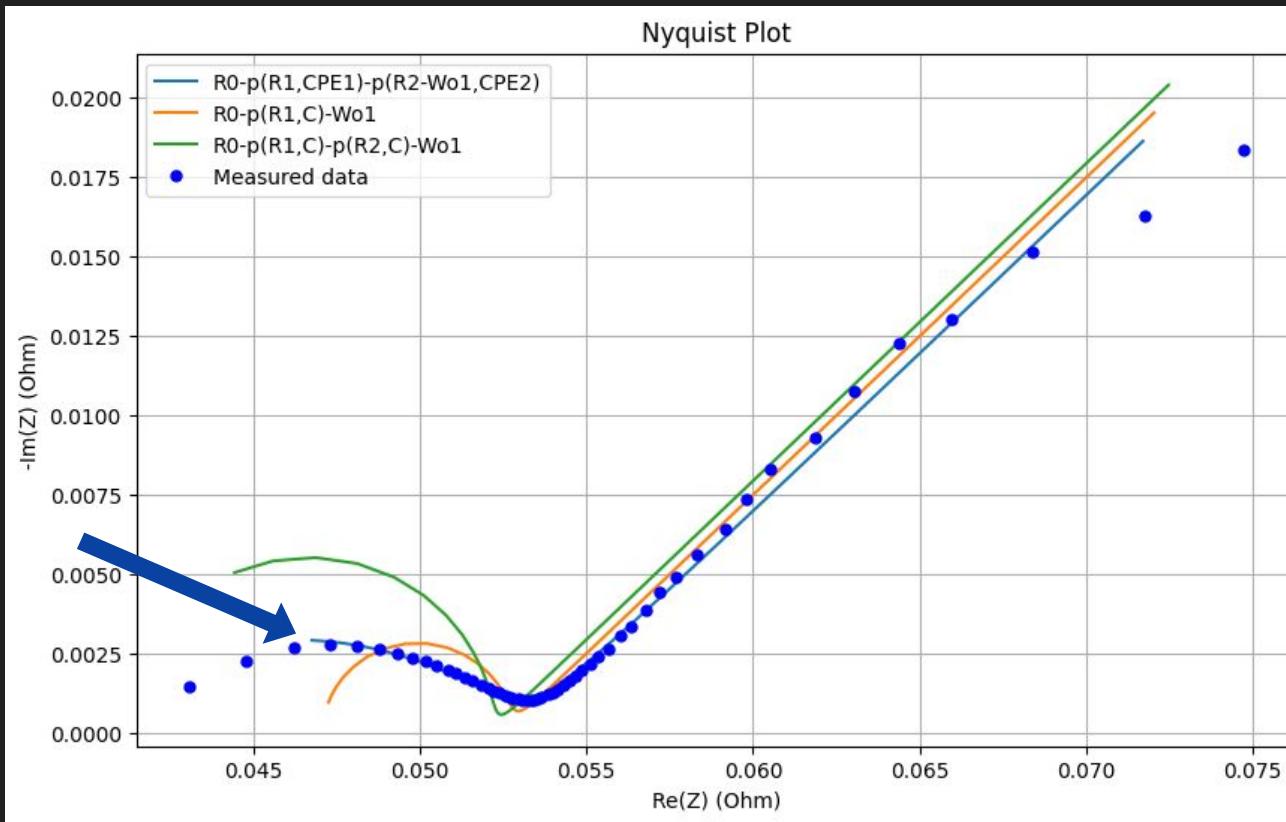
Impedance.py



Scipy.optimize



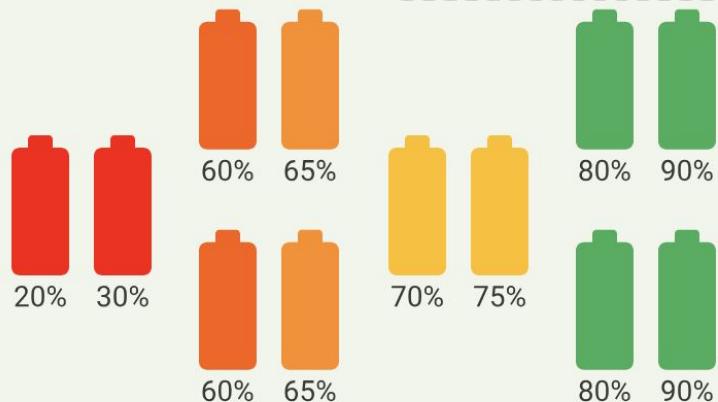
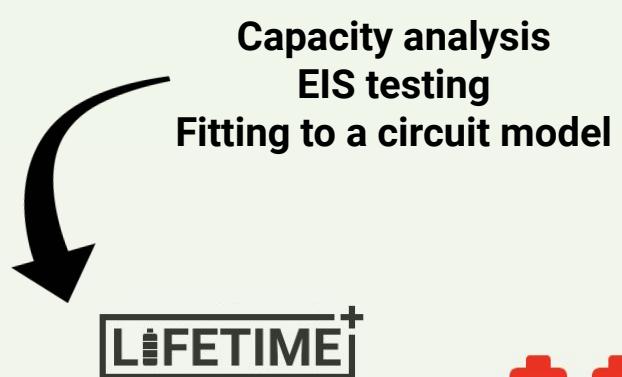
Scipy.optimize.curve_fit with KDE



Summary



Aged first-life pack



Suitable
for recycling

Suitable
for energy storage
if grouped $\pm 5\%$

Suitable
for EVs



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