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IDEAL DIMENSIONS OF BATTERY ENERGY STORAGE FOR GRID-CONNECTED AND ISOLATED WIND-POWERED MICRO-GRID

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Abstract: Renewable energy (RE) sources, particularly wind and solar are gaining more popularity due to their inherent benefits. Consequently, nations have set ambitious goals to enhance the penetration of RE into their energy-requirements. However, the Renewable Energy sources especially wind and photovoltaic sources are intermittent, uncertain, and unpredictable. Therefore, there is a need to optimize their usage when they are available. Moreover, energy storage system like battery energy storage has much potential to support the RE integration with the power grid. This study, therefore, investigates the sizes of battery energy storage required to support a grid- connected micro-grid and a stand-alone micro-grid for 12 months considering hourly wind power potential. In this study, we have considered three Scenarios of operations and have determined the BESS sizes and recommend the best based on the cost of operation. Scenarios 1 and 2 are grid-connected configuration while Scenario 3 is a standalone micro-grid supported with diesel generators. In each Scenario, the optimization problem is formulated based on the optimal operation cost of the micro-grids. The study evaluates and analyses the operational environmental effects and costs between the three Scenarios. The formulated problems are solved using the nonlinear optimization method.

I. Introduction

The ESS is a necessary component in micro grids. Micro grid is a small-scale intelligent power system and it is designed to function as large power system, which is supplying electrical energy to customers. Micro grids can be connected to a main grid or islanded. If a micro grid is connected to a main grid, it can exchange power by buying power from or selling to the main grid. Micro grids have several features such as distributed generators, energy storage systems (ESS), and controllable loads. Those features make micro grids more flexible and efficient than traditional centralized power systems. In addition, the existence of distributed renewable energy sources (RES), like solar photovoltaic or wind turbines, reduces the cost energy delivered to customers, due to the high reduction in operation and maintenance cost. For the stability and the effectiveness of micro grids, an ESS is critical. In the past few years, ESSs were improving and their price was decreasing, and it is expected to continue due to the attention it is receiving from the industry and academia. ESSs provide the grid with so many benefits, such as improving control, load following, peak load management, power quality improvement, voltage and frequency stability, and reducing the effects of intermittency of solar photovoltaic and wind turbine.

However, due to the relatively high cost of storage systems, we are trying to optimally size the storage system capacity with the most accurate modeling to justify its economic viability and further prevent over or underutilization. The topic of ESS is regularly visited. Research regarding ESS integration to the power system has several applications. Several papers studied ESS in a buying- selling mode, where ESS is used for energy trading in all forms. Another area of study is ESS providing auxiliary services. Lastly, ESS is integrated with renewable energy sources technologies transforming them to dispatch able and controllable generators capable of participating in the electricity market reviewed the integration of renewable distributed generators into a distribution system, and how they lower the cost of supplying energy. They also reviewed how renewable distributed generators are improving local reliability, power quality, and system emission. In [8], the author proposes a probabilistic approach for sizing a battery storage system with the aim of mitigating the net load uncertainty associated with the off- grid wind power plan, the sizing and control strategy co-optimization for an existing IPV power plant is proposed and implemented. A global linear programming (LP) optimization algorithm is developed, where the optimal components sizing is computed directly in the same optimization as the operating management of the storage system. Furthermore, in, the objectives are tailored towards locating, sizing and operation of energy storage devices in distribution systems considering a typical load curve on a horizon of 24 hours is presented. Proposed that incorporating renewable energy sources and ESSs enhance the reliability of a microgrid. Also, an analytical approach to determine the reliability-constrained size of a backup storage unit in a power system. The backup could be in the form of electrical energy storage or fuel storage.

Each of these applications of storage has different quality requirements and performance constraints. Moreover, a wide range of storage technologies are available today, each with unique performance characteristics, but none being able to meet the requirements of all applications. For instance, super capacitors provide very high power, but low energy capacity, making them unsuitable for off-grid micro grids. In contrast, compressed air storage provides high energy capacity but relatively lower power, making them unsuitable for loads with a high peak-to-average power ratio. This motivates us to design hybrid energy storage systems (HESS) that combine the beneficial features of several storage elements to satisfy the performance requirements of an application. The optimal design of an HESS must take advantage of the best features of the underlying storage elements and overcome their weaknesses.

