Paper No: 20PESGM0752

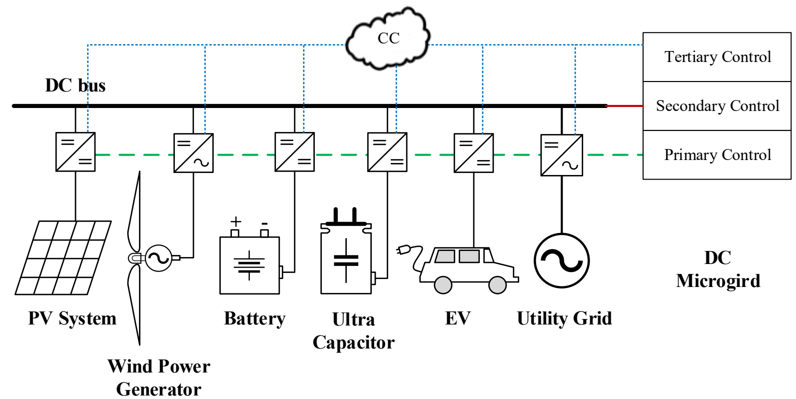
Energy Management System for DC Microgrids Considering Battery Degradation

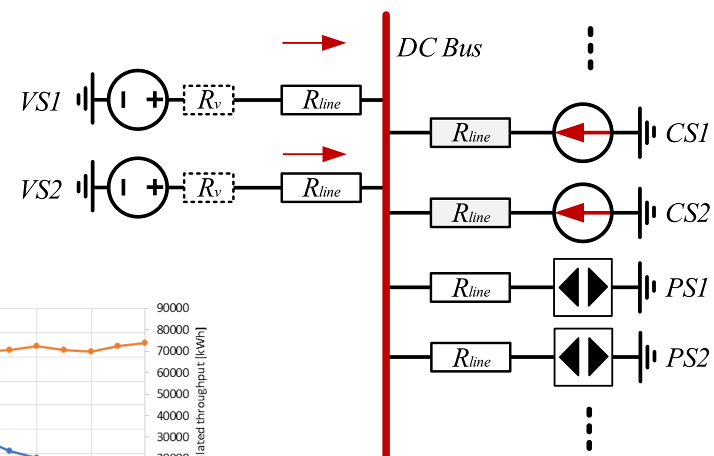
Fulong Li, Claudio Cañizares, Zhengyu Lin
Loughborough University, University of Waterloo, Loughborough University
f.li@lboro.ac.uk

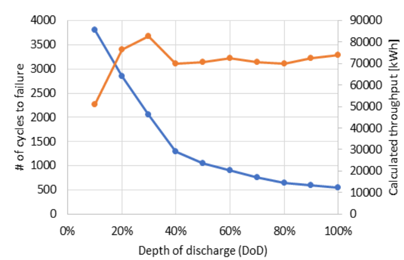
This work has received funding from the U.K. EPSRC UKRI Innovation Fellowship scheme under grant No. EP/S001662/2, and the European Union's Horizon 2020 research and innovation programme under grant agreement No.734796. Funding from the Natural Sciences and Engineering Research Council (NSERC) of Canada is also acknowledged.

Introduction & Background

- DC microgrids:
  - Various DERs, especially battery storage systems.
  - DC/AC loads.
  - Grid connection (no always).
- Energy Management System (EMS):
  - Defines controllable DER and load dispatch decisions.
  - Battery degradation should be considered.





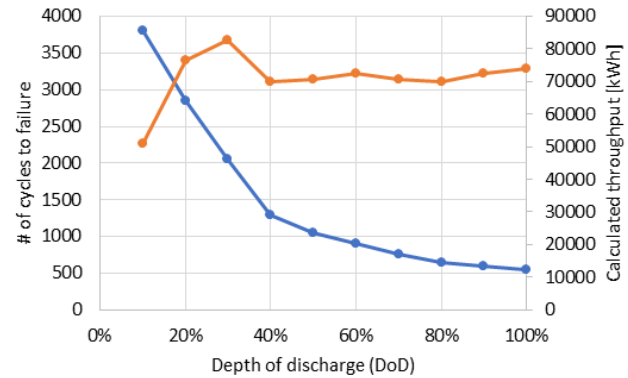


EMS Model

- Battery degradation model:

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

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



- Objective function:

$$\mathcal{C}_t = min \sum_{\Delta t} [\alpha \cdot \xi^{dc}_{g,t} P^{dc}_{g,t} + (1-\alpha) \cdot \varphi(P^{dc}_{bat,t} + P^{c}_{bat,t})]\Delta t$$

- Other constraints:
  - SOC:

$$SoC_{bat,min} \le SoC_{bat,t} = SoC_{bat,t-1} + \left(\eta_c P^{c}_{bat,t-1} - \frac{P^{dc}_{bat,t-1}}{\eta_d}\right)\Delta t \le SoC_{bat,max}$$

