Power Management Strategies in Microgrid: A Survey

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Abstract- Since the potential benefits are resulting from the use of renewable energy sources, Microgrid and Distributed Generation (DG) are becoming a significant research area. Microgrid can generally be composed of renewable microsources placed close to the load centre. In order to have control over the real and reactive power of individual DG and for the smooth operation, Voltage-Frequency control and Power management strategy is required in microgrid. Hence the main objective of this article is to make a comprehensive survey on challenges over power management in microgrid. Six different approaches have been studied in detail for AC, DC and hybrid AC/DC microgrid.

Keywords- Microgrid; Distributed Generation; Power Management; Storage Devices; Multi agents;

1. Introduction

Microgrid (MG) concept make reference to a cluster of loads and Distributed generations (DG) which operate as a controllable entity[1] providing electric power (and optionally heat which is known as cogeneration) to its nearest region. The microgrid concept has been implemented to solve the interconnection problem of separate DGs in various power systems [2], [3]. DG systems are decentralized and are located close to the load. An example of microgrid structure is shown in Fig.1. DG systems typically use renewable energy sources like biomass, biogas, solar, wind etc.,are growingly play an vital role in the electric power distribution system [4]. Integration of Distribution energy sources and controllable loads within the distribution network makes an unique challenge to the power management [5].

Fundamentally, microgrid is working in two operating environments [6]. When the microgrid is connected with he utility grid, then it is said to be in the grid-tied mode and when the microgrid is detached from the utility grid then it is in autonomous mode. During fault conditions, microgrid automatically switchs over to the autonomous mode [7].

The issues arises in microgrid could be a challenging one in autonomous mode. The various effects are voltage sag [8], harmonics [9], [10], voltage flickering [11]. To enable smooth and proper working of microgrid, Power Management strategy is vital. This strategy helps i) to control the terminal power of individual DGs [12] ii) to regulate the voltage and frequency of microgrid [13], iii) to have optimum cost [14], iv) power sharing [15] and v) maintain the balance between the power generation and the power demand. Power management of a resilient and sustainable power infrastructure in remote area is a challenging one which provides a reliable and efficient power supply [16]. This strategy is needed for quick operation of a microgrid with multiple DG units particularly in autonomous mode. The microgrid Power management assigns the real and reactive power references for all the DG units to share the real and reactive power requirements of loads among DG units effectively [17].

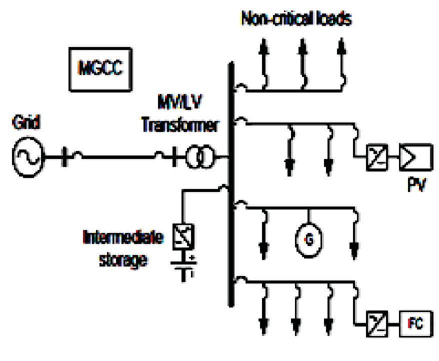

Fig. 1. Structure of microgrid

By considering the above said significance of Power management, this work reviews on Power Management for optimum performance of microgrid with manifold DGs. This paper has been organized into 9 sections. The power management strategy is briefly explained in Section 2. Section

3 describes about the power management in hybrid AC/DC linked Microgrid. The power management technique in DC microgrid is briefly elaborated in Section 4. Section 5 provides the role of energy storage devices in microgrid power management. The utilization of hybrid energy storage is briefly explained in Section 6. Section 7 discusses the power management techniques based on multi agents. Multi-objective optimization based power management is deliberated in Section 8. Finally, the conclusion is stated in Section 9.

2. Power Management Strategies

In general, Power management (PM) planning is done by strategic deployment of DGs in microgrid that involves the determination of best DGs along with its size, position, and the way in which it is interconnected to the system. The block diagram of power management control functions is shown in Fig.2 and its principal task includes:

i) Collecting the information about the microgrid regarding initial cost, power demand and production etc.,

ii) Determining the amount of real and reactive power exchange between microgrid and the main grid.

iii) Stabilizing the microgrid during the transition from grid-tied to autonomous mode.

The Power Management system is classified based on duration as [18]:

i) Long term Power management: preplanning the renewable energy resource management of controllable loads and the provision of ample power reserve.

ii) Short term power balancing: rms voltage regulation, frequency control and instantaneous power dispatch.

