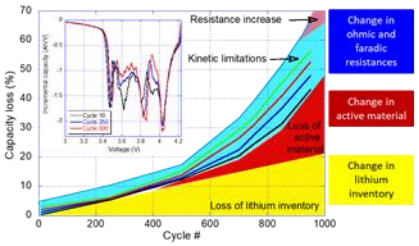


Battery Durability and Reliability Under Grid Operations

Matthieu Dubarry

matthieu@hawaii.edu

SCHOOL OF OCEAN AND EARTH SCIENCE AND TECHNOLOGY
UNIVERSITY OF HAWAI'I AT MĀNOA

HNEI
Hawai'i Natural Energy Institute
University of Hawai'i at Mānoa

1680 East West Road, POST 109, Honolulu, HI 96822

Ph: (808) 956-2349 ● Fax: (808) 956-2336

UH Materials Science
Consortium for Research and Education
CoRE

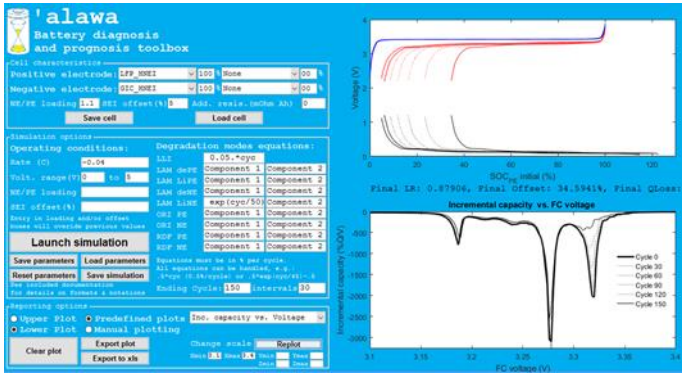
HiSERF

HNEI PakaLi Battery Laboratory

HNEI
Hawai'i Natural Energy Institute
School of Ocean and Earth Science and Technology
University of Hawai'i at Mānoa

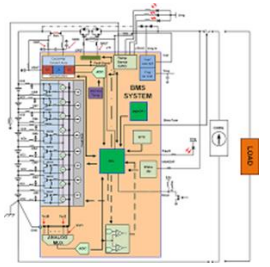
Diagnosis and Prognosis

- 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)

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.

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

Reduce further oil consumption
Reduce emissions
Additional storage for the grid

Hawaii Clean Energy Initiative

Battery powered transportation in Hawaii

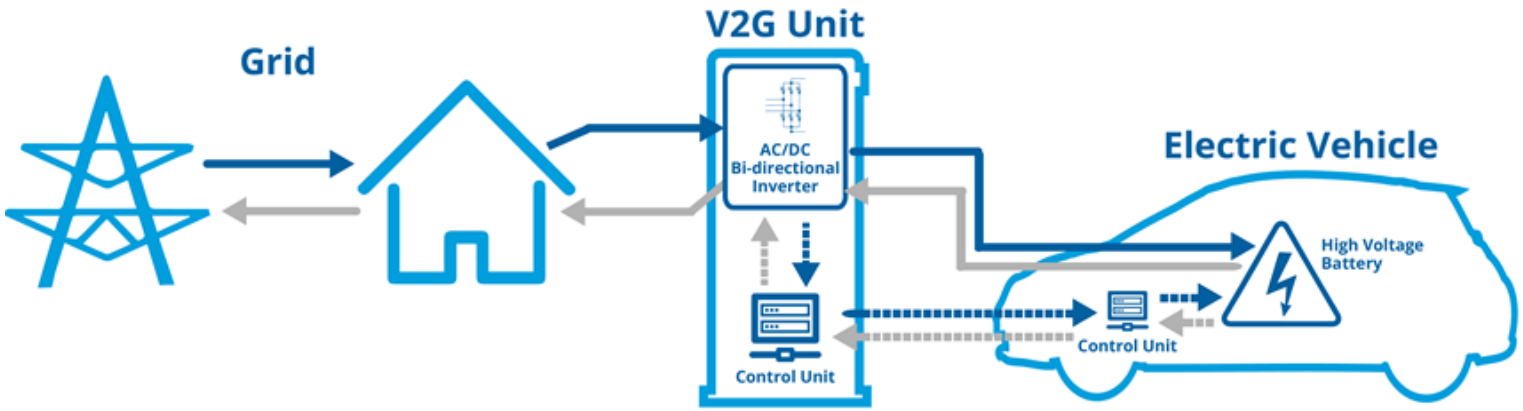
Hawaii grid storage (as of 2017) ~ 40 MW & 30 MWh

