

Alaska Energy Storage Workshop

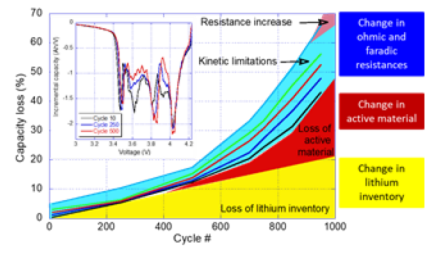
January 12-13, 2021



ALASKA ENERGY AUTHORITY



REAP | Renewable Energy Alaska Project

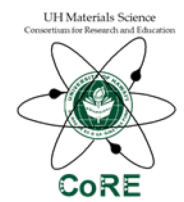


Battery Durability and Reliability Under Grid Operations

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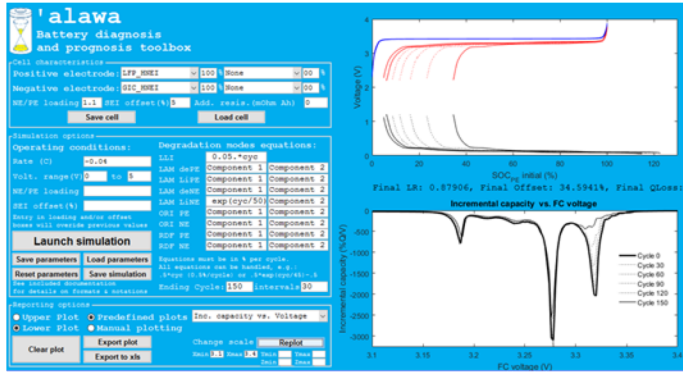


HNEI PakaLi Battery Laboratory



Diagnosis and Prognosis

- Well defined performance metrics
- Experience in experimental design
- Operando Diagnosis and prognosis
- Non-destructive analysis

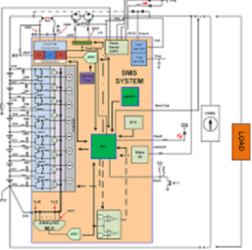


Online SOC and SOH monitoring

- New methodologies for deployed systems

Large storage systems modeling

- Account for cell-to-cell variations
- Transfer knowledge from single cell to packs



Applications to commercial batteries

- BESS
- V2X / X2V
- Second use, Recycling (To be started)



Hawaii Clean Energy Initiative

Battery powered transportation in Hawaii



Battery systems will be essential for the Hawaii Clean Energy Initiative

The Hawaii Clean Energy Initiative is leading the way in relieving our dependence on oil by setting goals to achieve 100% clean energy and transportation by 2045.



Battery Energy Storage Systems (BESS)

Need to increase penetration of renewables
BUT Intermittency:

- Need to store the excess renewable energy
- Need to stabilize the grid

Batteries are most likely candidates:

- Fast response
- Efficiency > 95%,
- Plug and play installation
- Can be distributed at strategic locations



Battery powered electric vehicles (EV)

