7 kWh energy management

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The rest of the paper is ordered as: In the subsequent section, the system under investigation is described, and the modeling of its components is presented. The suggested bi-level EMS and the used recent optimization algorithm (CHIO) are introduced in "Bi-level energy management strategy" section. "Simulation results" section provides an analysis and discussion of the simulation results obtained. Finally, the last section presents the conclusion derived from the results.

An important first step in energy management is precise modelling, because the optimization algorithm uses it in order to determine the optimal dispatch decisions. Distributed energy sources in the MG and their related constraints are modelled in the following subsections.

The output power of a wind farm, which consists of Nw wind turbines at any given time t (PWT(t)), is proportional to the prevailing wind speed (Vt) and can be calculated, as shown in Eq. (2). The wind speed is measured over a 24-h period, taking into account the minimum wind speed required to start the turbine (cut-in wind speed) and the maximum wind speed required to stop the turbine from running (cut-out wind speed)28:

where PBESS (t) is the net power produced by the battery (PBESS,dis - PBESS,ch), CCbat is the capital cost of the battery, Ncycle is the number of battery life cycles and Cdeg is a factor to penalize the high stress during the charging and discharging process that causes the batteries to deteriorate.

The proposed EMS aims to achieve the optimal power sharing between DG, BESS and the grid to meet the system load demand and achieve MG economic dispatch. The objective function of the suggested EMS is to minimize the microgrid''s daily operating cost (COP_MG), and it is formulated as follows:

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