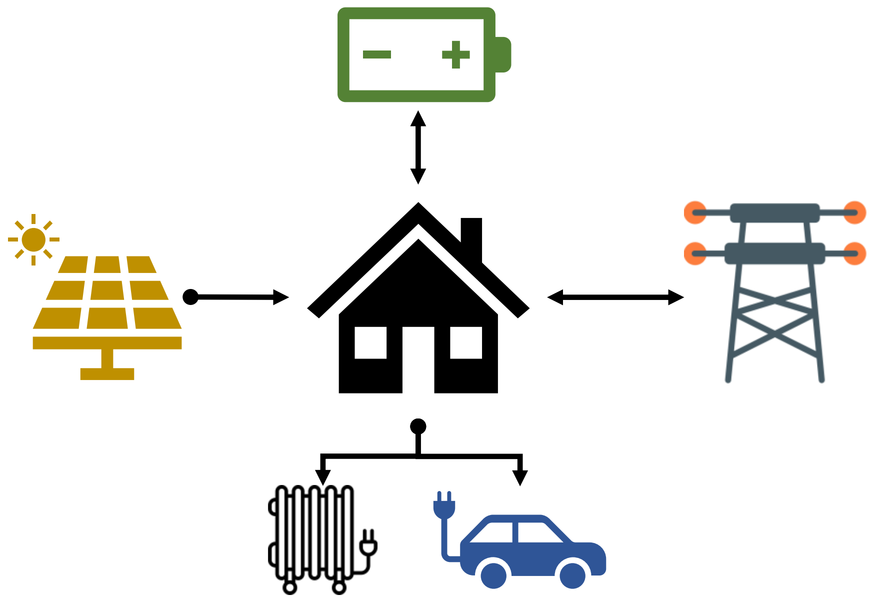
Residential Battery Management Tool (RBMT)

Version 1.3 (12/2020)



Developed

by

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This work is part of SPIRE 2 project (Storage Platform for the Integration of Renewable Energy), supported by the European Union's INTERREG VA Programme, managed by the Special EU Programmes Body (SEUPB). The views and opinions expressed in this document do not necessarily reflect those of the European Commission or the SEUPB.

1. Introduction:

Behind the meter battery energy storage systems are attracting more customers due to their ability to achieve a profitable energy arbitrage in the presence of heat-pumps, electric vehicles (EV) and solar photovoltaics (PV) with time of use tariffs. From the distribution system operator's perspective, these units can be utilized to support the network, especially with the rapid deployment of microgeneration and the electrification of transportation and heat. This code contains three different management strategies for the residential behind the meter batteries (BESS) in order to maximize the customer's profitability and enhance the network performance.

The three algorithms are briefly explained as:

1- Conventional Rule-Based Algorithm (CRBA): This is the conventional method of (dis)charging the BESS according to upper and lower thresholds that maximizes the customers profitability only through maximizing the PV self-consumption.
2- Proposed Day-Ahead Scheduling Algorithm (PDSA): This is an optimization-based algorithm aims to optimize the electricity bill and load variance using the WORHP solver. Optimizing the load variance supports the network through flattening the household net profile.
3- Proposed Rule-Based Algorithm (PRBA): This is a rule-based algorithm that does not require any optimizer however, it optimizes the electricity bill and load variance according to a set of inputs.

This tool can be used to generate the power dispatch of residential batteries (with any specifications) to minimize the household's electricity bill for any time series data (single day to multiple years) with any temporal resolution. The outputs of the RBMT are:

1. The net household demand.
2. Electricity bill with and without the battery.
3. Battery power dispatch.
4. Battery state of charge.
5. Battery degradation.
6. Household's voltage.
7. Household's losses.

Two plots are developed after the program converges: 1) the net demand with the battery state of charge; 2) the battery degradation.

This tool was validated and detailed in a submitted paper titled 'Domestic Battery Power Management Strategies to Maximize the Profitability and Support the Network', authored by Ahmed A.Raouf Mohamed, Robert J. Best, Xueqin Liu, and D. John Morrow. School of Electronics, Electrical Engineering and Computer Science, Queen's University Belfast.

2. Guide:

The tool has three MATLAB files and one excel file, described as:

BESSMA.m	Used to enter the tool inputs and run the tool.
data.m	Used to enter the time-series profiles of household demand, PV, and EV.
MAINCODE.p	Main file contains the algorithms.
Results.xls	Excel template for the results. Results are saved in this file.

In order to run the code, the required inputs are detailed as follows:

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- The household profiles should be entered in any data resolution in the file (data.m) in the following format:

Demand (kW) (first column)	PV (kW) (second column)	EV (kW) (third column)

- These data can be copied directly from excel/CSV file, all values should be positive.
- To add measurements of a heat pump, please add their values to the demand (sum) in first column.