II. Optimization Techniques Involved in Control Strategies

In remote areas (e.g. high mountains and Sea Islands), the fuel supply (e.g. coal and natural gas) is costly. Also, it could not be economical to expand the utility distribution networkto energise the remote users. On the other hand, these regions typically possess abundant natural resources, which proliferates the application of off-grid micro grids with hybrid renewable energy and flexible loads as a clean and sustainable alternative of power supply. In these off- grid micro grids, battery energy storage system (BESS) is essential to cope with the supply– demand mismatch caused by the intermittent and volatile nature of renewable energy generation. However, the functionality of BESS in off-grid micro grids requires it to bear the large charge/discharge power, deep cycling and frequent charging process, which may lead to non-negligible and irreversible degradation of storage capacities. Owing to the capacity degradation, the energy storage modules in micro grids will be replaced for several times. In addition to the capital investment, the expense of facility replacement is also a crucial factor in the economic measures of micro grid planning. Hence, the optimization of BESS investment and replacement (I&R) decisions should be fully considered at the planning stage of off-grid micro grids.

Generally, the main task of BESS planning contains the optimal sizing and type selection of storage modules, which has been extensively studied in current literature through either optimization methods. The design approaches of hybrid electrical energy storage (HEES), where the power processed by HEES was separated into the low-frequency and the high- frequency parts. In the proposed methods, the low-frequency part was levelled by energy storage batteries while the high-frequency part was compensated by the quick-response power storage devices. Adopted the wavelet analysis to make the investment decision of the hybrid energy storage system. Applied the discrete Fourier transform method to coordinate the sizing of BESS and diesel generators (DGs). Note that in a practical micro grid, the operation of BESSis highly correlated to the power generation of other distributed energy resources (DERs), e.g. wind turbines (WTs), solar panels and DGs. Thus, it is essential to coordinate the optimal configuring of BESS and other DERs (as generation sources), which could be hardly captured by the modelling in the aforementioned studies and require for more advanced optimization tools. Moreover, the component sizing has

a tight relation with many factors, e.g. the long-term trend of load demand, precise component modelling, different energy management strategies and component contingencies. The importance of utilizing accurate battery models in sizing standalone photovoltaic (PV) systems. The positive effect of demand response programs in component sizing. We note that the joint planning of BESS and DERs, which is an effective way to improve the entire performance of micro grids, has been discussed in some current studies. a two layer co-optimization framework for the sizing of different energy resources in a hybrid renewable energy micro grid designed a heuristic sizing strategy for a wind–solar– battery micro grid based on several principles, e.g. high reliability, cost- minimization and the complementary of a natural resource. Implemented the sequential

Monte Carlo simulation (MCS) under a pattern search optimization framework to seek for a least-cost sizing plan of a micro grid with BESS integration. The combination of heuristic optimization framework (e.g. PSO, genetic algorithm and ant colony algorithm) and performance assessment methods provide a generic computational framework for BESS planning problems. The performance assessment criteria could be defined as a variety of reliability and economic indicators, e.g. loss of power supply probability (LPSP), net present cost (NPC) and liveliest cost of energy (LCE). To capture the coherent and stochastic behaviors (incurred by intermittent renewable energy generation.

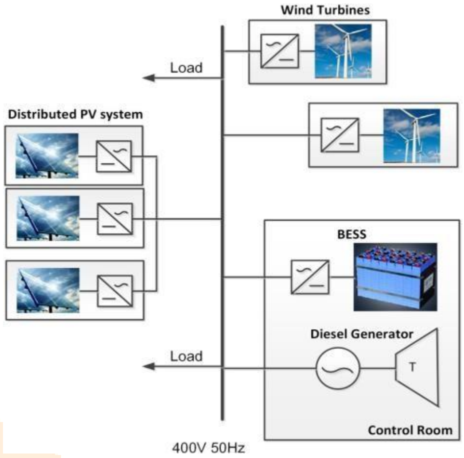

Figure 1 Configuration of an off-grid wind–solar–diesel micro grid

III. Fuzzy Logic

As discussed by the use of fuzzy logic controller (FLC) controls the state of charge (SOC) of the hybrid energy storage systems (HESS) and as compared to rule based control (RBC) saved 13% by optimizing the utilization cost and the life of the HESS. In renewable energy the sizing of the HESS, the Photovoltaic panels and the inverters is based on the optimization. According to in off grid photovoltaic system with HESS there is always a need for optimization in order to prevent excess battery storage if a super capacitor with battery is used. For a given solar radiation and load profile, the optimization of different system elements has been done considering the peak power requirements. The super capacitors are used to supply the peak power requirements of the load with the average power supplied by the battery bank.