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

http://evinfo.info/nissan-revive-car-to-grid-plan-with-enel/

The complexity of battery diagnosis

Path dependence of the degradation

Traffic

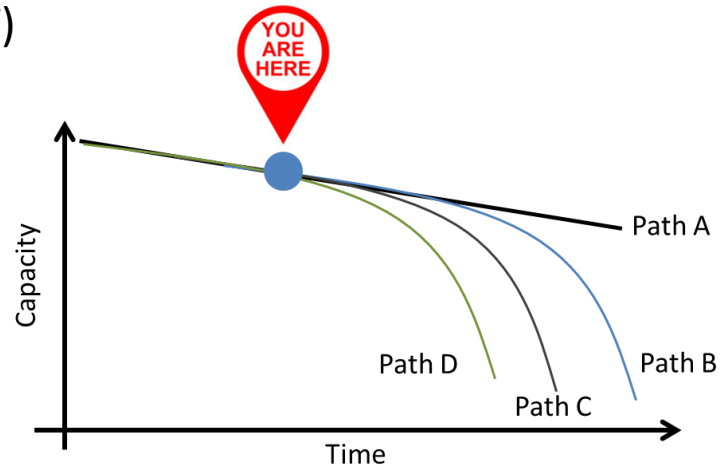
Road type

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