Reduce further oil consumption
Reduce emissions
Additional storage for the grid



Hawaii Clean Energy Initiative

Battery powered transportation in Hawaii

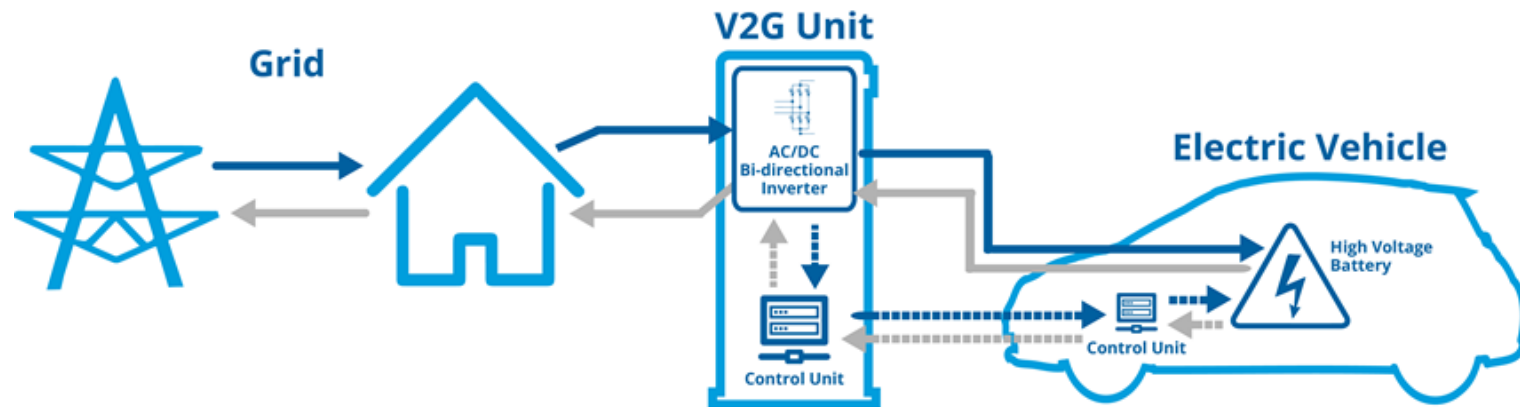
Hawaii grid storage (as of 2017) ~ 40 MW & 30 MWh

Hawaii total EVs > 10000: >500 MWh of potential storage

Forecast: between 100,000 and 250,000 in 2040 (M. Coffman, UHERO)

5000 MWh to 25000 MWh of potential storage

Vehicle to grid (V2G)



Battery second use

Use of used EV batteries (>20% capacity loss) for grid storage

The complexity of battery diagnosis

Path dependence of the degradation

Traffic



Road type



Driving habits



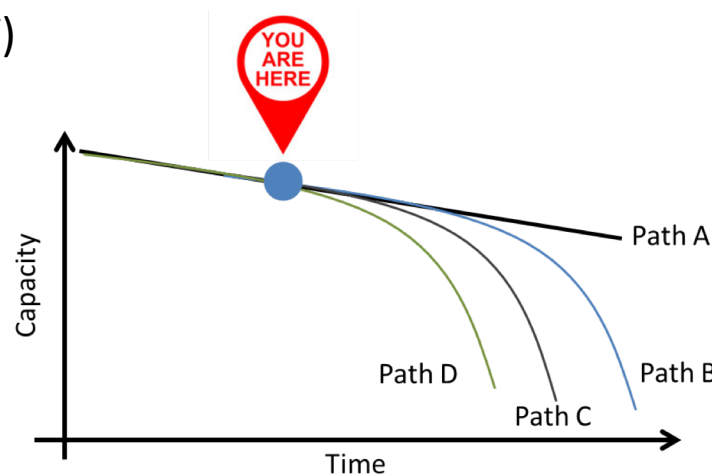
Charging habits



Temperature



Grid ties (V2G / G2V)