3. Power Management in Hybrid AC/ DC linked bus Microgrid

In this section, the authors Dong Bo [19], Hossam A. Gabbar [22], Ye Zhang [23] emulate an outline of power management in Hybrid AC/ DC linked bus. In this section, attempts are made to focus the role of droop control,FACTS devices based on SVC and power flow control in power management. The authors Dong Bo et al. [19] investigates the power management strategy of dissimilar converters in the hybrid AC/ DC linked microgrid in grid tied, stand alone and transition mode using droop characteristics. The microgrid structure consists of AC and DC zone. Battery, super capacitor, PV and Wind turbine with rectifier forms a DC zone. An inverter circuit is used to attach the DC zone with the utility grid (AC Zone). Here the DC bus voltage is controlled by the inverter in grid tied mode and in case of autonomous mode it is adjusted by microsources and storages. Likewise, AC bus voltage magnitude and frequency are synchronized with the utility grid by voltage and frequency droop control of inverters [20] [21].

The author Hossam A.Gabbar et al. [22] discusses the power management using FACTS device. Similar to [19] the microgrid structure comprises of AC and DC subgrid. The variable load used in this system is designed as a typical day of all the four seasons (summer, winter, spring and fall). Static Var compensator (SVC) is engaged as a supervisory controller which is the parallel combination of TSC and TCR. In order to control the active power flow, SVC 1 and SVC 2 are connected in AC and DC subgrid. To achieve the reactive power compensation, equivalent susceptance of SVC is changed by adjusting the firing angle of TSC and TCR. Voltage stabilization and power factor enhancement are done by connecting SVC 3 on load side. The value of Total Harmonic Distortion (THD) is reduced to 30% in grid tied mode and in case of islanded mode it is reduced to 40%.

Ye Zhang et al. [23] extended his research by employing the same approach with hybrid AC/DC microgrid. The power management strategy adopted in this article utilize power flow control scheme that helps to maintain the State Of Charge (SOC) of batteries in appropriate limit, neglecting the over charge/over discharge of batteries and frequent transformation between charge and discharge. The major contribution of power flow control is assigning the highest and lowest values of SOC. By this the lifetime of batteries will get increase.

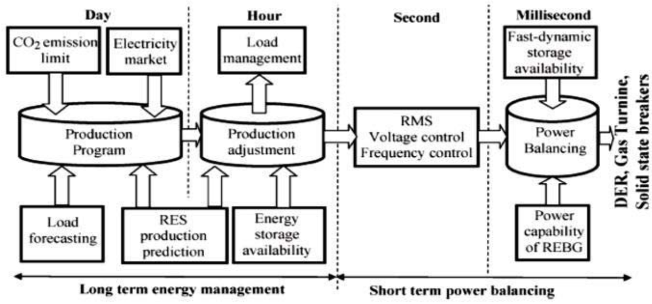

Fig. 2. Classification of control functions for PM

4. Power Management in DC Microgrid

The idea of power management in DC microgrid with the help of super capacitor (SC) as an energy storage was given by Grzegorz Iwanski [24]. This article reveals certain objectives like voltage balance in DC bus, overvoltage protection, and the protection against SC overcharge and deep discharge. The system consists of wind turbine with permanent magnet synchronous generator (PMSG), Power electronics converter that attaches PMSG and DC link and a BI-DC/DC converter which is used to connect storage and DC link. In this Power management technique four PI voltage controllers are involved. Out of this four voltage controller, two controllers will take care of DC bus voltage and the remaining two for protection purpose. During energy surplus, DC link voltage is greater than the voltage of the SC. By this time the energy is transferred from the DC side to storage whereas in the case of energy deficit the energy will flow in the reverse direction. The charging and discharging of SC depends upon the reference current i_{sc}. In power shortage the reference current reaches its positive maximum to withdraw the maximum power from the SC. Whereas in the case of power excess the reference current attains its negative maximum i_{sc} and energy storage attains its maximum accepted value. Hence the overcharge/deep discharge is prevented by maintaining the reference current i_{sc} nearer to zero.

