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A LITERATURE SURVEY ON DEVELOPMENT OF MICRO-GRID

Sandeep Kedia [1],Prof. Madhu Upadhyay[2]
[1]M.Tech Scholar, [2]Assistant Professor,
[1,2]Department of Electrical Engineering,
[1,2]NRI Institute of Information Science and Technology Bhopal (M.P), INDIA,
[1] sandeep89kedia@gmail.com,

***Abstract* — In this survey paper discuss on development of a micro grid. In the current generation micro grid play an important role for rural electricity. In the last decade there are many research work on micro grid. In this review paper discuss parts of micro grid. Micro grid dependent on the different renewal energy such as solar, wind and biogas based. Also discuss the major parts of micro grid such as battery energy storage (BES), DC-DC converter, DC-AC inverter, solver PV system and wind turbine system. In the last discuss the micro grid based controlling system.**

Keywords—Battery Energy Storage (BES), Renewable Energy Resource (RERs), Solar Energy Conversion System (SECS), Wind Energy Generation System (WEGS), Power Quality (PQ), Maximum Power Point (MPP) etc.

I. INTRODUCTION

The Expansion of economies has led to the rise of energy demand. By 2050, the demand may double or even triple as an outcome of population rise. The conservation of energy, research on renewable energy resource (RERs) applicability and halting the dependency on fossil fuels, is of utmost importance. The RERs are dominated by their intermittency and geographic location availability. The variability of the energy supply is overcome by the use of storage systems like battery energy storage (BES). As an effective application, microgrid (µ-grid) acts as an localized entity, which is low or medium voltage including sources of electricity, BES, and loads that operate either in grid connected or off grid mode. µ-grid provides promising alternatives of electricity generation. The aim of the power providers is to feed the highest level of generated power into the grid when the electricity price and the load demand is at its highest value. This results in recovering the additional revenue utilized in the installation. The combination of solar energy conversion system (SECS) and wind energy generation system (WEGS), increases the system efficiency and power reliability. Their combination provides energy surety and continuity as both the resources complement each other and cut down the reserve or storage requirements. In this work, the hybrid system consists of single stage SECS and synchronous generator (SG) driven by wind turbine producing wind energy.

The Grid integration to renewable energy sources, provides the alternative for continuous power supply. An increased penetration of renewable to the power grid under normal and abnormal operating conditions is aimed to provide the desired power support. the grid code compliance by introspecting the renewable energy source penetration into the grid. The wind generation system integration to the utility grid, poses the importance of consideration of the issues of power quality (PQ), voltage fluctuations at the point of common interconnection (PCI), voltage unbalance, sudden voltage variations such as voltage sag and swell. The operating characteristics of the components are studied to relate with the issues deteriorating power quality.

In this work, the solar PV array (single stage) is linked to a BES at the DC link through the bidirectional DC-DC converter. It manages the charging and discharging of the BES. It also eliminates the second order harmonic that appears in the battery current enhancing battery vitality in comparison to the configuration, where the BES is connected directly to the DC link and in which during dynamic conditions, the fluctuations in the DC link, are reflected directly on the battery current and harm the battery life. The enhanced dynamic performance is obtained by including feed-forward terms for wind and solar in the analysis. The wind speeds and solar insulation changes are uncertain. The identification of the maximum power is feasible by utilizing maximum power point (MPP) extraction schemes for both the resources. Numerous techniques are available in the literature listing specifically from conventional schemes i.e. perturb and observe (P&O), incremental conductance (InC), soft computing based fuzzy logic, artificial neural network and optimization based schemes. The conventional schemes are preferred due to their simplicity and ease of operation. In this work, for wind optimal power estimation, P&O technique is used and adaptive P&O with variable perturbation step size for solar MPP assessment. The salient features of proposed work are given as follows.