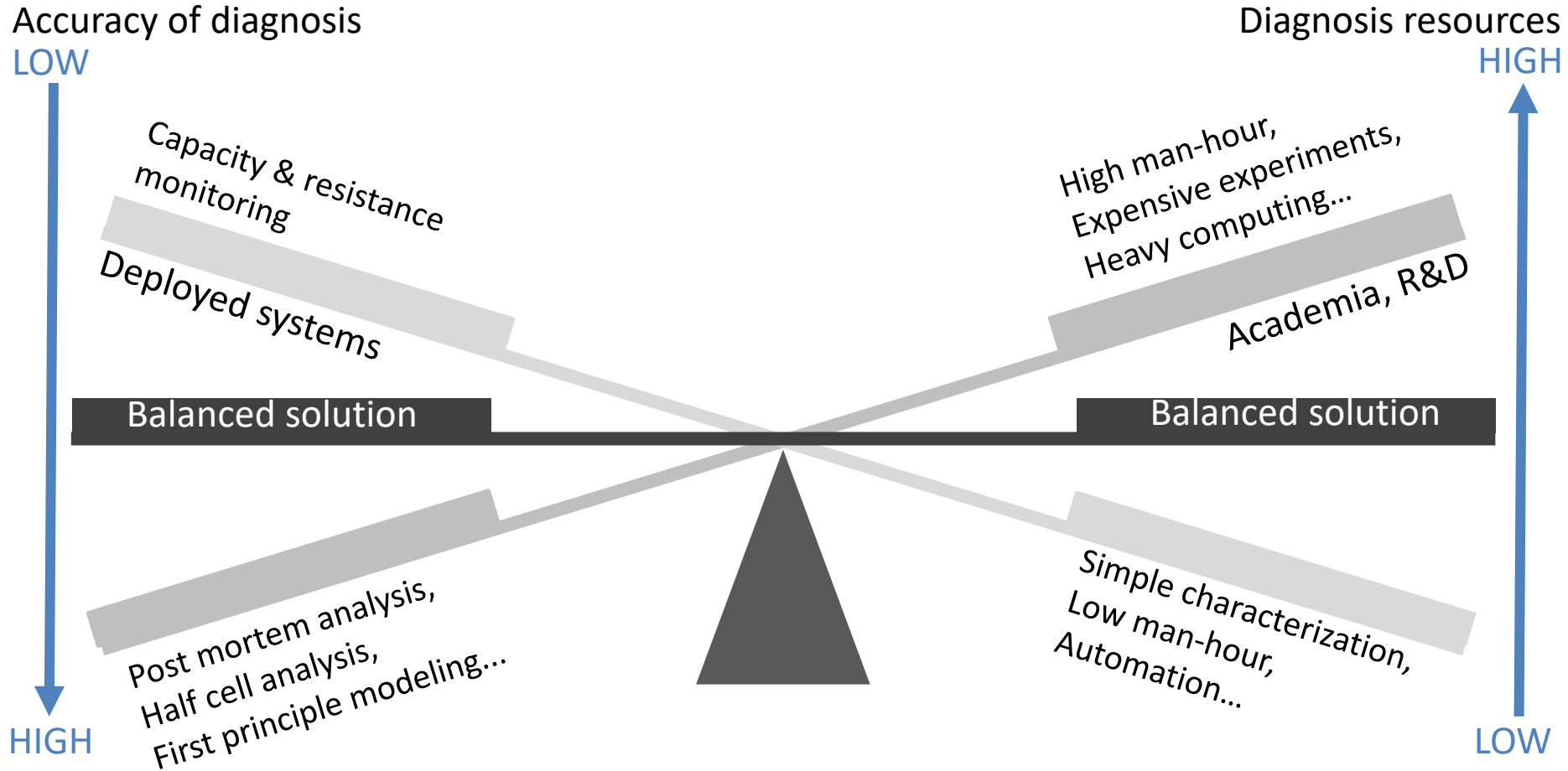
Different paths will lead to different degradation