5. Role of Battery based Energy Storage Element in Microgrid for Power Management

In this segment, Power management in microgrid was explored using energy storage elements like composite energy storage system (CESS) [25], super magnetic energy storage systems (SMES) [26] and wireless Power management with battery [27]. Haihua Zhou et al. [25] discoursed about CESS in both grid-tied and autonomous mode. The vital function of the storage is to prevent the load variation, uninterrupted supply and power equilibrium respectively. Since these objectives cannot be achieved by a battery of single type, this paper develops a PV array with composite energy storage system (CESS). This system consists of battery and ultra capacitor with high energy and power density for storage. Power converter modular design is the best approach to attach both battery and ultra capacitor with DC link [25]. To achieve soft switching and high switching frequency operation even at high power levels, Phase shift controlled dual active bridge (DAB) is chosen as the basic module. It is able to transmit the power bi-directionally by modulating the phase shifting between primary and secondary side bridges. Power management scheme by using CESS are analyzed by allocating the demand to batteries and ultra capacitor effectively based on current reference generation, Power management of batteries based on SOC and SOC control of ultra capacitor.

The authors Seung-Tak Kim and Jung-Wook Park[26] is putting forth a new methodology for power management with SMES.The purpose of SMES in grid tied PV array is to reduce the terminal voltage oscillations and to control the real and reactive power which is mandatory to be in the steady state condition. In order to regulate the power from SMES, it is essential to transform the DC current mode to DC voltage mode by implementing the I/V converter. The I/V converter control manage the power on

the basis of SMES current and SMES will operate in 6 operating modes to neutralize the power oscillations. To smoothen the output voltage, SMES entirely governed by the state of charge/discharge under different operating conditions. The operating modes of SMES and corresponding energy flows are represented in Table 1.

Table 1. Operating Modes of SMES

Mode	System control	Condition
1.	PV only	SMES fully charged/discharged
2.	SMES charge 1 mode	PV Farm to SMES
3.	SMES charge 2 mode	Grid to SMES
4.	SMES charge 3 mode	PV farm+Grid to SMES
5.	SMES discharge 1 mode	SMES to grid
6.	SMES discharge 2 mode	SMES+PV farm to grid

Konstantinos O. Oureilidis et al. [27] detailed study explains about the Microgrid Power management technique based on wireless technology. This method helps to maintain the voltage and frequency in an appropriate limit by adopting battery as an energy storage. The charging/discharging of the battery depends on its State of charge (SOC) which should lie in the range of 20%-90% to extend the battery lifetime. Microgrid consisting of two parallel inverters integrated with power resources, battery and constant load. The real and reactive power sharing between the two parallel inverters are attained by the droop characteristics on the basis of virtual impedance control [28], [29]. The virtual reactance is controlled by regulating the real power with frequency and the reactive power with voltage magnitude.

6. Utilization Of Hybrid Energy Storage in Microgrid Power management System

The operation of the microgrid Power management system with Hybrid Energy Storage is briefly shown in Junliu ZhangA [30] and Etxeberria [31]. Junliu Zhang A et al. [30] executes the Power management system (PMS) in standalone mode. In this paper hybrid energy storage system includes the combined operation of lithium battery and super capacitors for both generation and load side management. The role of battery is to smoothen the system output and super capacitors (SC) are responsible for real time power balance and frequency regulation. The charging and discharging time of Lithium battery depends on the output power of Wind/PV. SC employs the comparator which compares the reference power with the regulated power of the microgrid and it is used to eliminate the extra power due to frequency deviation. PMS is operated under 3 cases:

1.Generation management: If the capacity of Lithium battery is overrated then PV with MPPT (Maximum Power Point Tracking) mode shifts to power limitation mode.

2. Load side management - load shedding has to be done for certain controllable loads if the generation is less than the demand.

3. Coordination management- Due to atmospheric condition, it is not possible to maintain the supply and demand in balanced condition. So the combined operation of lithium battery and the SC are required in this management.

