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Battery Energy Storage System' Sizing in Microgrid: Review Paper

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Abstract
Micro grid is a small size power system consisting renewable & non-renewable energy resources and energystorage devices. A Battery Energy storage (BES) system isan important component of microgrid that enhances the stability and reliability of the micro grid. Total cost of BES includes one-time investment cost and annual maintenance cost. The investment cost of BES depends upon its size. If the size of BES is more than optimal than it will increase the investment cost whereas the size less than optimal will not satisfy the economic target of the microgrid. Therefore it is essential to know the best size of BESso that additional installation cost. In the presented review paper sizing of BES in both grid connected and isolated has been studied.

Keywords—Battery energy storage, Grid connected, Isolated, Microgrid, Optimal size.

I.INTRODUCTION

To mitigate the carbon emission and fulfil the ever increasing energy demand, renewable energy sources are used in power system to generate energy thus giving rise to the concept of microgrid. Microgrid is a small size electrical network with renewable (wind, solar, biomass) & non-renewable (fuel cell, micro-turbine, internal combustion engine) energy resources and energy storage [1-3]. Since renewable sources are intermittent by nature and power produced from them is uncontrollable, their increased penetration will have negative impact on the operation of microgrid. Battery energy storage (BES)is an effective solution to reduce output variations of renewable sources. BES stores the surplus power from renewable sources when demand is low and discharge it when demand is high [4]. Energy storage helps to increase the use of existing transmission & distribution equipment. In short run BES can control frequency & stability and for long duration BES can be used for energy management or reserves.

Microgrids can operate either independently or connected with main grid.In both modes Battery energy storage systems increases the microgrid flexibility and reliability [5].But the high investment cost of BESS and low cycle life limits its utilization in microgrid. The investment cost of BESS depends upon its size. If the size of BESS is more than optimal than it will increase the investment cost whereas the size less than optimal will not satisfy the economic target of the microgrid. Therefore it is essential to know the best size of BESso that the additional installation cost can be avoided [6].

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II. LITERATURE SURVEY

Optimal sizing problem of BES for both modesof microgrid is studied in many literatures.

A. Standalone Mode

Sizing of microgrid in standalone mode has been studied in [7-21]. In standalone mode BESS primary aim is to continue the reliability of microgrid. [7-8] determines the best size of BES for frequency regulation in isolated microgrid. In these papers, the economic viability of using BESS is not investigated and the BESS is mainly used for frequency regulation purpose. Sizing of BESS in isladed microgrid is done by coordinated dispatch strategy method based on discrete fourier transform in [9].In [10] Sizing of BES is determined based on particle swarm optimization with load shedding scheme for improving the system frequency after islanding. In [11] sizing of BESS is performed based on MILPmodel to minimize the net present cost.

For microgrid, how the energy cost is affected by BES of different sizes is examined in [12]. [13] determines the optimal size of hybrid energy storage system having battery and super capacitor. In [14] microgrid development model is presented to find out the size as well as technology of BES for an isolated microgrid. In research work [12-14] BES depth of discharge' effect on its lifetime was neglected that would cause battery replacement before it could reach the end of life.[15] determines the size of BES using an optimization model considering the impact of depth of discharge on lifetime of BES. In order to minimize the annual cost of microgrid size of BES is determined by using particle swarm optimization technique in [16]. Reliability and economic benefits of microgrid are improved by using a control strategy consistingtwo modes acting BES & diesel generator as master unit in each mode. [17] presented an optimal sizing based on triple objective optimization model for minimizing net present cost, emissions and unmet demand.In [18] BES supports the ancillary services and size of BES is regulated based on an optimization model for minimizing the NPV of total cost. The optimal year of BES installation is also determined. In these work sizing is majorly performed for lead-acid and li-ion batteries.[19] sizing of vanadium–redox battery is determined for both modes with the objective of minimizing cost and maximizing benefits of microgrid.[20] determines the size of HES consisting SC, li-ion and lead-acid battery depending on their response speed to satisfy the critical and normal loads. By using the hybrid storage the replacement time of battery during microgrid project life is reduced. In majority of the research works lifetime characteristics of BES have not been fully considered. As the lifecycle of BES is usually short and cost is high, sizing results are not optimal especially for lead-acid battery. A novel energy scheduling approach is proposed in [21] to enhancebattery lifetime and optimize the operation cost of remote microgrid.In order to minimize cost of generation and battery life loss [22] presented multi-objective model for sizing the BES. lead-acid battery' lifetime is supposed to be increased.

