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A Review of Microgrid Concept

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ABSTRACT: This paper represents the work done in the field of micro grid has been reviewed .A better way to realize the emerging potential of distributed generation is to take a system approach which views generation and associated loads as a subsystem or a “micro grid”. The fossil fuels are diminished due to growing electricity consumption the customer demand for efficient energy production, delivery and utilization keep rising. The potential to solve major problems that can be arising from large penetration of distributed generation in distributed system, the micro grid concept has been used .In micro grid, for successful operation, a proper control strategy should be implemented. Various types of micro-grid should be explained and its value proportion over utility grid is also given. The energy storage system critical play role in stabilization of voltage and frequency in micro-grid. Therefore various technologies are reviewed.

KEYWORDS: DER, MG, PCC, PV, ES, DG.

I. INTRODUCTION

The electricity generation, transmission and distribution is revolutionizing due to various economic, technical and environmental reasons. Micro-Grid (MG) is among the new technologies that has attracted a great attention, recently .Existing centralized grid system is actively replaced by distributed energy resources located closer to consumers to meet their requirements effectively and reliably[1].A Micro-Grid is a modern distributed power system using local sustainable power resources designed through various smart grid in initiatives .A system or a subsystem in which the local generation is combined with the loads in a small neighbourhood is called as Micro-Grid.
The various energy resources like small capacity Hydro Units, Ocean, wind, PV, energy storages etc are in MG for electrification mainly rural areas where grid electricity access is not possible due to poor access of remote areas to technical skills.MG concept is using because due to this there is ease in installation ,commissioning, operation and maintainances. Due to Micro-Grid, the Expenditure is reduced by reducing line losses,line costs and network congestion and the energy efficieny is improved[1]-[3] .

Penetration of distributed generation across the US has not yet reached significant levels.however changing the situation rapidly and within the distribution system the issues related to high penetration of distributed generation requires attention.During disturbances, the generation and corresponding loads can separate from the distribution system to isolate the microgrid’s load from the disturbance (providing UPS services) without harming the transmission grid’s integrity. MG provide higher flexibility and reliability as it is able to run in both grid connected and islanded mode of operation and its components may be physically close to each other or distributed geographically[4].
In grid-connected mode, the micro-grid operator can take economic decisions-such as to sell or buy energy depending on on-site generation capability , its cost, and the current prices on the energy market .In case of a utility power system outage . the point-of-common-coupling breaker will automatically open, and own generators will continue to supply power to loads within the micro-grid[5].

The idea of micro-grids is not new .In very beginning of rural electrification ,several micro-grid structures had been installed[6].The assumption is taken in micro-grid concept that large number of distributed generators are connected to network to lower the need of transmission and high voltage distribution system[7].

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II. OPERATION AND CONTROL

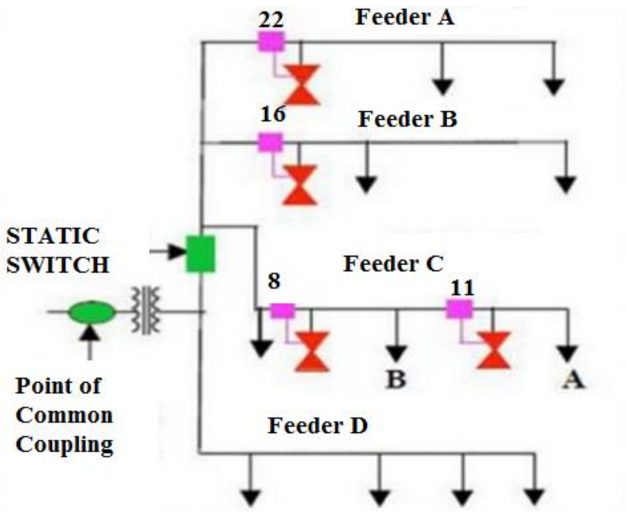

FIG1: Micro grid

Basic microgrid architecture is shown in fig1.This consists of a group of radial feeders, which could be part of a distribution system or a building's electrical system.There is a single point of connection to the utility called point of common coupling. Some feeders , (feeders A-C) have sensitive loads,which require local generation.The non-critical load feeders do not have any local generation. In our example this is feeder D. Feeder A-C can island from the grid using the static switch which can separate in less than a cycle[8].In this examples there are four microsources at nodes 8,11,16 and 22, which control the operation using only local voltages and currents measurements. When there is a problem with the utility supply the static switch will open ,isolating the sensitive loads from the power grid.Feeder D loads
ride through th event. It is asuumed that there is sufficient generation to meet the loads' demand.Whenthe microgrid is grid-connected power from the local generation can be directed to feeder D.