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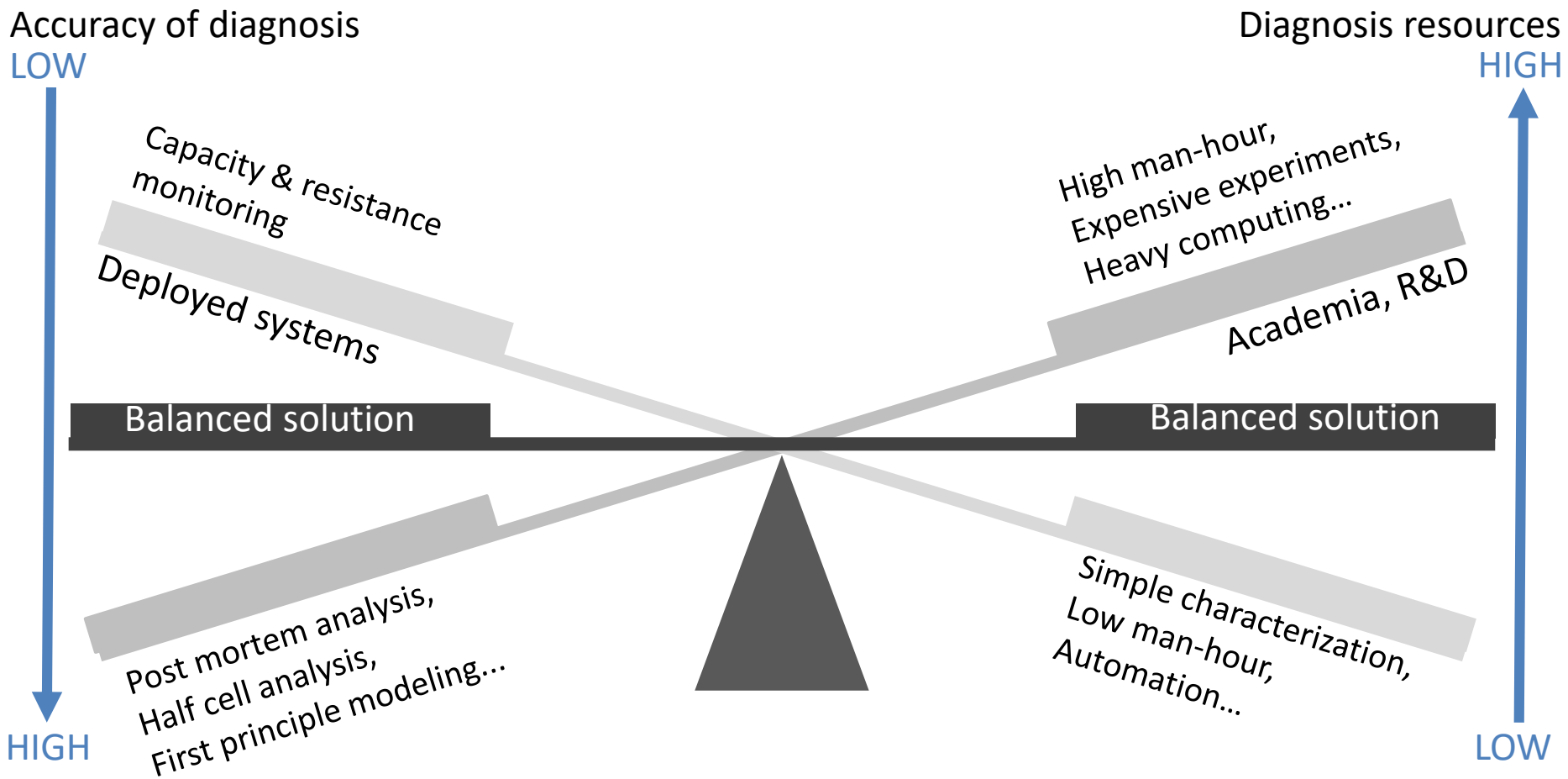
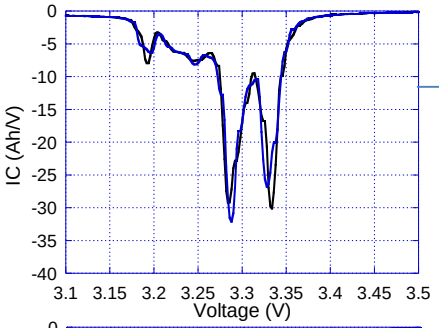
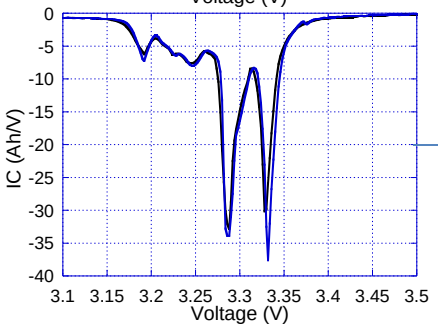
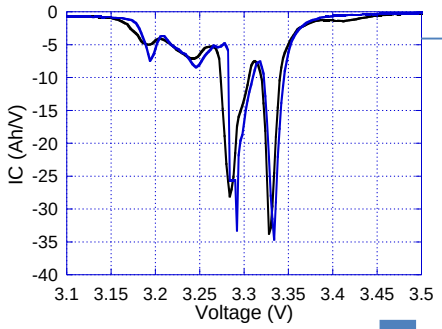
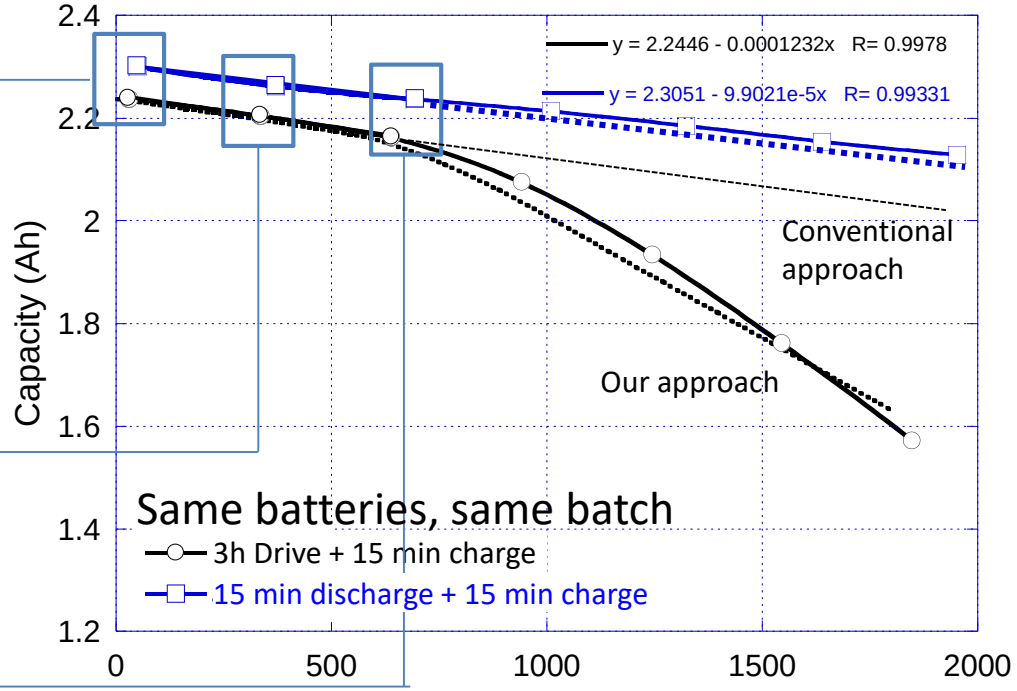