- µ-grid offers the functionality for the integrated operation of the grid connected wind-solar PV-BES system.
- The integration of the power from renewable i.e. wind and solar into the utility grid without hampering the reliability of the supply is the basic objective.
- The BES allows the favorable solution of mitigation of the fluctuations caused by the generation from renewable.
- The state of charge (SOC) of the battery acts as the referral
- quantity to identify the charging and discharging rate of the BES along with the bidirectional DC-DC converter control.
- The switching of VSCs with the proven control algorithms lead to the improvement in the power quality as stated by the IEEE-519 standard.
- The feed-forward terms of wind and solar, enhance the system dynamic response.

II.LITERATURE SURVEY

Suganthi, S. T., et. al. (2021)- In this research study, Computational-intelligence classifiers like MLP, SVM, and NB have been used to identify and classify distinct PQDs in the MG network shown. Simulated using Matalb/Simulink, the MG network model (25 kV) includes several PQDs, such as voltage sag, voltage swell as well as interruption. The common bus of MG network is also included in the simulation. The DWT analysis is used to examine the voltage signals during these PQ episodes. The signals are sampled with mother wavelet of db4 and WT coefficients (different level) such as D1, D2, D3, D4, D5 and A5are used to extract the features of energy values.MG network PQDs are classified based on the extracted energy values, which are utilised to train the intelligent-based classifiers. Probabilistic NB classifier and SVM classifier results demonstrate that in the MG network they can identify single as well as multiple PQDs with 100% accuracy. The MLP classifier, on the other hand, has an accuracy rate of just 66.7 percent when classifying PQDs (swell with harmonics, transients-1, as well as transients-2). For example, the KS index, MAE and RMSSE may be used to evaluate the performance of classifiers at the next level. According on the PI assessment findings, the suggested NB classifier outperforms the SVM and MLP classification algorithms by a wide margin. Furthermore, for classification of different PQDs and electrical faults in is landed MG power network, development of advanced hybrid signal processing techniques with implementation of ensemble classification models are the future scope of this work [01].

Zia, M. F., et. al. (2020)- This research work, has summarized recent discussions on architectures, distributed ledger technologies, and local energy markets for realization of a microgrid trans active energy system in particular and a decentralized power system in general. Both centralized and decentralized microgrid trans active energy systems were discussed and the potential reasons for avoiding the use of centralized microgrid transactive energy system were also highlighted. Existing architectures for a decentralized transactive energy system were discussed. Seven functional layers were proposed for decentralized transactive energy system architecture design. System operator layer is represented by microgrid or energy management operator in microgrid system, and transmission or independent system operator in smart grid. The Brooklyn microgrid case study was evaluated to the suggested seven-layer design. Also widely considered for the decentralised transacting energy system were the most prominent distributed ledger systems such as blockchain and the directed acyclic graph and hashgraph. Performance characteristics such as hash-chain structure, scalability as well as energy consumption were taken into account while comparing the two. The challenges of these distributed ledger technologies implementation were also highlighted. Finally, two main types of local energy markets, P2P and community-based energy markets, were presented. The challenges and potentials of these markets were also highlighted [02].

Berizzi, A., et.al. (2019) – In this research work presented, the electrification process can be classified into top-down and bottom-up approaches. The former is based on a classical evolution of the national transmission and distribution grid, while the latter is looking to scattered areas where stand-alone microgrids could provide a technically and economically viable solution. In this article, a third approach (named a smart microgrid) is also discussed, which stresses the need to properly design microgrids in order to allow a future connection to the national grid and the provision of ancillary services, allowing the microgrid to support the reliability and quality of supply. This is needed to guarantee to final users (citizens) proper support for their energetic growth [03].

***Chishti, F., et. al. (2019)* -** The presented wind-solar AC microgrid has been designed and implemented to illustrate its improved PQ performance for local nonlinear load using MLMS adaptive control. The weight component and system performance using MLMS has been found with reduced oscillations. Effectiveness of the MLMS is realized through successful harmonic elimination, extraction of load current fundamental component with low static error and faster convergence rate. The wide range of wind speeds, solar insolation and load variations have been considered and the test results obtained from the prototype provide exceedingly well performance for the entire operational range. The grid current THD has been found well within the IEEE-519 harmonic standard. The presented system has operated well under all the dynamic conditions as well as the power quality issues are mitigated satisfactorily [04].