- Use BESSMA.m, to run the code. The inputs for the (BESSMA.m) are described in the following table:

Main Inputs	
`SaveR`	To save the data in excel sheet: 1 will save in Results.xls, other values will not
`Prog`	Selects the required algorithm: 1 for CRBA, 2 for PDSA, and 3 for PRBA
`DataRes`	Data resolution in minutes: 10 for 10 minutes, 30 for 30 minutes, 60 for 1 hour
BESS Inputs	
`BESS`	Actual Battery Capacity [kWh]
`DOD`	Maximum depth of discharge in fraction (0 to 1)
`SOCMAX`	Maximum state of charge (0 to 1)
`BESSP`	Maximum rating of the BESS [kW]
`RE`	BESS System efficiency = BESS Efficiency ($\sqrt{roundtrip\ efficency}$) $\times$ Inverter/Charger Efficiency
`SOCI` *(v 1.1)*	Initial value of SOC that the simulations will start with, default=minimum SOC
Time of use tariff inputs (The algorithms are developed for the double tariff rates of UK)	
`SC` *(v 1.3)*	Standing charge [p/day]
`HR`	High rate value (day rate) [p/kWh]
`LR`	Low rate value (night rate) [p/kWh]
`TLS`	Start hour of low rate tariff
`TLE`	End hour of low rate tariff
`EX`	Export tariff rate in [p/kWh]
`TPR`	Tariff daily profile, please insert the values of high rate (HR) and low rate (LR) at each hour according to your preference.
Network Details to calculate the losses and household voltage	
`VT`	Network Transformer voltage [V]
`PF`	Power factor
`R`	Resistance from the transformer to the household [Ohm]
`X`	Reactance from the transformer to the household [Ohm]
Program 1 (CRBA) Inputs	
`PTHD`	Upper threshold for discharging [kW]
`PTHC`	Lower threshold for charging [kW]
`PCN` *(v 1.2)*	A percentage of the BESS capacity to be charged using low tariff rate. Default = 0 (no charging during the low tariff period). It can be entered as a single value or different values for each day.
Program 3 (PRBA) Inputs	
`EVS`	EV charger rating [kW]
`AVGD`	Average daily consumption [kWh]
`Season`	The PV seasons (1 for high PV season / summer, 0 for low PV season / winter)
`PTHDn`	Normal upper threshold for discharging [kW]
`EVA`	Average EV charging hours
`EVC`	Electric vehicle status, if the EV will be charged next day EVC=1, otherwise, EVC=0
`FPV`	Forecasted PV daily generation
`PVL`	Forecasted of number of PV hours calculated from the start time of PV (`PVS`) and the end time of PV (`PVe`)

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- To use the PDSA, the WORHP solver require to be installed in your machine. You can download the solver and request the License from this Link: https://worhp.de/. After the installation completes according to the WORHP guide, please copy the license file (worhp.lic) and the XML file (worhp.xml) to this folder or add it to the MATLAB directory.
- The electricity and export tariffs are entered in British pence / kWh. However, it can be changed to different currency according to the country regulations and tariff structures.
- The main code content is obscured in the file (MAINCODE.p). After publication, this code will be revealed as an open source.
- More details on the work implemented in this code will be available soon through a published paper (see citation [1]).

3. Download and licensing:

The RBMT is available for free download from (https://github.com/ARa2of/Behind-the-Meter-BESS-Management-Strategies-). This open source simulation tool is published under the MIT-License.

4. Citation:

- If you will use this tool in work for a publication, please cite the following papers:

A. If you used any part of this code, please cite this paper:

[1]. A. A. R. Mohamed, R. J. Best, X. Liu, and D. J. Morrow, 'Domestic Battery Power Management Strategies to Maximize the Profitability and Support the Network', p. 5. (**The exact Proceedings will be added soon**)

B. If you used the optimization-based algorithm (PDSA), please cite the following paper in addition to paper number [1]:

[2]. C. Büskens and D. Wassel, 'The esa nlp solver worhp', in Modeling and optimization in space engineering, Springer, 2012, pp. 85–110

C. If you used the BESS degradation results, please cite the following paper in addition to paper number [1] and (paper [2] in case of using the PDSA):

[3]. B. Xu, A. Oudalov, A. Ulbig, G. Andersson and D. S. Kirschen, "Modeling of Lithium-Ion Battery Degradation for Cell Life Assessment," in IEEE Transactions on Smart Grid, vol. 9, no. 2, pp. 1131-1140, March 2018, doi: 10.1109/TSG.2016.2578950

5. Contact Details:

For any inquiry or bug/issue reporting, please use the following emails: Ra2ooof@gmail.com / amohamed06@qub.ac.uk / ahmed.raouf@aast.edu

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