Etxeberria et al. [31] extended the above research by employing a Super capacitor (SC) and Vanadium Redox Battery (VRB) as hybrid energy storage. The major venture of this paper is comparing three different topologies(parallel active topology, floating topology and Three-Level Neutral Point Clamped (3LNPC) converter topology).These topologies analyze THD, power losses and reliability. Two different cases are the impact of renewable energy resources i) when the microgrid is attached to the weak grid and ii) when the microgrid is detached from the weak grid. Table 2 shows the THD and the power converters involved in three topologies in two different case studies. In both cases, 3LNPC obtain the best result in THD and so the author concluded that better choice to improve the power quality in hybrid storage microgrid.

Table 2. THD and power converters in three different topologies

Topologies			Parallel DC-DC topology	Floating Topology	Three-Level Neutral Point Clamped (3LNPC) converter topology
First Case (microgrid is attached to the weak grid)	THD (%)	Voltage	3.24	3.22	2.03
		Current	3.96	3.95	3.49
	Power converter in the topology		DC/DC SC,DC/DC VRB and 2L inverter	DC/DC SC, 2L inverter	3LNPC inverter
Second Case (microgrid is detached from the weak grid)	THD (%)	Voltage	3.78	3.68	2.39
		Current	4.98	4.96	3.57
	Power converter in the topology		DC/DC SC,DC/DC VRB and 2L inverter	DC/DC SC, 2L inverter	3LNPC inverter

7. Multi agent Based Power Management

In [32], [33], [34], [38] the authors highlighted the use of multiagent in Power management system. The author Mao Meiqin et al. [32] illustrates the common multi agent based method for the ordered and distributed power control of microgrid. In this method agents with three dissimilar levels are classified and defined. It is used to provide the base for Power management scheme of Microgrid (PMS-MG) and modeled in terms of Client-Server and propagated in C++ environment. The ordered control is used to reduce the complexity of PMS-MG and this control is classified into three stages. They are:

i) Local control stage: Control of voltage, power and frequency, protecting against faults, and control over the operating conditions of equipments.

ii) Central control stage: It involves Supervisory control and data acquisition (SCADA) agent and Economic Dispatch Control (EDC) agent to formulate the stable and reliable micro grid.

iii) Top control stage: Decision making in grid-tied and islanding modes.

The present PMS-MG based on multi agent method consists of Agent server, Agent client and Agent communication. Automatic Generation Control (AGC) is the basic function of PMS-MG that is used to regulate the voltage and frequency. The proposed system analyzes AGC with the help of multi agent.

Frank Ibarra Hernández et al. [33] excellently analyzed the Multi Agent Method (MAM) for real time action of the smart grid. The present approach mainly concentrates on the Power management scheme and regulation of the upgrade behavior of the autonomous microgrid. Additionally the proposed system provides the interactions between PV and autonomous microgrid without the interruption of other generating technology. In order to achieve better accuracy of standalone microgrid , real time action based on MAM is essential . An agent used in MAM is a hardware/software that can act independently with respect to the ecological changes and plan the future action accordingly. The intension of working comprises three types of agents producer agent, storage agent and observer agent.

The simulation is done in RSCAD/RTDS. This power management scheme is capable of extracting maximum capacity from the micro sources. l-Yop Chung et.al [34] extended his research by employing the same MAM to calculate the power production and utilization. This paper develops a MAM controlled microgrid and also establishes the demand response program during energy deficit. Multi agents are implemented using microcontrollers and Zigbee wireless communication techniques for effective communication.

In MAM each intelligent agent take care of the decision making for distributed generations or smart loads Coordination of multiple intelligent agents is a major issue and hence Microgrid Central Coordinator (MCC) is developed. When the MCC receives a control request such as an emergency demand response from the main grid. MCC intimates the agents about the control objective and the agents analyses and send the individual proposal to the MCC. After receiving the proposal, MCC dispatches the control command from the agents. In order to achieve the optimal solution using fuzzy based artificial intelligent algorithms Contract Net Protocol (CNP) is developed [35] [36] [37]. The MCC decides the overall operation of microgrid after receiving the information from the agents. If the information is not enough to meet out the request, the MCC modify the task conditions to lead extra involvement from the agents.