***Dicorato, M., et. al. (2019)* -** In this research work, the concept of electric vehicle supply infrastructure for the management of EV fleet has been presented. It is structured around a DC microgrid involving photovoltaic panels, energy storage and multiple EV stations, even exploiting bidirectional technology, with dedicated converters. The main technical features and challenges of the DC microgrid have been illustrated, individuating the possible applications and the envisaged innovations in the framework of the evolution of technical rules and laws. In particular, the presented control functions have been described, showing the potential of the system to provide services to the user, in the form of affordable and cost-effective energy supply to the EVs, as well as to the network, by controlling the energy exchange and taking part to ancillary service mechanisms. The demonstrator is planned to be completed and run by the end of concept project activity, and future work will deal with the field tests in actual operation [05].

***Sirviö, K., et. al. (2019, November)* -** In this research work, the RPW controller was developed from a SIL controller to real hardware. The simulations bring into question that the RWP controller could be predictive to define the RPW limits simply according to the TSO's requirements. This development demonstrated that for long-term tests and simulation studies, a suitable coefficient for Td could be defined to present, e.g., one-year study cases reliable enough. Also, the effect of the communication delay was demonstrated in real-time simulations and was compared to offline simulation results. Thus, in the CHIL tests, also the processing time of the hardware affected the results[06].

***Abubakr, H., et. al. (2019, October)* -** This research work, LFC was implemented for two area interconnected microgrid (MG) to obtain zero steady state error in the frequency deviation and power in tie line. The traditional (I- controller) is used and the specific parameters are optimized by using a new robust and powerful technique called Electro-Search Optimization (ESO). A comparative study was conducted between the systems using adaptive particle swarm (PSO), ESO and fixed-I controller under step load and changes in wind power. The obtained results portray that the performance of the system using adaptive ESO is enhanced in terms of rise time, steady sate error and maximum overshoot [07].

***Zhao, B., Wang, et. al. (2018)* -** This research work as a result, the energy management of the MMG system was defined as a bi-level optimization problem for a grid-connected SoS model. The energy management was treated as a two-stage robust optimization at the level of individual MGs. The model considered the RES uncertainty in deriving an optimal operating schedule for the DGs, ES, and load shedding, which minimizes the daily operating cost under the worst scenario.When it came to the MMG system, the goal of energy management was to minimise overall costs by planning the interchange of power between the MGs and the DN. The research work also developed computational methods for solving the complex optimization model. A C&CG algorithm was implemented for solving the robust optimization problem for participating MGs, and then an iterative method was developed to solve the optimization problem for the MMG system. Based on a real world project, the research work developed three cases to assess the advantages of the SoS based energy management for MMG systems. Results indicate that unincorporated individual MGs are able to achieve their own purpose, but the total operating cost is expensive. The presented energy management method significantly improves the interests of the entire MMG system through an optimized coordination of power exchange among MGs and power trading with the DN [08].

III. DESIGN GUIDE LINES FOR MICROGRID

This section presents and defines the design guidelines required for a successful implementation of a university campus micro grid. In addition, an explanation of key components constituting the micro grid and their main characteristics are also provided. A micro grid is divided in three main parts (i) the energy consumption, (ii) the energy generation, and (iii) the energy storage, all within a bounded and controlled network.

A. Load Profiles and Load Clustering

A crucial aspect for developing a micro grid is to identify the energy demand which the system has to satisfy. Ideally, the loads of the microgrid should be categorized into several clusters that can be individually managed by a central controller. This categorization is especially important for the implementation of controllable loads which can be used in load shedding schemes and energy management optimization scenarios, providing more flexibility and sustainability to the micro grid.