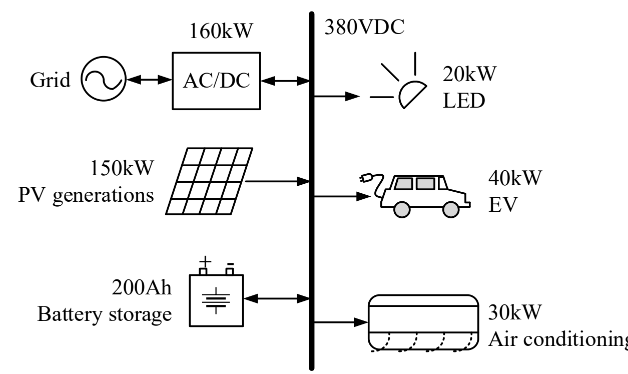
  - Charging and discharging:

$$P^{c}_{bat,min} \le P^{c}_{bat,t} \le P^{c}_{bat,max} \qquad P^{dc}_{bat,min} \le P^{dc}_{bat,t} \le P^{dc}_{bat,max}$$

$$P^{dc}_{g,t} \cdot P^{c}_{g,t} = 0 \qquad P^{dc}_{bat,t} \cdot P^{c}_{bat,t} = 0$$

  - Power balance:

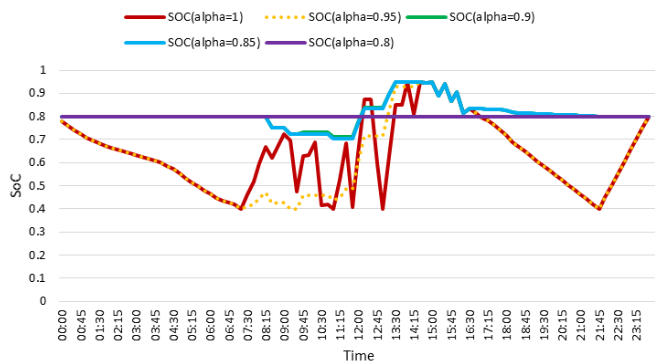
$$P^{dc}_{bat,t} + P^{dc}_{g,t} + P_{PV,t} = P_{EV,t} + P_{AC,t} + P_{LED,t} + P^{c}_{bat,t} + P^{c}_{g,t}$$

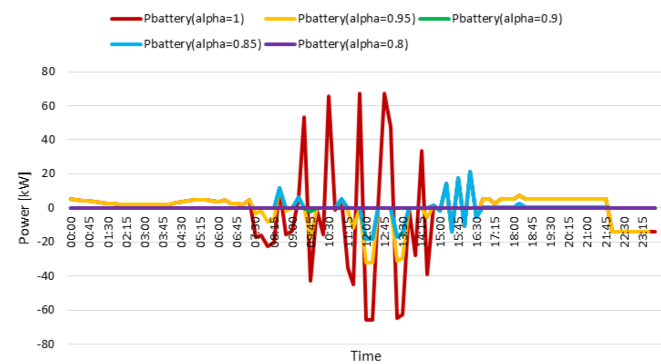


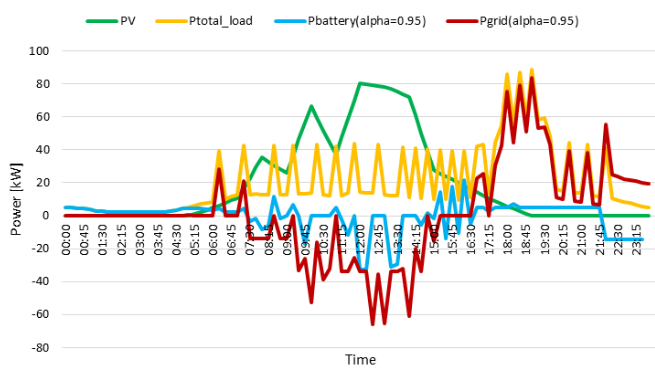
Results

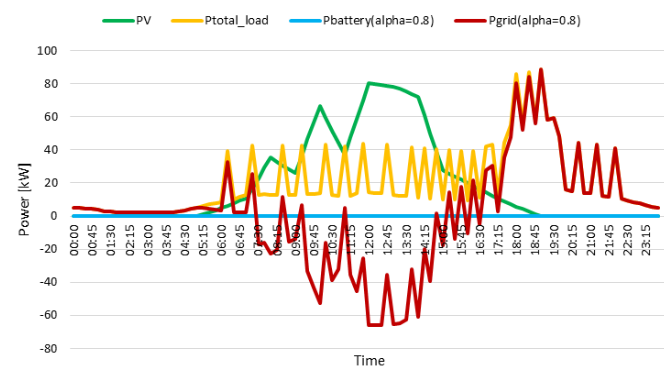
- Weight factor α adjusts the amount of battery power in the energy dispatch:

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









Conclusions & Future Work

- An EMS for a dc microgrid considering battery degradation has been proposed.
- The EMS reduces the battery storage participation in a dc microgrid and thus increases its lifespan.
- To consider dispatchable loads such as EVs and air conditioning loads in future work.

Thank you!