

Paper No: 20PESGM0752



Energy Management System for DC Microgrids Considering Battery Degradation

Fulong Li, Claudio Cañizares, Zhengyu Lin

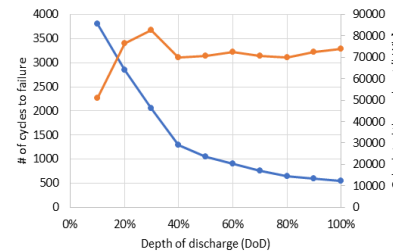
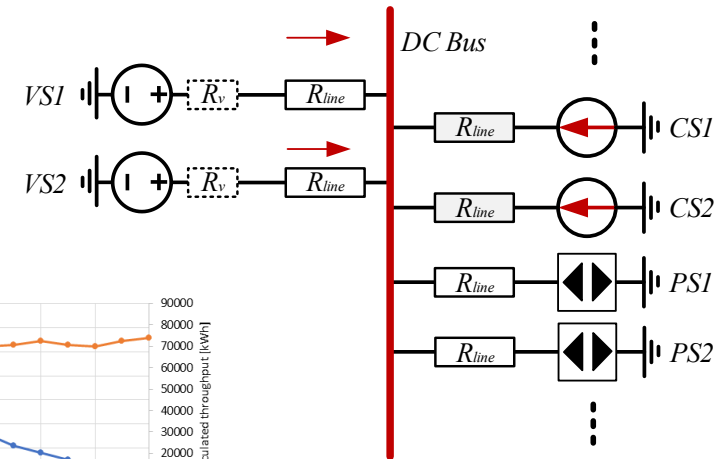
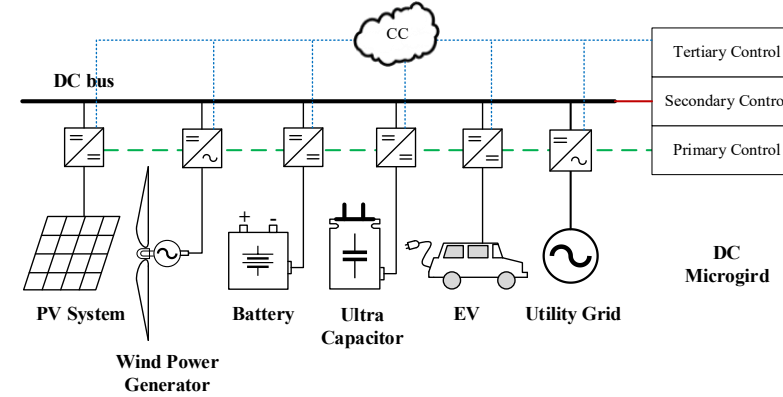
Loughborough University, University of Waterloo, Loughborough University

f.li@lboro.ac.uk

This work has received funding from the U.K. EPSRC UKRI Innovation Fellowship scheme under grant No. EP/S001662/1, and the European Union's Horizon 2020 research and innovation programme under grant agreement No.734796. Funding from the Natural Sciences and Engineering Research Council (NSERC) of Canada is also acknowledged.

Introduction & Background

- DC Microgrids
 - Battery Storage
- Energy Management System
 - Battery Degradation



EMS Model

- Battery Degradation Model

$$\varphi = \frac{C_{rp}}{E_{lc}} = \frac{C_{bu} \cdot E_b}{2 \cdot \mathcal{L}_b(DoD) \cdot E_b \cdot DoD} = \frac{C_{bu}}{2 \cdot \mathcal{L}_b(DoD) \cdot DoD}$$

$$C_{dg} = \sum_{\Delta t} \varphi \cdot (P_{bat,t}^{dc} + P_{bat,t}^c) \Delta t = \sum_{\Delta t} \frac{C_{bu}}{2 \cdot \mathcal{L}_b(DoD) \cdot DoD} (P_{bat,t}^{dc} + P_{bat,t}^c) \Delta t$$

- Objective Function

$$C_t = \min \sum_{\Delta t} [\alpha \cdot \xi_{g,t}^{dc} P_{g,t}^{dc} + (1 - \alpha) \cdot \varphi (P_{bat,t}^{dc} + P_{bat,t}^c)] \Delta t$$

- Other Constraints

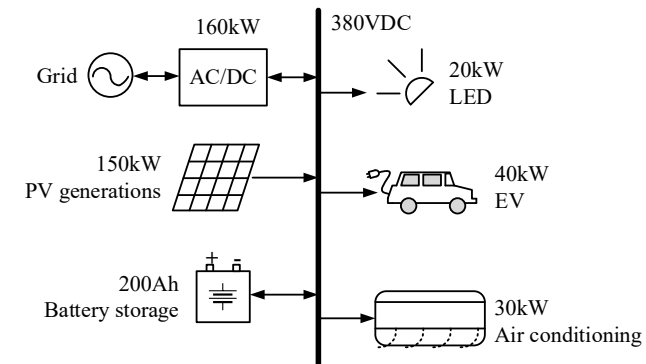
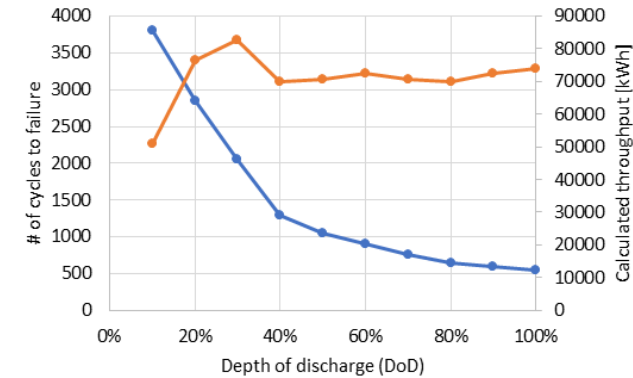
$$SoC_{bat,t} = SoC_{bat,t-1} + \left(\eta_c P_{bat,t-1}^c - \frac{P_{bat,t-1}^{dc}}{\eta_d} \right) \Delta t$$