Proposed maximum power point tracking (MPPT) fuzzy logic based solar charge controller to track the maximum power that is produced by the solar panel and to simultaneously control the charging of the battery when power is directly being supplied to the load.

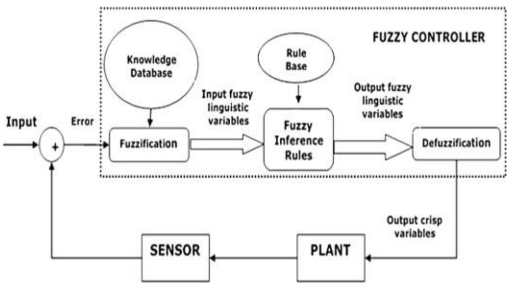

Figure2 Fuzzy logic control components

IV. Artificial Neural Network (ANN)

Implementation of artificial neural networks (ANN) for maximum power point tracking (MPPT) and wind energy resource management has been provided. The MPPT principle uses optimal voltage and current values in order to extract maximum from the photovoltaic power system. The main purpose of MPPT inverter using neural network controller is to control and set the input signal value and keep the output current and voltages values as close to the optimal values of the PV power system. In the standalone PV system comprising of 1.33KWp PV power system and a 24V /150 Ah lead acid battery as a load is used for simulation purpose. The Neural MPPT controller for a PV battery charging system is discussed and it has been concluded that the MPPT controllers using Neural Networks, the related parameters such as optimal operating point of the PV generator and the environmental conditions are known in advance and the main purpose of functioning of this inverter is to keep the system in an optimized set points which is not the case with the other techniques used in MPPT controllers. Furthermore, even during the enormous changes in the weather and environmental conditions there is no oscillation seen around the maximum power point and this controller operates fast and with minimum errors. The neural network based controlled for a standalone photovoltaic system is shown in figure 3.

The training patterns were set up for the network. The back propagation (BP) algorithms are used for the supervision of the training technique. The training patterns consist of the inputs and the desired outputs and are subjected to the ANN model. For each repeated submissions of the patterns desirable adjustments for each iteration are done unless and until the required outputs of acceptable levels are obtained successfully.

The figure below shows two outputs nodes representing the power from the diesel generator along with its On/Off status. It is concluded that the developed ANN model for the optimum operation of an integrated hybrid renewable energy based water and power supply system (IRWPSS) can predict the diesel generator status (On/Off) at any given time instant, if we know the power generated from photovoltaic panels, power supplied from the Energy Storage System and the inverter respectively.

Details regarding the ANN and hybrid systems, ANN architecture, operation and training are provided. The definitions of inputs, outputs and data preparation are considered as the most important step for an ANN modelling. In ANN training the system is defined as made up of photovoltaic modules, integrated with the diesel generator and the battery bank for storage.

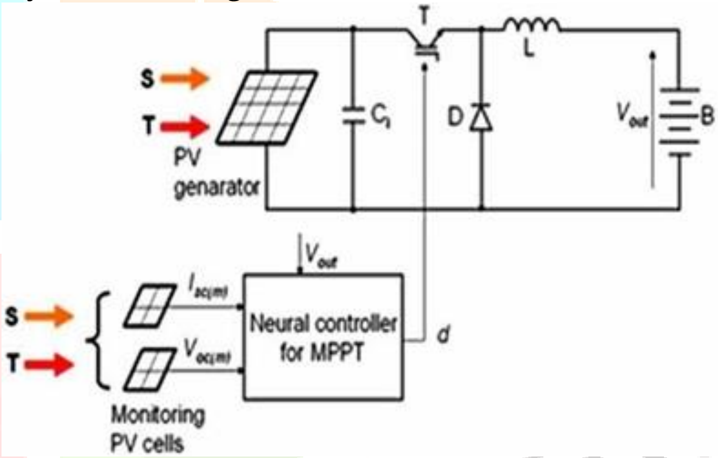

Figure 3 A standalone PV systems using the neural network based controller for MPPT