Different control actions are required for managing each type of loads. Thus, some loads (i.e., lights) can be controlled through controllable circuit breakers (on/off actions), while other loads can be managed by sending some operating set-points (i.e., temperature set-point in an air-conditioner). The load clusters are usually separated into essential, non-essential and thermal loads. Essential loads consist of fixed loads that always need to be satisfied. Non-essential loads are loads that may be shed in cases where energy demand of the micro grid cannot be satisfied while thermal loads provide flexibility to the micro grid operator in order to shift or managed the load profile characteristic within a day. It should be noted that particular requirements for the electrical installation of each building consisting the micro grid need to be ensured prior to allow the proper clustering of loads.

After the load clustering, it is important to perform a measurement campaign for the total energy demand and to identify the load profiles for each load cluster. Afterwards, the load profiles can separately be analyzed according to seasons (i.e., winter, spring, summer, autumn) and the type of day (i.e., working day or holiday). Such an analysis of the load measurements can give a useful insight of how the load demand varies throughout the year and what should the generation and storage capacity of the micro grid be in order to satisfy this demand.

B. Network Configuration

Apart from the categorization and the profiles of the loads, the identification of a suitable network configuration is also important. The majority of existing micro grid solutions are implemented in a circular configuration which satisfies the “N-1” criterion for ensuring the resilience of the micro grid even under a failure of a critical component (i.e., line, substation). The network of a micro grid is connected to the main grid through a single controllable breaker (single PCC). Such a single PCC, allows a straightforward and seamless transition between interconnected and is landed mode.

C. Generation and Storage Units

One of the most crucial components for the development of a micro grid is to include proper generation and storage units in the design of the system. The selected units must be able to cover the majority of the demand, whenever the micro grid operates in an islanded mode. The generation side of a modern micro grid can be separated into controllable and uncontrollable generation. The former, can be further divided into flexible generation (such as diesel/gas generators or fuel cells) and battery storage systems (BSSs). The latter, includes the installation of RESs, which have a varying generation output according to environmental and weather conditions (such as wind turbines and photovoltaic systems). Although renewable energy output cannot be controlled, various control architectures have been proposed to provide support for micro grids, such as voltage controls through reactive power output.

The inclusion of controllable generation units is essential for the successful implementation of the micro grid. This is because the existence of solely RESs in the system cannot ensure the provision of adequate power whenever is needed and the adoption of optimized operating scenarios. Therefore, this paper utilizes a diesel generator equipped with associated controllers, such as an exciter (type AC5A) and a speed regulator (based on the synchronous governor model). The governor controller is able to change the generator’s active power output according to set points derived from the micro grid central controller for a proper energy scheduling during the interconnected mode. The adopted BSS operates in such a way so that it can charge or discharge according to the micro grid operator in order to cover the energy demand or manage the energy scheduling of the micro grid. A BSS of 15 kW/20 kWh is initially suggested for the MCAST micro grid. Lastly, regarding RESs, a total penetration of 63 kW peak of photovoltaic (PV) is considered for the proposed micro grid. These PVs are equally distributed in three buildings of the MCAST campus (with 21 kW peak PV installation in each building). The PV inverters are capable of providing reactive power support in case it is needed, thus contributing to the voltage stability of the micro grid. It is worth mentioning that the rated power for the diesel generator and the BSS should be appropriately selected to satisfy the base and intermediate loads of the micro grid in order to enable its islanded operation.

More information regarding the micro grid to be implemented in MCAST campus is provided in the single line. In this figure, one can note the following: the proposed micro grid is based on three buildings (D, F and J), the “N-1” criterion is ensured by the network connection of the two substation in both medium and low voltage side, and the single PCC is ensured by the connection of the micro grid to the main grid through a circuit breaker on the medium voltage side of substation SS1. Further, all the buildings have PVs installed on their rooftops, and all the load types of each building can be controlled through the two main switch gears. It is also noted that the thermal loads for air conditioning can be controlled through ON/OFF actions and managed through temperature set-points.