Diagnosis to Prognosis





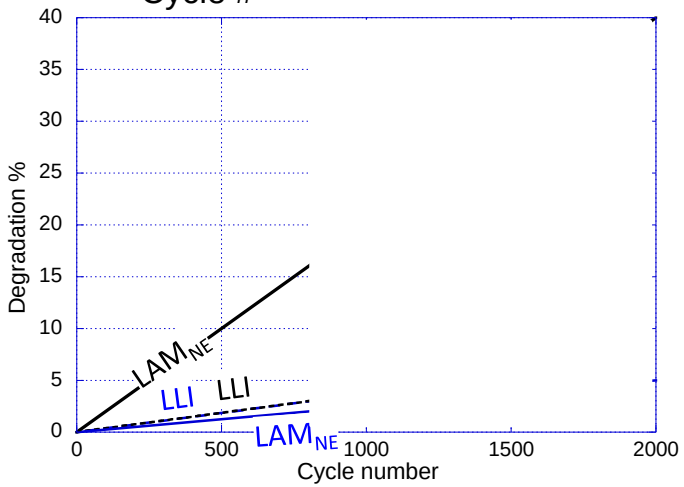




We then use that knowledge to predict what will happen to the cell

To understand the degradation from a material stand point

We study voltage variations



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

D. Ansean, M. Dubarry et al., *J. Power Sources,* **356** (2017), 36.

HNEI methodologies

‘alawa

100 registered users from >50 organizations worldwide

Idaho National Laboratory

Sandia National Laboratories

BROOKHAVEN NATIONAL LABORATORY

AIST NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)

Imperial College London

UNIVERSITY OF OXFORD

National Electric Vehicle Sweden

saft

ATL

SHARP

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

Grid-tied Storage

Monitoring of 3 grid-tied systems (≥ 1MW)

Laboratory testing of single cells (similar to the one in large batteries)

> 80 battery tested under different conditions

Vehicle Storage

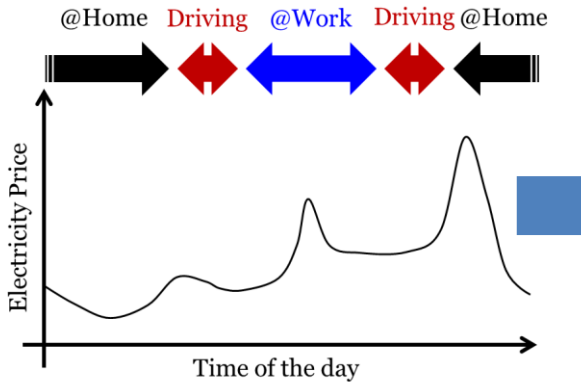
Study impact of vehicle to grid usage on EV battery degradation