Cheol-Hee Yoo et al. [38] presents the smart control for Battery Energy Storage System (BESS) and the Power management scheme of standalone microgrid using MAM. The proposed system contains two layers in the decision making process that is top layer and bottom layer. Top layer holds the MCC and its operation is explained in [34]. Bottom layer consists of smart agents that decides the optimal operation of a microgrid entities like BESS, backup generators and decision making process in CNP. The proposed scheme is applied to demand response program by analyzing in three different cases:

i) Case1: Operation of microgrid in normal day without Emergency Demand Response (EDR).

ii) Case2: Main grid sends a request to reduce the load slightly during EDR event in peak loading condition.

iii) Case3: Microgrid operation without the prior information of EDR and the main grid asks for heavy load reduction that exceeds the capacity of BESS and the size of convenient loads.

8. Optimal Power Management By using Optimization Techniques

A new methodology is put forth by Xianjun Zhang et al. [16], Martin Strelec et al [39] and Daniel E. Olivares et al. [40] for Power management on the basis of optimization techniques. Xianjun Zhang.et.al [16] work the microgrid system with combined cooling heat and power (CCHP) to enhance the system effectiveness and minimize the ecological problems produced by the animal manure by using multi-objective optimization. The main venture of this work is to enhance the output power and decrease the operating cost. The proposed model comprises of two parts i.e. electrical part and thermal part. Electrical part employs biogas which utilize animal wastes to feed the internal combustion engines (ICES), boilers, and chillers. To increase the system reliability, the cool water and the exhausts from (ICES) are utilized on the basis of thermal system designing. This can be done with the help of refrigerator and heat exchanger which constitutes the thermal part.

Microgrid Power management posses a challenging endeavor for the optimization of unit commitment and economic dispatch and it is addressed by Martin Strelec et al. [39] and Daniel E. Olivares et al. [40]. Martin Strelec et al. [39] introduces a power management based on Approximate Dynamic Programming (ADP) which is an optimization technique that is less complex and faster in nature. In this optimization technique the problem is formulated by i) satisfying the energy balance equations ii) unit commitment and the economic dispatch problem are examined to maximizing the optimal power output and minimizing startup and shut down cost. The different cooling demand, air temperature, and various wind speeds are simulated using two algorithms the first is full dynamic programming approach (FDP) and next is ADP. Full dynamic approach computes the unit commitment and economic dispatch problem without employing the thermal storage. ADP reduces the computational time 50-70% when compared to the FDP. But in terms of cost function FDP will perform better than the ADP.

A different optimization technique in Power management is addressed by Daniel E. Olivares et al. [40]. The optimal Power management is investigated and analyzed based on two main approaches:

i) Centralized Power Management System (CPMS): In CPMS the central controller collects the appropriate information from several agents to perform the optimization and determines the input for the next period.

ii) Distributed Power Management System (DPMS):It provides the market environment where the microgrid agent buying/selling the bids to Microgrid Central Operator (MCO) based on necessity and operating costs through the multi agent system (MAS). DPMS realizes the Unit Commitment (UC) to examine the agents will operate in that particular period.

By considering the advantages and disadvantages of CPMS and DPMS, the conceptual design of CPMS is the better choice for Power management in an autonomous microgrid. Therefore the system is proposed on the basis of CPMS which has two main blocks: Economic load dispatch block (optimal dispatch of Distributed energy resource(DER)) and UC block (optimal schedule of DER).

9. Conclusion

The study extends over the past two decades specify how the microgrid spans over a wide area due to its technical viability. Hence this review is about the challenges over the Power management strategies in microgrid.Considerable onward movement towards energy management principle are highlighted in this survey. Various method of analysis like optimization technique, multiagents, FACTS and storage devices in AC, DC and hybrid AC/DC microgrid are discussed in this review.

References

[1] Alvaro Llaria, Octavian Curea, Jaime Jiménez,HaritzaCamblong," Survey on microgrids: Unplanned islanding and related inverter control techniques",*Renewable energy 36*,pp 2052-2061,2011.

[2] R. H. Lasseter, "Microgrids," in Proc. Power Eng. Soc.Winter Meeting, vol. 1, pp. 305–308, 2002.

[3] P. Piagi and R. H. Lasseter, "Microgrid: A conceptual solution,"in Proc. Power Electronics Specialists Conf., Jun. 2004, vol. 6, pp.4285–4290.