Micro-grids can be classified into three types depending on its operational frequency. They are AC micro-grid, DC micro-grid and hybrid AC/DC micro-grid .The brief details on each of these types is given in the following section.

A. AC Micro-grid

An AC micro-grid system may consist of a medium or a low voltage AC distribution network . Distributed sources, storage devices and loads are connected to this AC network with or without a converter depending on the frequency ratings. Native AC generations such as diesel generators, micro turbines and wind turbines can be directly connected to the AC network without any converters. For native DC sources like PV systems, DC/AC converters are normally used. Similarly, AC loads are connected directly while for the case of DC loads, AC/DC rectifiers are required. Even though a great deal of research work is carried out in AC micro-grids, it does have some disadvantages. A few of the major problems in such network include the complexity in control and synchronization issues.

B. DC Microgrid

A more recent research trend have shown much interest in the area of development of DC Microgrid systems [9]. Figure 2 shows the schematic of a DC microgrid. As compared to an AC microgrid, it can provide significant energy shavings by reducing the number of converters inside the microgrid system. This includes converters for interfacing the distributed renewable generations,loads and energy storage devices.

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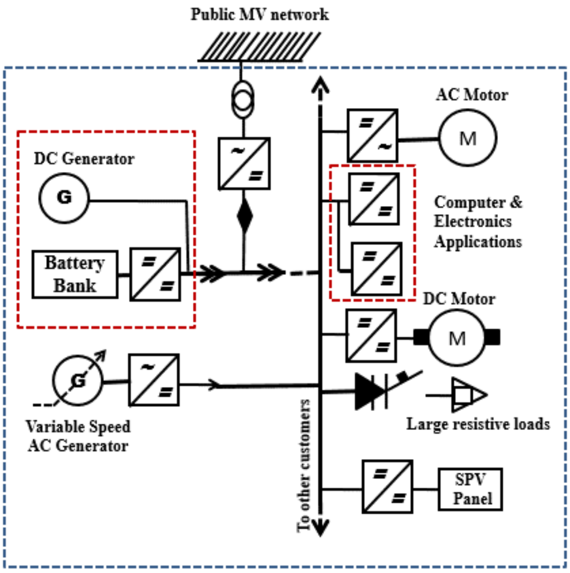

FIG 2: Schematic diagram of DC Micro-Grid.

A DC system also brings about other significant advantages solving some of the control issues inside a micro-grid. For instance, synchronization of the distributed generations is no longer required and the controls are directly based on DC bus voltage. Moreover the primary control is much simpler due to the absence of reactive power flow control. And finally, most of the modern appliances also run in DC power, which provides an added benefit.

C. Hybrid AC/DC Micro-grid

As the name suggest hybrid micro-grids consist of AC and DC network connected together by multi-bidirectional converters [10]. A hybrid system can reduce the number of AC-DC-AC and DC-AC-DC conversions in individual AC or DC micro-grids. Here, AC sources and loads are connected to the AC network whereas DC sources and loads are tied to the DC network. Energy storage devices can be connected in either of the network. Figure 3 shows the schematic diagram of a hybrid AC/DC micro-grid

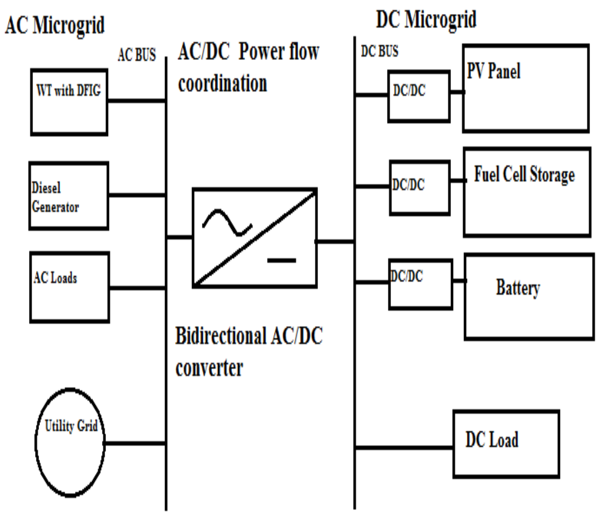

FIG3: Schematic diagram of hybrid AC/DC micro-grid.