Laboratory testing of single cells (similar to the one in EVs)

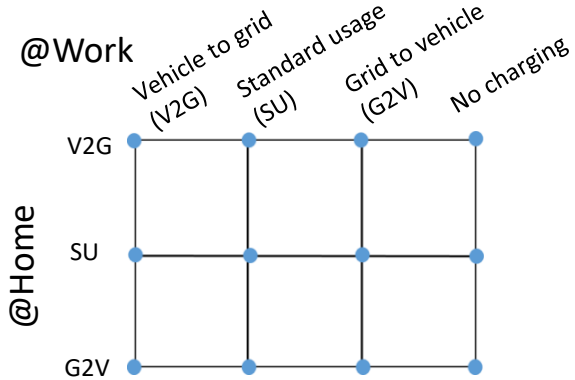
> 100 battery tested under different conditions

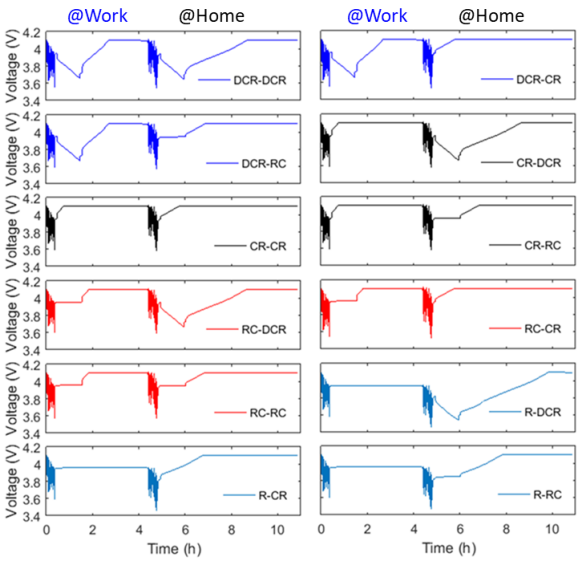
EV Cell Degradation under Electric Utility Grid Operations

Design of experiment methodology: cycle and calendar aging

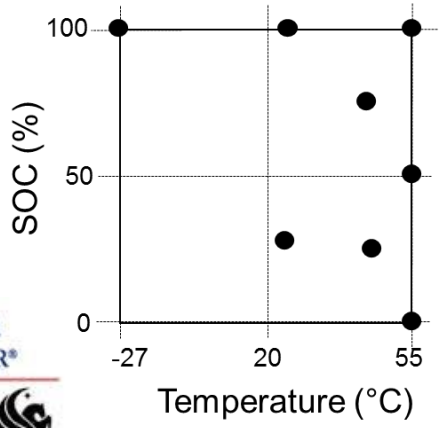


Cycle aging experiment





Calendar aging experiment



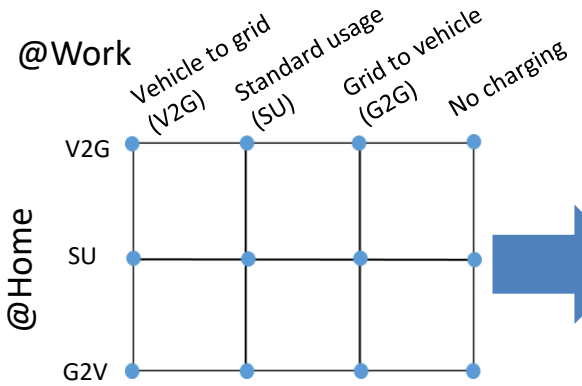
Electric Vehicle Transportation Center

Florida Solar Energy Center®
A Research Institute of the University of Central Florida