B. Grid-Connected Mode

In order to minimize the annual cost of the system with zero unmet load and maximize the use of PV system [23] proposed an iterative techniquefor sizing BES. Decision variable are size of PV generation &capacity of BES. With the aim of minimizingthe cost considering battery capacity loss and net power purchased from the grid sizing of BES is determined for PV grid-connected system in [24]. In [25]optimal size of Li-ion battery is determined by predicting the stochastic nature of renewable generation using time-series model. The result produced is optimal only for the applied time-series pattern not for the other possible patterns. Optimal size of BES is determined by using Genetic algorithm in [26]. Since the BES size has great impact on energy management strategy (EMS), to determine the power output of BES author optimizes BES &EMS(fuzzy expert system based). With the aim of maximizing the profit dynamic economic dispatch problem is solved by applying dynamic programming to determine size of BESin [27]. To handle uncertainty in wind speed and load forecasting errors are considered.A stochastic optimization model is solved in GAMS environment in [28] for sizing BES. Uncertainty in wind speed was tackled by using monte carlo simulation. Loss of load expectation & expected energy not served indices are used to improve reliability of hybrid microgrid. Based on net present value, optimum capacity of BES is

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determined in [29] by applying self adaptive bee swarm optimization (SBSO) algorithm. Lead-acid & vanadium-redox battery were taken for comparative analysis and VRB is proved more cost effective than LAB on the basis of one year NPV.

Siting and sizing of BES is done by using artificial bee colony algorithm in [30]. To dispatch the wind power effectively sizing of BES is analyzed in [31] by using Bat optimization algorithm. Grey wolf optimization technique is applied in [32] to optimize BES size. The objective is to minimize the total cost of the hybrid microgrid. The performance of the proposed technique is good in comparison to other existing optimization techniques like genetic algorithm [26], particle swarm optimization [33], tabu search, bat algortithm etc.

Distributed generation and Energy storage both are optimized simultaneously in medium voltage microgrid in [34].Grid connected hybrid system' sizing is performed by using Homer software in [35-36].[37] investigated the operation of grid connected

PV-battery system in which the best size of BES is determined. [38] presented a new energy management technique to find optimal size of BES. To handle uncertainty in wind generation a stochastic optimization model is presented in [39] to find out best size of BES.With the aim of minimizing total cost as well as emission [40] presented a joined PSO and Technique for Order of Preference by Similarity to Ideal Solution (PSOTOPSIS) technique to determine the size of li-ion battery.[41] proposed a two stage probabilistic model to jointly optimize the storage as well as reserve.

With the application of demand side management in microgrid optimal size of BES is determined in [42-44]. [42] presented a stochastic optimization model for sizing the components of residential microgrid considering demand response program of controllable house appliances. The author also examined the impact of demand flexibility on component sizing. In this work author used electric vehicle as load only. A bi-level optimization model is solved using e-constraint method to optimally site and size BES in [43]. Demand response program flatten the load curve giving reduced operating cost of microgrid. With the aim of minimizing the annual cost & maximizing the customers' satisfaction a dual objective optimization model is formulated in [44-47] considering demand side management for sizing of distributed generators and BES.

CONCLUSION

Microgrid is a small sized power system consisting renewable and non-renewable energy resources and energy storage system. Microgrid can operate either independently or connected with main grid. In both modes battery energy storage (BES) plays an important role. Improper size of BES will either increase the investment cost or will not serve the economic target of microgrid. Therefore optimal sizing of BES is essential to be determined for the operation of microgrid. This paper presents the literature review of past research work in which sizing of BES has been studied for microgrid in standalone & grid-connected mode.From the research studies it was found that by using BES of optimal size total cost is decreased in standalone microgrid and total benefit is increased in grid-connected microgrid. For size greater than optimal total cost will increase in standalone mode and total benefit will decrease in grid connected mode.

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