Every battery is different

HNEI developed accurate diagnosis using onboard parameters

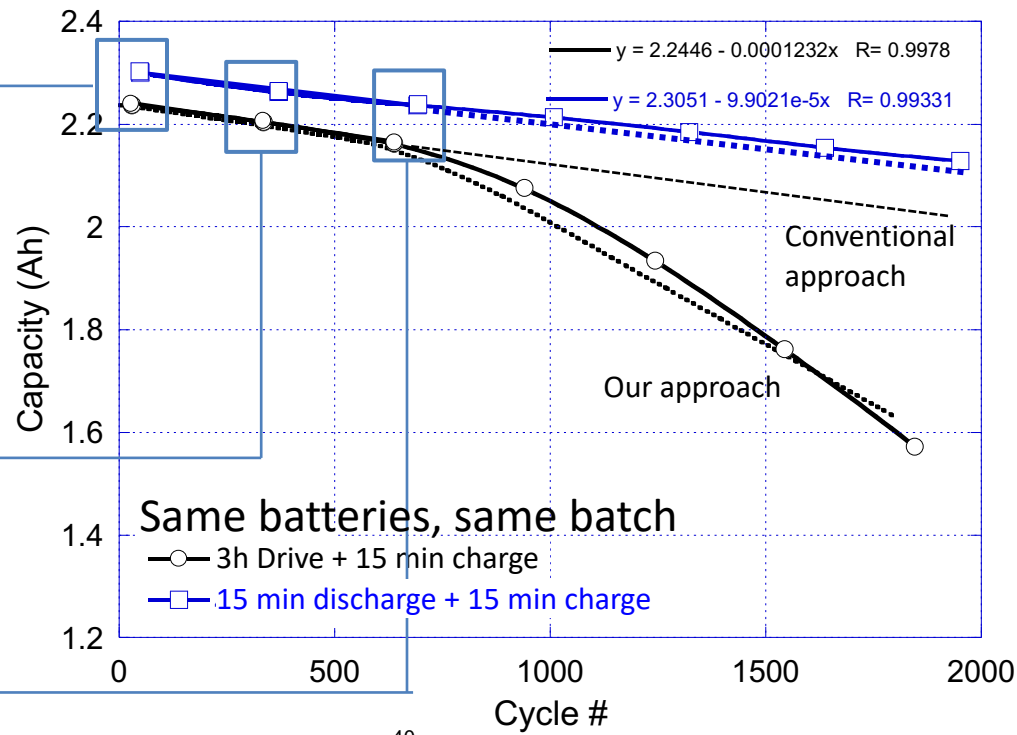
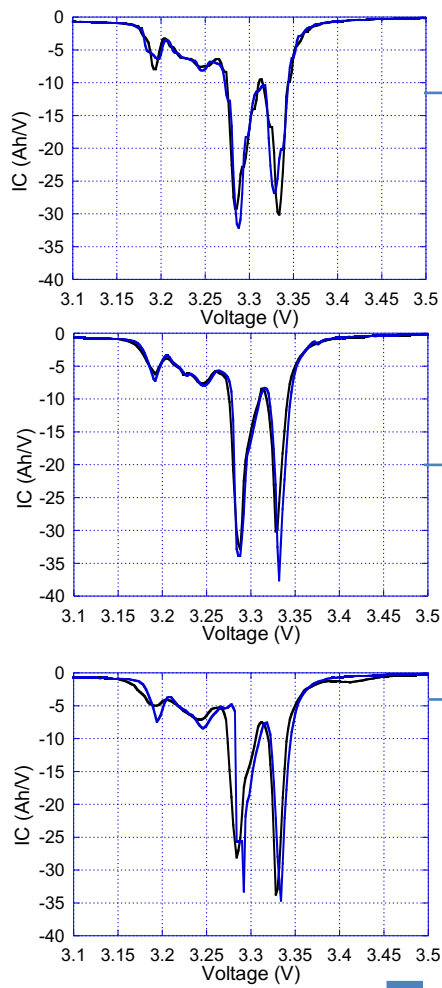
The complexity of battery diagnosis

Complex balance

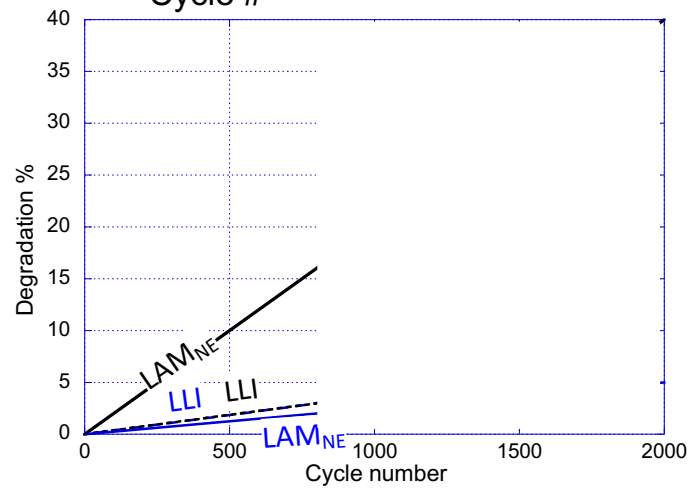




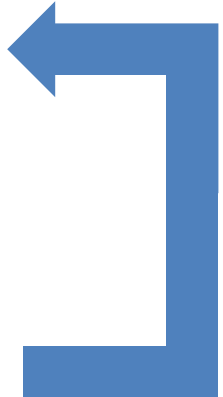
Battery Diagnosis Diagnosis to Prognosis



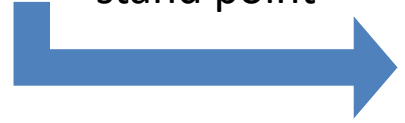
To understand the degradation from a material stand point