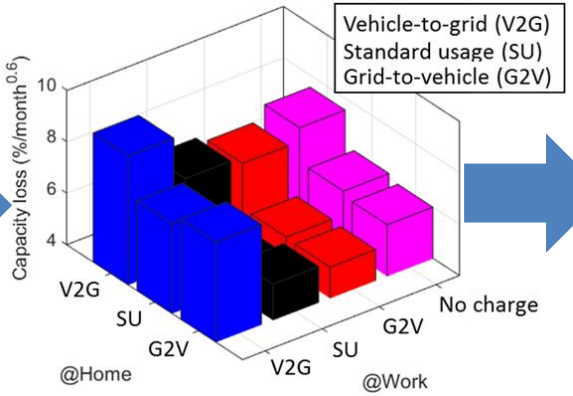
Dubarry et al., J. Power Sources 358 (2017) 39-49

EV Cell Degradation under Electric Utility Grid Operations

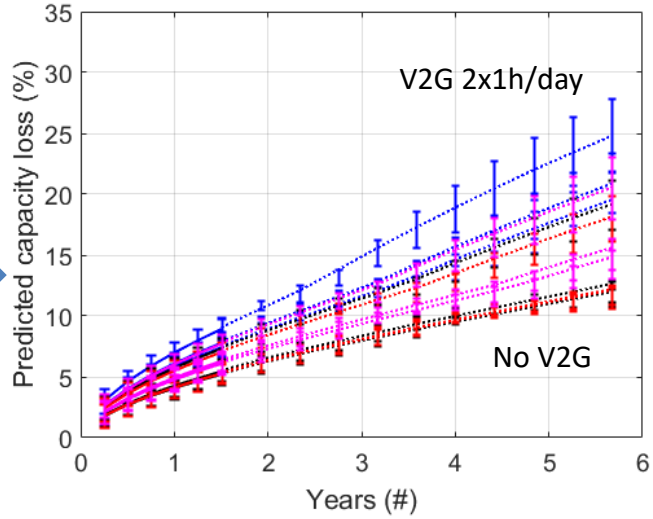
Cycle aging experiment



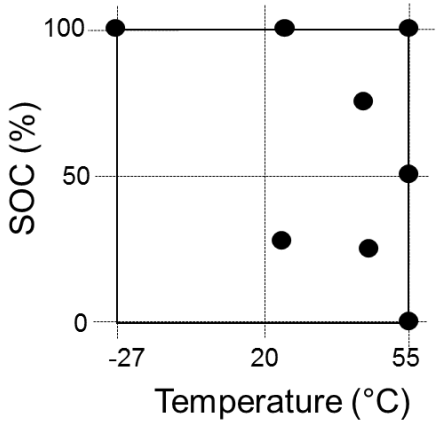
Results:
V2G 2x1h/day @ P/4 : +75% capacity loss
V2G 1h/day @ P/4 : +33% capacity loss
Charging 2x/day vs. 1x/ day: -5% capacity loss
SU vs. G2V : no significant effect

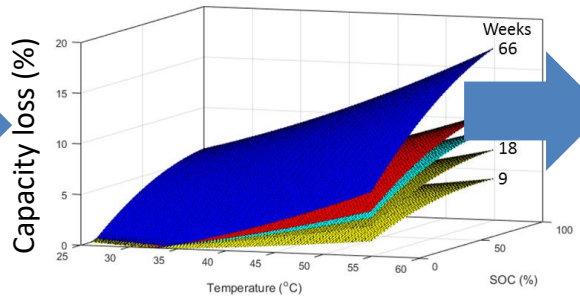


Prognosis:
V2G strategy drastically reduces durability
G2V might be beneficial in warm climates