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Even though a hybrid system reduces the number of converters in individual AC and DC systems, there are some disadvantages for using such type of configuration. The total efficiency of the system greatly depends on the type (AC or DC) and amount of connected sources and loads. Hybrid micro-grids are more suitable for smaller isolated installations with PV and wind generations as a major power supply.
From the above discussions, a clear picture on the types and the capabilities of the different micro-grid configurations can be seen. And due to the inherent simplicity and advantages of the DC system, the article focuses mainly on the DC micro-grid configuration.

III. Utility grid shortcomings and micro-grid value proportions

The following paragraphs summarize the related power supply challenges and the benefits of micro-grid installations.

A. Power quality challenges

The term "power quality" refers to the quality of the supply voltage in a certain area, which strongly depends on the characteristics of the loads and the transmission and distribution grid infrastructure in this area. Long distribution lines with asymmetric loads, for example, may lead to significant low voltage quality, eventually resulting in effects such as low and unbalanced voltages, voltages harmonics , and flicker in certain load locations.
Power quality challenges are mainly caused by a lack of investment in the grid. In several countries, demand for electricity is growing so fast that the construction of generation plants as well as transmission and distribution lines cannot keep pace. This situation leads to power outages in certain areas when demand exceeds actual generation, or the thermal limits of the power system equipment endanger the integrity of the power systems. Deregulation and tough competition forces utilities in some other countries to economize on investments-a situation that ultimately leads to low power supply quality.
A micro-grid with an option to disconnect from the utility grid in case of power quality problems may benefit the loads inside its borders significantly. Depending on the field of application (military, industrial, commercial, or residential, for instance), power quality requirements of the loads inside the micro-grid may be different. In highly sensitive industrial areas with semiconductor or chemical manufacturing facilities, for example, reliable power at a high power quality level is required. This may be achieved with the installation of reliable fossil-fueled generators within the micro-grid. Additional power-conditioning equipment may be an option if there are nonlinear loads.
In off-grid areas in some developing countries, where residents have no option other than a micro-grid solution, Most of them will be satisfied with somewhat poorer power quality.

B. Natural disasters

In some areas of the world, the Americas or the Indian subcontinent, for instance, natural disasters such as tornados, hurricanes, and earthquakes followed by tsunamis may completely annihilate parts of the transmission and distribution infrastructure. Even if a certain area is not directly affected by the disaster, its power supply may be interrupted for weeks or even months if its connection to the utility grid has been interrupted by such an event. Due to the fact that a micro-grid does not depend on the power supply of the utility grid, the immediate construction of micro-grids appears feasible in some areas, especially those that have been repeatedly struck by natural disasters, such as some southern parts of the USA. On the other hand, a micro-grid can be planned and assembled in a comparatively short time. It could turn out to be more beneficial to decide for the immediate construction of a micro-grid instead of waiting for the reparation and reinstallation of the common transmission and distribution infrastructure after a natural disaster.

C. Growing demand, grid extensions, and social resistance

Everybody wants a reliable power supply. The demand for electrical power is growing in many areas of the world, and people expect appropriate enhancements of the power system, such as new power plants and new transmission and distribution lines. However, reality shows that everyone opposes the construction of a power plant or a power line in their own neighborhood. This "not in my backyard" attitude makes investments difficult, so building permissions may take ten years, or even longer. In an area with micro-grid structures, a growing demand for electrical energy can be satisfied by the installation of new distributed generators, preferably based on pollution-free generation from renewable sources .This way, micro-grids can help defer investments in transmission and distribution systems and solve related social problems such as demonstrations against the installation of transmission lines close to residential areas.

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D.Optimal Utilization of distributed generators

According to today's grid codes, all distributed generation, renewable or fossil fueled, must shut down during power outages. But it is exactly in such "emergency situations" that distributed generators offer the greatest benefit to both generation owners and society: micro-grids can provide power services to consumers, when the larger grid system fails.

E. Peak load limitations

From the utilization point of view, there are three major types of power plants. A base-load power plant produces base-load supply. Base-load plants are the power generation facilities used to meet some or all of a given region's continuous power demand. They produce power at a constant rate, usually at comparatively low cost as compared to other production facilities available to the system. Examples of base-load power plants include nuclear and coal-fired plants.