We then use that knowledge to predict what will happen to the cell



We study voltage variations

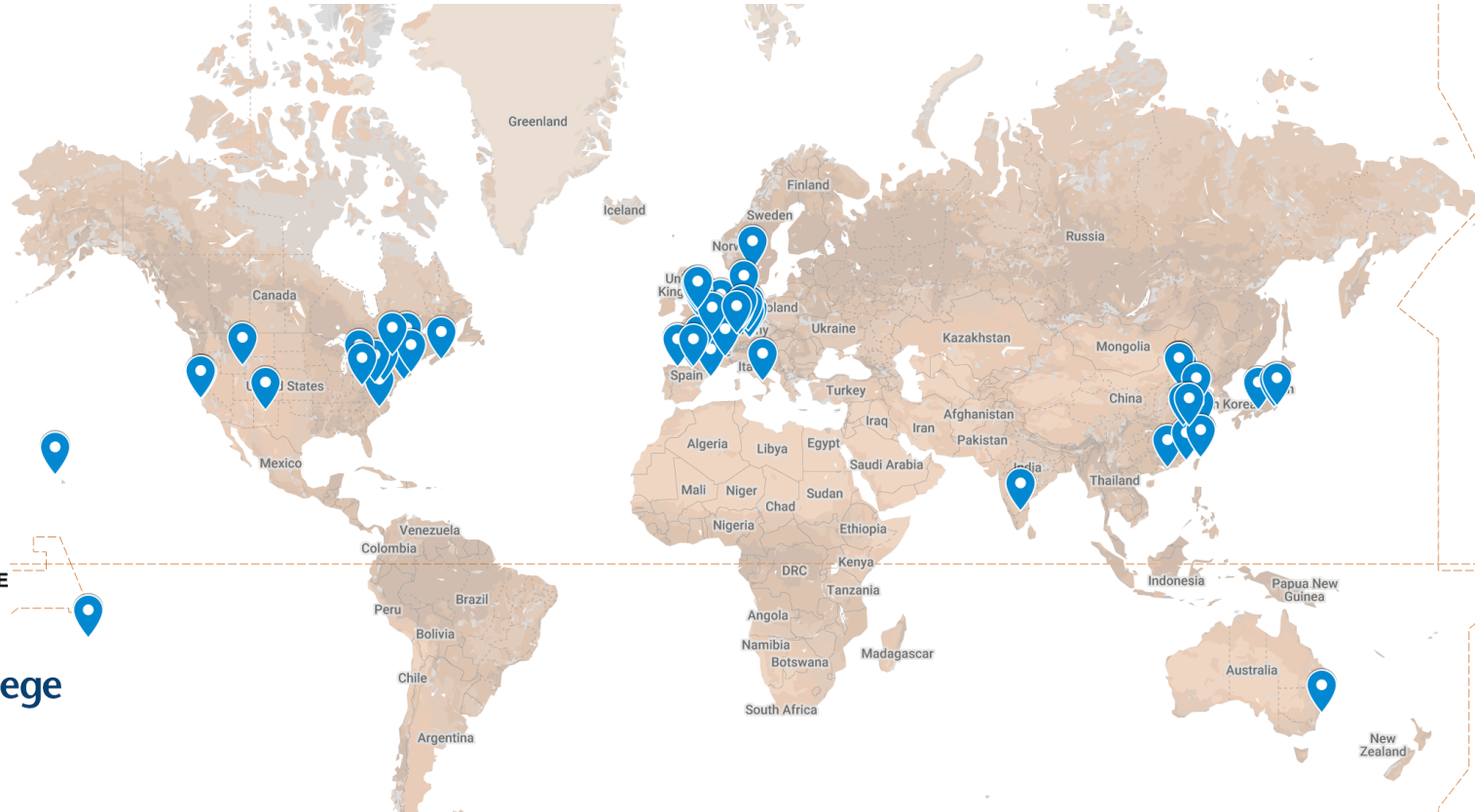


LAM_{NE}: loss of negative electrode material
 LLI: Loss of lithium inventory



Mechanistic diagnosis and prognosis HNEI methodologies

100 registered users from >50 organizations worldwide





Recent focus on batteries for storage, grid-tied or in vehicles

Grid-tied Storage

Monitoring of 3 grid-tied systems
($\geq 1\text{MW}$)