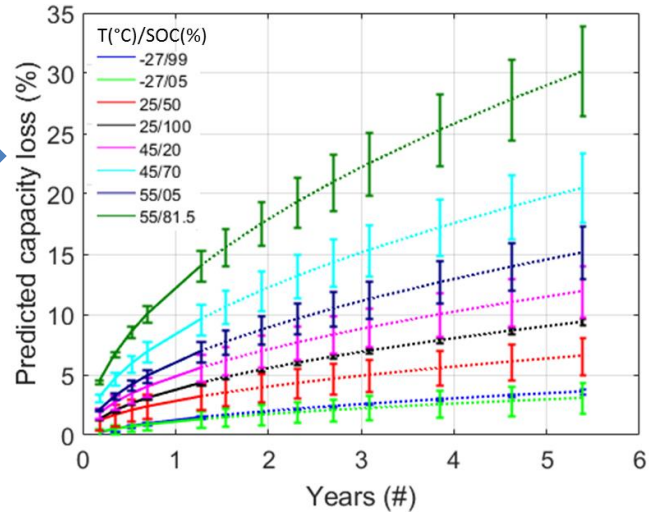


Calendar aging experiment





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



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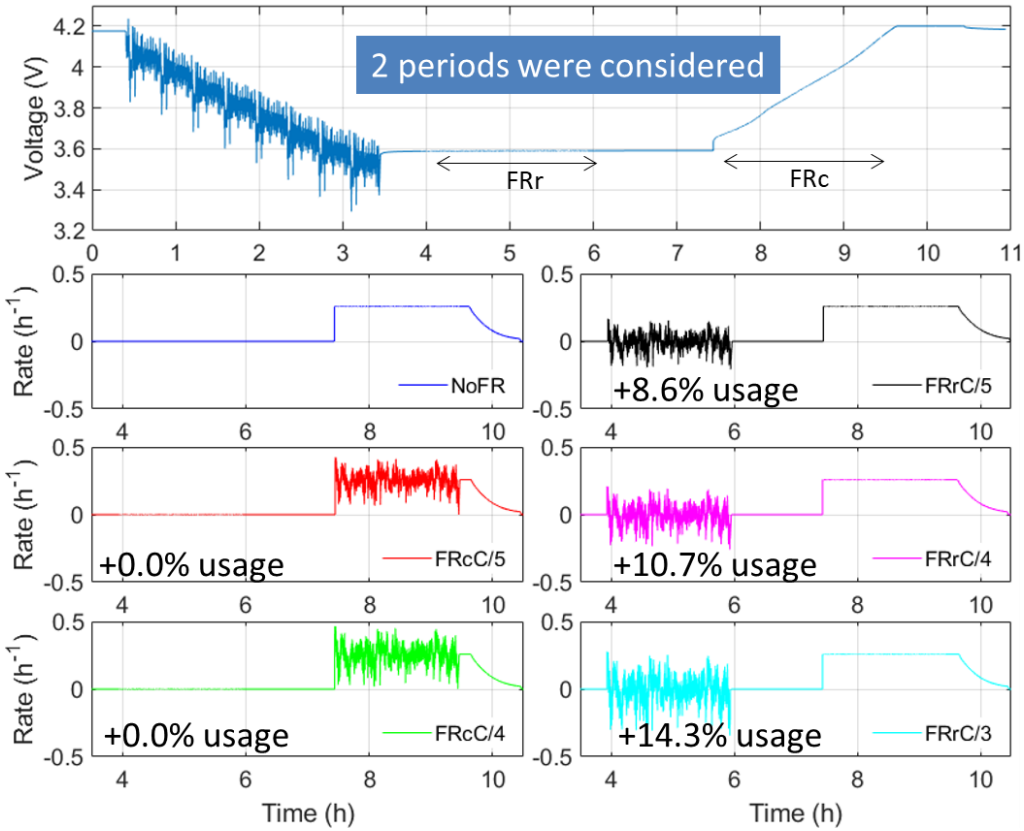
Impact of Frequency Regulation Usage on Cell Degradation

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

Energy Policy 113 (2018) 342–347

Acknowledgments

My students, especially Arnaud Devie and Cyril Truchot

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Mahalo for your attention! Questions ?

HNEI
Hawai'i Natural Energy Institute
University of Hawai'i at Mānoa

matthieu@hawaii.edu