Peak-load power plants are "power plants that generally run only when there is a high demand for electricity, so-called peak demand. In many countries of the world, this often occurs in the afternoon, especially during the summer months when the air-conditioning load is high" (Wikipedia). Natural-gas-fired turbines are the typical prime movers in peak-load power plants.

A load-following power plant is a power plant that adjusts its power output to the actual demand for electricity, which fluctuates throughout the day. Load-following plants are typically in-between base load and peaking power plants in terms of efficiency, ramp times, construction costs, cost of electricity, and capacity.

Due to economical limitations, the capacity of load-following power plants and peak-load power plants is limited. Also, the load on transmission and distribution systems must not exceed certain thermal limits,

Especially during hot summer days that are characterized by a high demand for electrical energy. Utilities need to shed load in such cases when actual demand exceeds given generation and grid capacities.

A micro-grid, however, can manage its own generation and load balance. The system can always shed load if necessary and avoid peak load. If a certain amount of peak load becomes "regular," the generation capacity of the micro-grid can be enhanced with the installation of additional distributed generators.

F. Transmission and distribution losses

Average transmission and distribution losses of a power system amount to six to eight percent of total generation. A solution that can reduce this figure will help save significant amounts of money and will also support the reduction of CO_2 emissions.

If the generation capacity of a micro-grid covers its own demand, and generation costs are within an acceptable range, energy import from the utility grid will only be necessary in exceptional situations. This means that energy transport losses will be less than one percent under normal circumstances, which is a significant contribution to the reduction of CO_2 emissions. A micro-grid will only import energy from the power grid if its own demand exceeds its given generation capacity.

If micro-grids gain wide acceptance in future, however, regulations governing energy-trade practices as well as related laws will also need to be adapted. This may change established utility structures significantly.

IV. Needs for ESSs in Micro-grids

It is well known that within an envisioned micro-grid, various types of distributed generator (DG) and customers create and demand varying active and reactive power profiles that may challenge the stability of the system[11]. The ESSs, therefore, play a critical role in stabilizing the voltage and frequency of the micro-grid for both short- and long-term applications. From the device to system level, the ESS is a crucial element in the integration of DG into the micro-grid. Researchers have employed various types of energy storage at the turbine and farm levels for wind energy to smooth the power intermittency and make wind power more compatible with grids and micro-grids. Novel topologies for solar PV converters are being proposed and discussed for integrating batteries into solar PV systems to make them capable of providing continuous power during a cloudy day. For micro-grid planning, various projects have focused on the optimization of the allocation of ESSs for micro-grids. There is research underway aimed at determining the optimal location and size for energy storage within a micro-grid so that a minimal cost and system energy loss can be achieved while micro-grid reliability and surety are improved.

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Energy-storage units can either be distributed or centralized in a micro-grid. The distributed ESS not only actively manages and controls the functions of the storage devices to provide power support to local loads but also tries to maximize its life, efficiency, and safety. It also communicates to the upper-layer control unit such as the supervisory

control unit to perform other advanced operations. A centralized ESS is typically observed in a smaller micro-grid but typically when some critical facilities are involved. It usually performs similarly to a main backup power supply in the event of bulk grid blackout. A higher energy and power level is needed to support the whole system from couple of minutes to hours.

A. Energy-Storage Technologies

Energy storage with newer battery technologies has become a reality. The lead-acid battery-based technology has been replaced by lithium-ion (Li-ion) technology and many other alternatives. There are currently several types of energy-storage technologies with different characteristics, e.g., energy and power density, efficiency, cost, lifetime, and response time. Examples of ESSs are ultra capacitors, superconducting magnetic ESSs, flywheels, batteries, compressed air, pumped hydro, fuel cells, and flow batteries. Currently, energy storage is a tradeoff between power and energy density. Although ultra capacitors and hybrid batteries offer higher power density, their capacity (in Ah) and energy density are nowhere close to those of batteries[12].

They can release a large amount of power but only for a few seconds. On the other hand, fuel cells are capable of storing a vast amount of energy but are limited in the peak output power. Based on the available technologies, batteries are the best choice to provide both power and energy densities.