IV. CONTROL ARCHITECTURE

A part from the availability of all the aforementioned components, it is also necessary to include a control scheme in the design, in order to achieve an efficient and resilient operation of the micro grid. More specifically, this control scheme must satisfy certain characteristics. First of all, it must be able to transit smoothly to grid-connected or is landed mode whenever is required. The transition to is landed mode may occur after requisition by the power system operator or after the micro grid senses voltage or frequency violations on the main grid voltage supply. It should be noted that under certain contingencies, the overall resilience of the main power system can be enhanced if the main grid operator commands the micro grid to go in is landing mode. During the grid-connected operation, the micro grid will be synchronized with the main grid. In this mode, the micro grid operator should be able to regulate the active and reactive power exchange with the main grid according to predefined profiles (as they have been agreed with the power system operator). Moreover, the micro grid should be able to provide additional voltage or frequency support to the main grid when receiving new command signals by the power system operator. In is landed mode, the micro grid is responsible for maintaining its own frequency and voltage stability. Lastly, in both operating modes, the control scheme must be able to provide set-points and coordinate optimally all the micro grid's components. An example can be the application of economic dispatch or optimal power flow (OPF) in order to find the optimal operating scenario that satisfies a low operating cost.

Generally, two control architectures are commonly known, the decentralized and the centralized. The former refers to a control structure where a minimum communication infrastructure is required and every energy source of the micro grid is equipped with a combination of a primary and a secondary controller. The latter requires the existence of a central secondary controller along with the necessary communication infrastructure in order to be able to coordinate all the primary controllers. This work utilizes a hierarchical centralized control architecture combined with single master operation (SMO). SMO means that in case of is landing, the diesel generator is chosen to act as the master of the micro grid (for maintaining the voltage and frequency stability), while all the other generation units (PV and BSS) operate in PQ mode (for regulating only their active (P) and reactive (Q) power generation) in a synchronized way with the diesel generator.

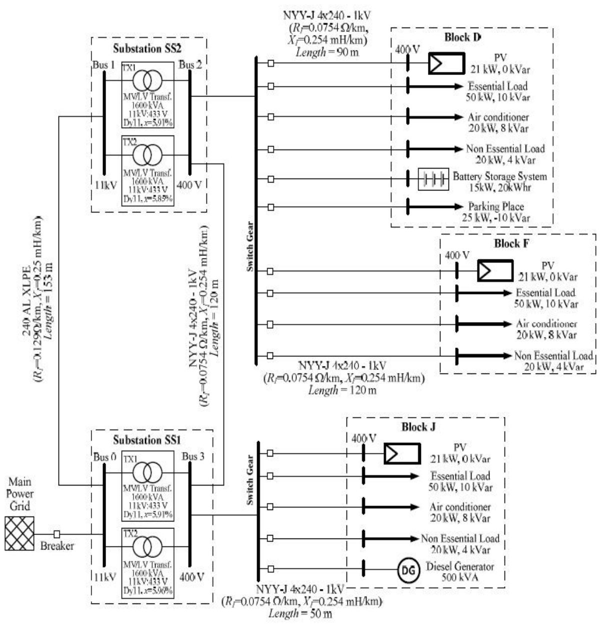

Fig. 1. MCAST micro grid single line diagram

The hierarchical control can be separated into primary, secondary and tertiary control. Primary control constitutes the first and faster level of control. Therefore, it is an uncoordinated droop control, responsible to maintain the voltage and frequency levels after a disturbance. Due to this reason, any remaining voltage or frequency oscillations after a severe disturbance in the micro grid can be compensated by the actions of a secondary controller. The tertiary control is the higher level of control hierarchy where more advanced scheduling algorithms regarding the micro grid operation can take place. These algorithms include: decision making for transition to is landing or grid-connected mode, techniques to regulate the power exchange with the main grid, methods for resources allocation, OPF and economic dispatch in order to minimize the operating cost of the micro-grid, etc.

V. CONCLUSION

In this survey paper discuss on micro grid and its different aspect. Also discuss the literature survey of micro system. Discuss the major parts of micro grid, that is divided in three main parts (i) the energy consumption, (ii) the energy generation, and (iii) the energy storage, all within a bounded and controlled network. Micro-grid controller is necessary to include a control scheme in the design, in order to achieve an efficient and resilient operation of the micro grid.

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