[4] Michael Angelo Pedrasa, Ted Spooner," A Survey of Techniques Used to Control Microgrid Generation and Storage during Island Operation".

[5] Wenbo Shi, Eun-Kyu Lee, Daoyuan Yao, Rui Huang, Chi-Cheng Chu, and RajitGadh," Evaluating Microgrid Management and Control with an Implementable Energy Management System", IEEE SmartGridComm, Venice, Italy, 3-6 Nov. 2014.

[6] ChitraNatesan, SenthilkumarAjithan, Shobana Mani, and PrabaakaranKandhasamy," Applicability of Droop Regulation Technique iMicrogrid - A Survey",Engineering Journal,Volume 18, Issue 3, July 2014.

[7] F. Katiraei, M. R. Iravani, and P. W. Lehn, "Micro-grid autonomous operation during and subsequent to islanding process," IEEE Trans.Power Del., vol. 20, no. 1, pp. 248–257, Jan. 2005.

[8] Puladasuravi, B.Muralimohan, O.Hemakeshavulu," Optimal placement of DSTATCOM for voltage sag mitigation using an anfis based approach for power quality enhancement", International Journal of Electrical, Electronics and Data Communication, , Volume-2, Issue-1, Jan.-2014.

[9] E. Ozkop, A. M. Sharaf, I. H. Altas," A Novel Control Algorithm for Self Adjusting Dynamic Voltage Stabilization Scheme", ElektronikaIrElektrotechnika, , VOL. 20, NO. 3, 2014.

[10] Mehdi Savaghebi,Juan C.Vasquez,Alireza Jalilian,Joseph M.Guerrero,Tzung Lin Lee," Selective compensation of voltage harmonics in grid-connected

microgrids",Else vier Mathematics and Computers in simulation,Vol 91,pp:211-228,May 2013.

[11] M. Gupta, S. Srivastava, J.R.P. Gupta," Online Tracking and Mitigation of Voltage Flicker Using Neural Network", Journal of Control Engineering and Technology (JCET), Vol.2 No.1, PP.43-49,Jan 2012

[12] Li YW, Vilathgamuwa DM, Loh PC ,"Design, analysis and real-time testing of controllers for multibusmicrogrid system",IEEE Trans Power Electron 19(5):1195–1204,2004.

[13] Hatziargyriou N, Asano H, Iravani R et al ,"Microgrids",.IEEE Power Energ Mag 5(4),pp:78–94,2007.

[14] Rosemarie Velik , Pascal Nicolay," Grid-price-dependent energy management in microgrids using a modified simulated annealing triple-optimizer",Applied Energy 130,pp: 384–395,2014.

[15] Xuan Zhang, Jinjun Liu, and Ting Liu," Virtual negatively resistive output impedance for power sharing among paralleled inverters in microgrid", 8th International Conference on Power Electronics ,June 3, 2011..

[16] Xianjun Zhan, Ratnesh Sharma, Yanyi He," Optimal Energy Management of a Rural Microgrid System Using Multi-objective Optimization", IEEE PES,pp:1-8,2012.

[17] F. Katiraei, and m. R. Iravani, "power management strategies for a microgrid withmultiple distributed generation units", IEEE transactions on power systems, vol. 21, no. 4, November 2006.

[18] HristiyanKanchev, Di Lu, Frederic Colas, Vladimir Lazarov, and Bruno Francois," Energy Management and Operational Planning of a Microgrid With a PV-Based Active Generator for Smart Grid Applications", IEEE transactions on industrial electronics, vol. 58, no. 10, October 2011.

[19] Dong Bo, Yongdong Li , and Zedong Zheng," Energy Management of Hybrid DC and AC Bus Linked Microgrid", IEEE International Symposium on Power Electronics for Distributed Generation Systems, pp:713-716,2010.

[20] Chandorkar MC, Divan DM, Adapa R ," Control of parallel connected inverters in standalone AC supply systems". IEEE Trans IndAppl 29(1–1),pp:136–143,1993.

[21] Guerrero JM, De Vicun˜a G, Matas J et al," A wireless controller to enhance dynamic performance of parallel inverters in distributed generation systems",IEEE Trans Power Electron19(5),pp:1205–1213,2004.