There are several types of batteries currently in use for industrial applications. Nickel cadmium (NiCd), lead acid, and Li-ion are the most popular existing battery types. NiCd-based batteries contain toxic metals and are environmentally unfriendly. Furthermore, the memory effect and high maintenance requirements are other drawbacks that make this type of battery less favorable for industrial applications. Nickel–metal hybrids (NiMH) are another type of nickel-based battery that offers higher energy density and shorter cycle life compared to the NiCd battery but still suffers from high maintenance requirements due to the memory effect. Lead-acid batteries are the most cost-efficient commercial batteries for power-supported applications. The short cycle life and low energy density are the two main disadvantages of these types of batteries. Lead-acid batteries could be a good choice for applications in which a power support with low depth of discharge rate is required. Deep cycling has a serious impact on the life cycle of the battery. Among all of the different types of energy storage currently available commercially, Li-ion batteries offer the best solution for high-power and high-energy applications. Recent technologies also provide a combination of high power and energy density with considerably high cycle and floating lifetime (a >5,000-cycle life). Li-ion batteries come in various types based on the chemistries for the active positive and negative materials. Different materials for the electrodes lead to various battery specifications in terms of power and energy density, voltage characteristics, life, and safety. Choosing the appropriate battery chemistry to meet the required specifications of the application is vital. Similar to other battery types, Lion batteries consist of two electrodes, an anode, a cathode, a separator to prevent shorting, and an electrolyte as a conductor. The cathode is a lithium metal oxide, and common materials such as lithium, cobalt, manganese, and iron phosphate oxide as well as combined chemistries including lithium nickel cobalt aluminum oxide (NCA) or lithium manganese cobalt oxide (NMC) are used as the cathode electrode. High capacity, energy density, and cycle life were the main advantages of cells based on $LiCoO_2$ as the positive electrode. However, high energy release when the battery is abused was a safety concern and a disadvantage of the earlier batteries. Lithium manganese oxide ($LiMn_2O_4$) was proposed to mitigate safety concern while representing similar voltage and energy density, however, with faster capacity fading. Combining several lithium metal oxides to take the advantage of several features has created new lines of batteries. The NCA type, which is a mixture of lithium, nickel, cobalt, and aluminum oxides, and the NMC type, which is a compound of lithium, nickel, manganese, and cobalt oxides, were two popular compounds based on nickel. Having nickel in the compound increases the lifetime and energy density of the device. NCA has high energy and power densities and an excellent life span, whereas NMC presents lower power density with almost similar energy density but represents better safety features. The development of lithium iron phosphate ($LiFePO_4$) in the 1990s for positive active materials was a significant safety improvement. However, lower energy and power density and cell voltage were the drawbacks of this type of battery cell.

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Figure 4 shows a comparison of several types of battery chemistries, considering lithium iron phosphate as a reference case. An appropriate type can be chosen based on the requirements for energy and power density, cost, cycle life, performance, and safety.

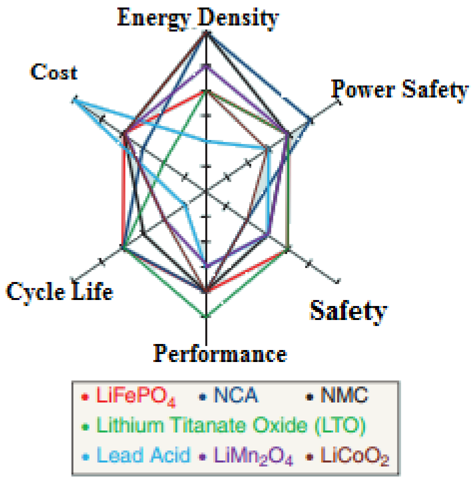

FIG4: A property component of several types of electrochemical batteries

B. Optimal Allocation for ESS in Micro-grids

Planning the best locations and sizes for ESSs can have a significant impact on the power system, including enhancing the power system reliability and power quality, reducing the power system cost, controlling high energy cost imbalance charges, minimizing power loss, improving voltage profiles, serving the demand for peak load, and correcting the power factor. In recent years, much research has been focused on determining the location and capacity of ESSs. Algorithms combining multi pass dynamic programming were proposed to maximize fuel-cost savings and benefits from energy pricing differences between peak- and light-load periods. Methodologies were also developed to optimize the allocation and economical operation of ESSs in micro-grids. A genetic algorithm optimization technique based on a multi objective function was used to evaluate the economic impact of the energy-storage-specific costs on the net present value of energy-storage installations in distribution substations. One research group proposed a two-stage stochastic optimal algorithm for sizing the ESS in an isolated wind-diesel power system. The authors considered wind penetration, ESS efficiency, and diesel operating strategy to minimize the cost of supplied energy. Research in another work presented an integrated electricity production cost analysis for autonomous electrical networks based on renewable energy sources and energy-storage configurations. The initial cost of the energy storage, the input electricity, and fuel cost, as well as the fixed and variable maintenance and operating costs of the entire installation were taken into consideration[13].