Laboratory testing of single cells
(similar to the one in large batteries)
> 80 battery tested under different conditions



Vehicle Storage

Study impact of vehicle to grid
usage on EV battery degradation

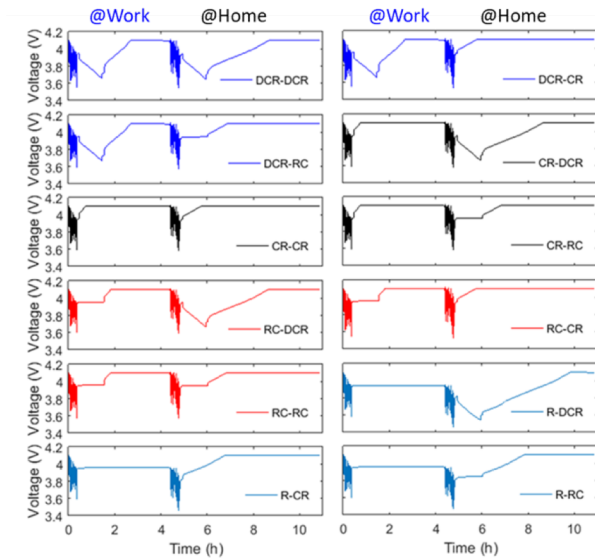
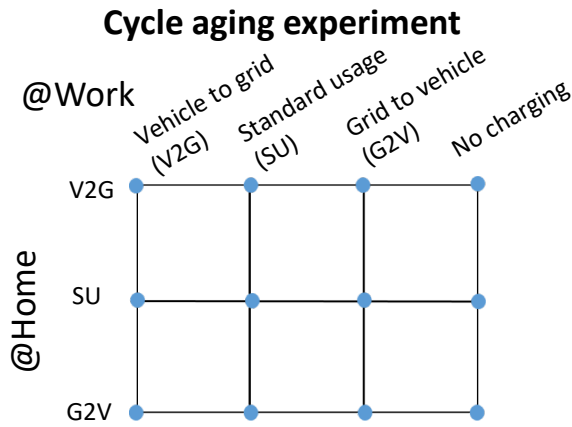
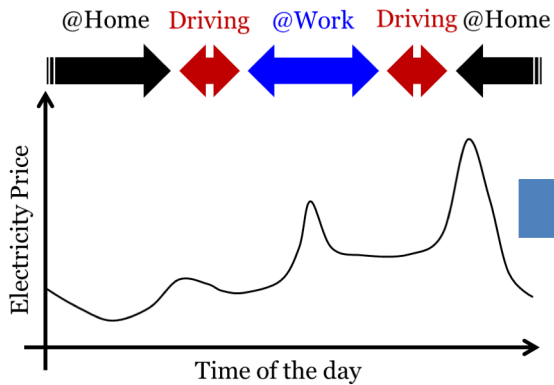


Laboratory testing of single cells
(similar to the one in EVs)
> 100 battery tested under different conditions