$$SoC_{bat,min} \leq SoC_{bat,t} \leq SoC_{bat,max}$$

$$P_{bat,min}^c \leq P_{bat,t}^c \leq P_{bat,max}^c \quad P_{bat,min}^{dc} \leq P_{bat,t}^{dc} \leq P_{bat,max}^{dc}$$

$$P_{g,t}^{dc} \cdot P_{g,t}^c = 0 \quad P_{bat,t}^{dc} \cdot P_{bat,t}^c = 0$$

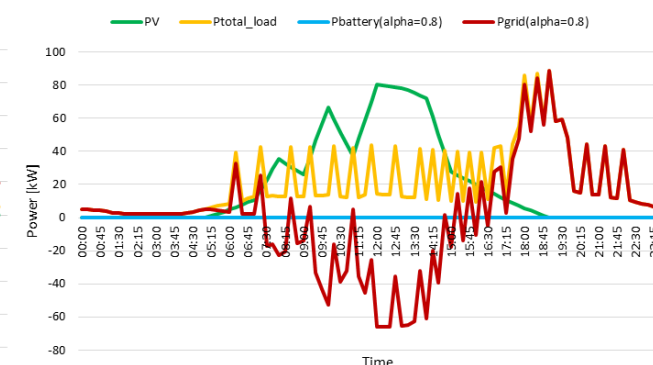
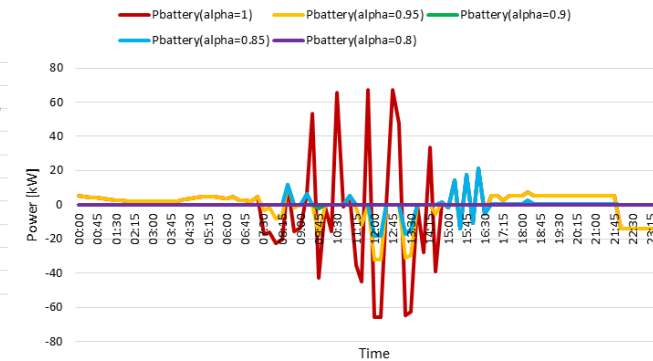
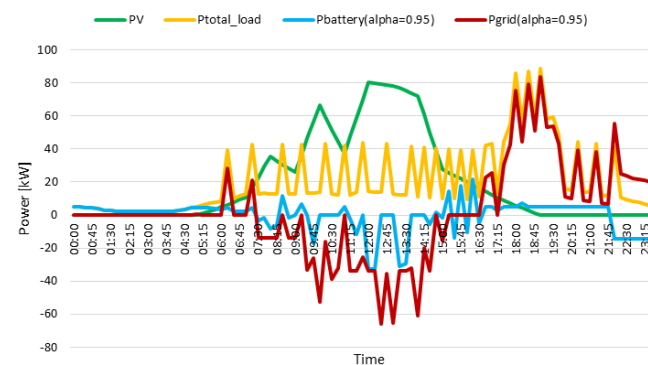
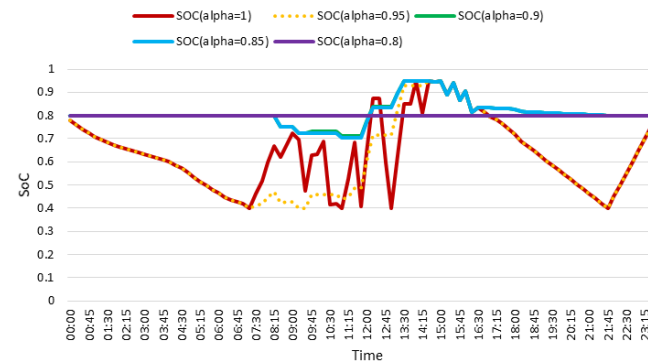
$$P_{bat,t}^{dc} + P_{g,t}^{dc} + P_{PV,t} = P_{EV,t} + P_{AC,t} + P_{LED,t} + P_{bat,t}^c + P_{g,t}^c$$



Results

- Change the weighting factor α can adjust the participation degree of battery power in the energy dispatch.

Parameter	Value
$SoC_{initial}$	80%
DoD	60%
$SoC_{bat,min}$	$1 - DoD$
$SoC_{bat,max}$	95%
$P_{bat,max}^d$	67.2kW
$P_{bat,min}^d$	0
$P_{bat,max}^c$	67.2kW
$P_{bat,min}^c$	0
η_c	95%
η_d	90%



Conclusions & Future Work

- An EMS considering battery degradation is proposed.
- The results match the expectations that proposed EMS can reduce the battery storage participation in a DC microgrid and thus increase its lifespan.
- Considering EVs and air conditioning loads as dispatchable loads in the future work.

Thank you!