V . CONCLUSION

After going through this review based on the given title , it has been concluded that issues of unreliable power quality, fulfill the growing demand of electricity, increased focus on ESSs and also focus on higher efficiency have resulted in more emphasis on developing micro-grid infrastructure. The MG ability to work in both island and grid –connected mode has a potential to provide a higher local reliability than that provided by power system. ESSs play an important role in stabilization of voltage and frequency of the MG. Various newer technologies of ESS has become into reality. The optimal allocation of ESS in MG is used to lower the power system cost, enhance the power system reliability and controlling high energy cost power quality.

REFRENCES

[1]. Tae-young Lee, Kwang-ho Ha, Hyun-jeaYoo, Jong-wan Seo and Myong-chul Shin, "Research for Data acquisition equipment with micro-Grid system", 5th International Conference on Electrical and Computer Engineering, IEEE, Bangladesh ,2008, pp. 712-715 .

[2]. Xiaoming Yuan and Yingqi Zhang, "Status and Opportunities of Photovoltaic Inverters in Grid-Tied and Micro-Grid Systems", IEEE Power Electronics and Motion Control Conference, vol.1, Shanghai,2006, pp. 1- 4.

[3]. T.K. Panigrahi, A.K. Saha, S. Chowdhury,S.P.Chowdhury,N.Chakraborty, Y.H.Song, S.Byabortta, "A simulink based micro grid modeling & operational analysis using distributed generators", Proceedings of the 41st International Universities Power Engineering Conference, vol.1 ,Newcastle, 2006, pp. 222-226.

[4]. A. Nagliero, R. A. Mastromauro, V.G.Monopoli, M.Liserre and A. Dell'Aquila, "Analysis of a universal inverter working in grid-connected, stand-alone and micro-grid", IEEE International Symposium on Industrial Electronics, Bari,2010, pp. 650- 657.

[5]. Mazheruddin H. Syed, H.H. Zeineldin and M.S. El Moursi, "Grid Code Violation during Fault Triggered Islanding of Hybrid Micro-grid", IEEE PES Innovative SmartGrid Technologies, Washington DC,2013, pp. 1-6.

[6]. Liu Qiang, Zhou Lin, Guo Ke," Review on the Dynamic Characteristics of Micro-grid System" , IEEE Conference on Industrial Electronics and Applications, Singapore, 2011, pp.2069-2074.

[7]. Elaheh Mashhour, S.M., Moghaddas-Tafreshi, "A Review on Operation of Micro Grids and Virtual Power Plants in the Power Markets", IEEE International Conference on Adaptive Science and Technology, Accra, 2009, pp. 273-277.

[8]. Zang, H.,M.Chandorkar, G. Venkataramanan, "Development of Static Switchgear for Utility Interconnection in a Microgrid."Power and Energy System PES, Feb.24-26,2003,Palm Springs,CA.

[9]. R.Chauhan, B.Rajpurohit, S.Singh, and F.Gonzalez-Longate, "DC grid interconnected for conversion losses and cost optimization," in Renewable Energy Integeration ,ed: Springer,2014,pp.327-345.

[10]. L.Xiong, W.peng, and L.Pohchiang, "A Hybrid AC/DC Microgrid and its coordination control," IEEE Transactions on Smart Grid, Vol.2, pp.278-286,2011.

[11]. Q. Fu, L. F. Montoya, A. Solanki, A. Nasiri, V. Bhavaraju, T.Abdallah, and D. C. Yu, "Microgrid generation capacity design with renewable and energy storage addressing power quality and surety," IEEE Trans. Smart Grid, vol. 3,no. 4, pp. 2019–2027, Dec. 2012.

[12]. M. Nick, M. Hohmann, R. Cherkaoui, and M. Paolone,"On the optimal placement of distributed storage systems for voltage control in active distribution networks," in Proc.2012 3rd IEEE PES Int. Conf. Exhibition on Innovative Smart Grid Technologies, 2012, pp. 1–6.

[13].C. Chen, S. Duan, T. Cai, B. Liu, and G. Hu, "Optimal allocation and economic analysis of energy storage system in microgrids," IEEE Trans. Power Electron., vol. 26, no. 10,pp. 2762–2773, Oct. 2011.