[22] Hossam A. Gabbar, Abdelazeem A. Abdelsalam," Microgrid energy management in grid-connected and islanding modes based on SVC", Elsevier Energy Conversion and Management 86 pp:964–972.2014.

[23] Ye Zhang, Hong JieJia, Li Guo," Energy Management Strategy of Islanded Microgrid Based on Power Flow Control", IEEE PES,2012.

[24] GrzegorzIwanski, PawelStaniak, WlodzimierzKoczara," Power Management in a DC Microgrid Supported by Energy Storage", IEEE International Symposium,pp:347-352,2011.

[25] HaihuaZhou,Tanmoy Bhattacharya, Duong Tran, Tuck Sing Terence Siew,and Ashwin M. Khambadkone,," Composite Energy Storage System Involving Battery and Ultracapacitor With Dynamic Energy Management in Microgrid Applications", IEEE transactions on power electronics, vol. 26, no. 3, March 2011.

[26] Seung-Tak Kim and Jung-Wook Park," Energy Management Strategy and Adaptive Control for SMES in Power System with a Photovoltaic Farm", J ElectrEngTechnol Vol. 9, No. 4,pp: 1182-1187, 2014.

[27] Konstantinos O. Oureilidis, Charis S. Demoulias," Microgrid Wireless Energy Management with Energy Storage System", IEEE International Conference,pp:1-6,2012.

[28] Li Y, Li YW ," Power management of inverter interfaced autonomous microgrid based on virtual frequency-voltage frame". IEEE Trans EnergConver 2(1),pp:30–40,2011.

[29] Li YW, Kao CN," An accurate power control strategy for power-electronics-interfaced distributed generation units operating in a low-voltage multibusmicrogrid". IEEE Trans Power Electron 24(12,)pp:2977–2988,2009.

[30] Junliu Zhang, DiankuiGuo, Fengping Wang YuechangZuo, Haiyan Zhang," Research on Energy Management Strategy for Islanded Microgrid Based on Hybrid Storage Device", IEEE International Conference on Renewable Energy Research and Applications,pp:91-96, October 2013.

[31] A. Etxeberria , I. Vechiu , H. Camblong , J.-M. Vinassa," Comparison of three topologies and controls of a hybrid energy storage system for Microgrids", Energy Conversion and Management 54 ,pp: 113–121,2012.

[32] Mao Meiqin, Dong Wei, Liuchen Chang," Multi-Agent Based Simulation for Microgrid Energy Management", International Conference on Power Electronics, June 3, 2011.

[33] Frank Ibarra Hernández, Carlos Alberto Canesin, Ramon Zamora, Fransiska Martina, Anurag K," Energy Management and Control for Islanded Microgrid Using Multi-Agents", IEEE,2013.

[34] Il-Yop Chung, Cheol-HeeYoo, Sang-Jin Oh,"Distributed Intelligent Microgrid Control Using Mul-ti-Agent Systems", Engineering, vol 5, pp:1-6,2013.

[35] Ren F, Zhang M, Sutanto D ," A multi-agent solution to distribution system management by considering distributed generators", IEEE Trans Power Syst 28(2):1442–1451,2013.

[36] Zhao P, Suryanarayanan S, Simoes MG ," An energy management system for building structures using a multi-agent decision-making control methodology",.IEEE Trans IndAppl 49(1):322–330,2013.

[37] Ko HS, Jatskevich J Power quality control of wind hybrid power generation system using fuzzy-LQR controller,IEEE Trans EnergConver 22(2):516–527,2007.

[38] Cheol-HeeYoo, Il-Yop Chung, Hak-Ju Lee and Sung-Soo Hong," Intelligent Control of Battery Energy Storage for Multi-Agent Based Microgrid Energy Management", Energies , 6,pp: 4956-4979,2013.

[39] Martin Strelec and Jan Berka,"Microgrid Energy Management based on Approximate Dynamic Programming", IEEE PES Innovative Smart Grid Technologies Europe (ISGT Europe), 2013.

[40] Daniel E. Olivares, Claudio A. Cañizares, MehrdadKazerani, "A Centralized Optimal Energy Management System for Microgrids",IEEE PES ,July 2011.