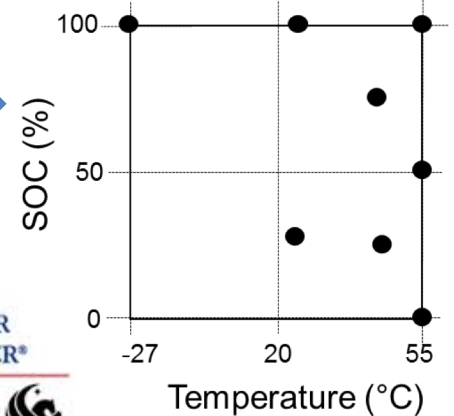


EV Cell Degradation under Electric Utility Grid Operations

Design of experiment methodology: cycle and calendar aging

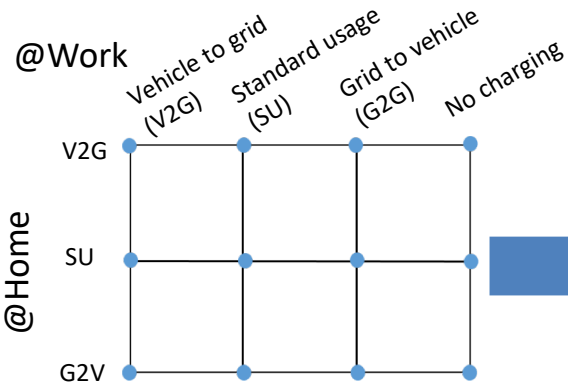


Calendar aging experiment



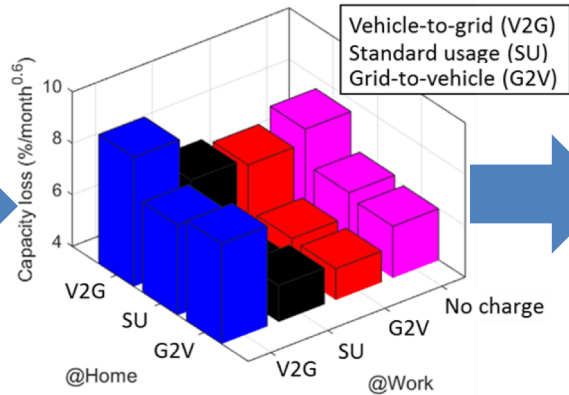
EV Cell Degradation under Electric Utility Grid Operations

Cycle aging experiment



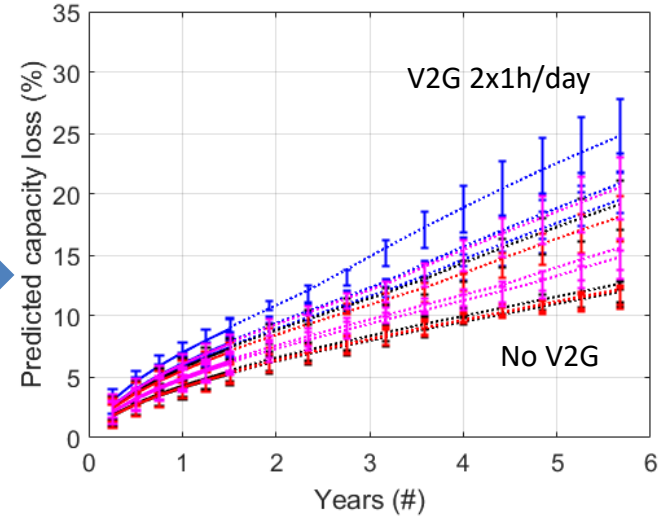
Results:

V2G 2x1h/day @ P/4 : +75% capacity loss
 V2G 1h/day @ P/4 : +33% capacity loss
 Charging 2x/day vs. 1x/ day: -5% capacity loss
 SU vs. G2V : no significant effect

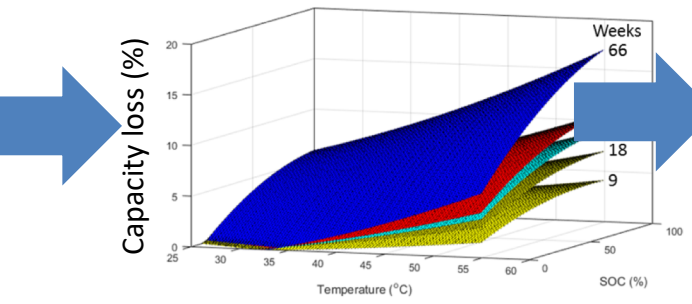
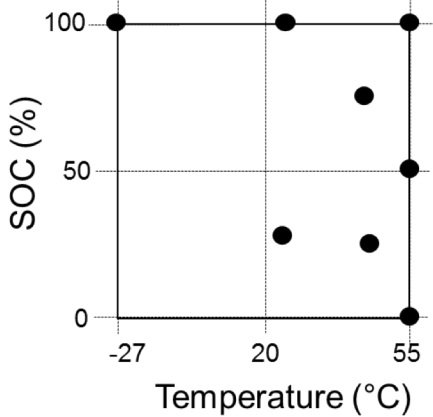


Prognosis:

V2G strategy drastically reduces durability
 G2V might be beneficial in warm climates