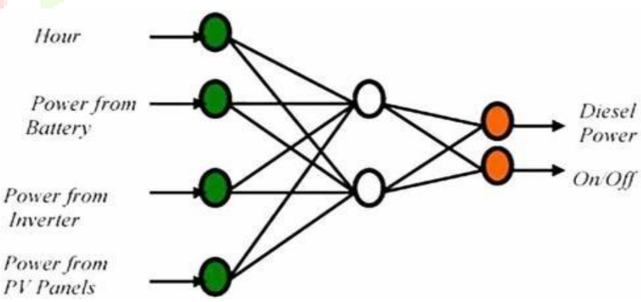

Figure 4 Architecture of ANN model

Artificial neural network based control strategy, in order to increase and improve power sharing between battery and the super capacitors connected with the micro grid as Hybrid Energy Storage System (HESS). When this ANN based controller performance is compared with the conventional controllers it is much faster, provides improved dc voltage regulation and have less settling time

The optimal sizing method with minimum annualized cost of the system in order to achieve the loss of power supply probability (LPSP) at customer size is discussed in detail. The proposed optimization method worked well and provided good performance when it's applied on a hybrid power system with ESS which is supplying power to the telecommunication relay station. This optimization also developed relation between the system power reliability and the system configurations. Provided an improved genetic algorithm based optimal sizing of hybrid energy systems for standalone applications. In order to find the best population strength the block diagram starts with population initialization and fitness function calculations. Crossover and Mutation rate determines the next generated population for the optimized solution.

V. CONCLUSIONS

Optimal sizing of BESS for a wind- penetrated grid-connected micro grid and standalone micro grid has been studied. In the three Scenarios considered, the sizes of BESS energy capacities and power capacities resulting from the minimum operational costs of the micro grid were computed. The optimization was done within 24 hours in every month from January to December. In particular, we have determined the minimum BESS investment cost needed operation of micro grid of the size proposed. Different optimization techniques were discussed in context with the control strategies applied in grid connected, off grid and hybrid renewable energy systems with Hybrid Energy Storages being used as a storage devices. It is concluded that each of the optimization method has its own pros and cons depending on the control strategy involved. Also using various new and latest optimization techniques such as artificial algorithms and hybrid algorithms for intelligent control can deliver more precise and correct results regarding multi objective optimization problems including the placement, sizing, design, planning and control problems in the field of renewable and sustainable energy.

VI. REFERENCES

[1] Al Muhaini, "Optimal sizing, allocation, dispatch and power flow of energy storage systems integrated with distributed generation units and a wind farm," in 2018 IEEE PES Asia-Pacific Power and Energy Engineering Conference (APPEEC), IEEE, 2018,pp. 680–684.

[2] Y. Ghiassi-Farrokhfal, C. Rosenberg, S. Keshav, and M. Adjaho, "Joint optimal design and operation of hybrid energy storage systems," IEEE Journal on Selected Areas in Communications, vol. 34, no. 3, pp. 639– 650, Mar. 2016, ISSN: 0733-8716. DOI: 10. 1109/JSAC.2016.2525599.

[3] S. Parhizi, H. Lotfi, A. Khodaei, and S. Bahramirad, "State of the art in research on microgrids: A review, Ieee Access, vol. 3, pp. 890–925, 2015.

[4] K. Bradbury, L. Pratson, and D. Patiño-Echeverri, "Economic viability of energy storage systems based on price arbitrage potential in real-time us electricity markets," Applied Energy, vol. 114, pp. 512–519, 2014.

[5] A. A. Akhil, G. Huff, A. B. Currier, B. C. Kaun, D. M. Rastler, S. B. Chen, A. L. Cotter,
D. T. Bradshaw, and W. D. Gauntlett, "Electricity storage handbook in collaboration with nreca," Sandia National Laboratories, 2013.

[6] About microgrids online kernel description, https : / / strategicmicrogrid . com / about - microgrids, accessed on December 2019.

[7] M. Sufyan, N. Abd Rahim, C. Tan, M. A. Muhammad, and S. R. Sheikh Raihan, "Optimal sizing and energy scheduling of isolated microgrid considering the battery lifetime degradation," PLOS ONE, vol. 14, pp. 1– 28, Feb. 2019. [Online]. Available: https://doi. org/10.1371/journal.pone.0211642.

[8] Y. Zhang, J. Wang, A. Berizzi, and X. Cao, "Life cycle planning of battery energy storage system in off-grid wind– solar–diesel microgrid," IET Generation, Transmission & Distribution, vol. 12, no. 20, pp. 4451–4461, 2018.

[9] T. S. Mahmoud, B. S. Ahmed, and M. Y. Hassan, "The role of intelligent generation control algorithms in optimizing battery energy storage systems size in microgrids: A case study from Western Australia," Energy Conversion and Management, vol. 196, pp. 1335– 1352, 2019, ISSN: 0196-8904.