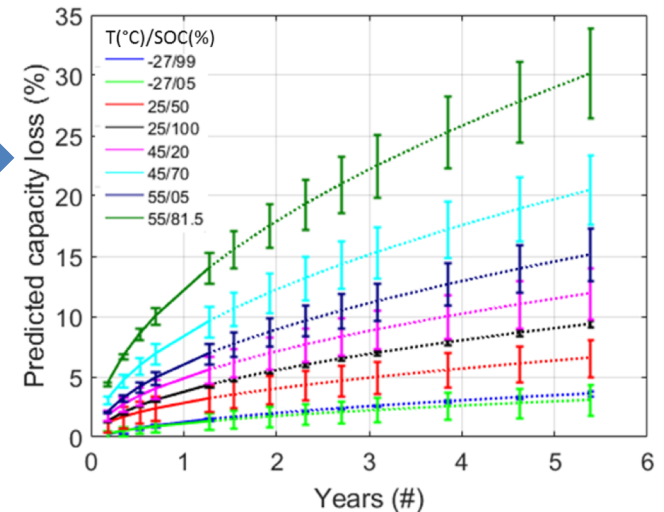


Calendar aging experiment



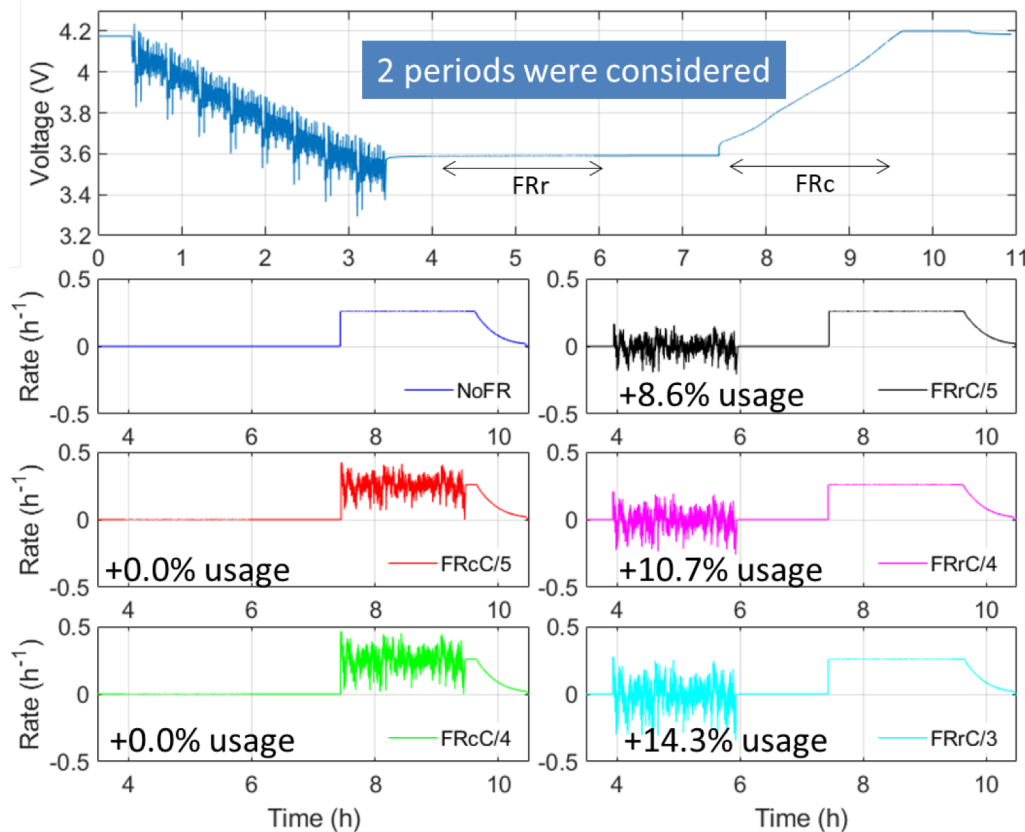
Results:

Significant effect of time, temperature and SOC.
 Temperature effect > SOC effect at high values



Impact of Frequency Regulation Usage on Cell Degradation

Study the impact of frequency regulation usage



Baure et al. / Energies, 13 (10) 2494 (2020) doi: 10.3390/en13102494

V2G could be beneficial to utility and EV owner
but only with proper control and understanding of battery degradation

Acknowledgments

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Mahalo for your attention! Questions?