International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8 Issue-6S, March 2020

An Anatomization of Microgrids

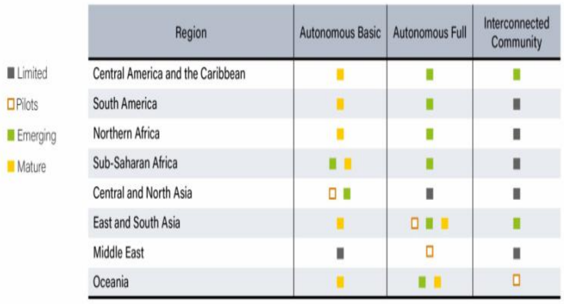
Bharathi V, M V Chilukuri, Arunachalam M

Abstract: ***A microgrid is a set of loads that are connected with each other and distributed energy resources within distinctly designate electrical boundary in such a way, it behaves as a one unit in regard to the grid. A micro grid associated with distributed energy resources (DER) has proved alternate sources of electricity rather than the fossil fuels likecoal. The consequential comfort associated with microgrids has paved the way to extend their perforation in a network of electrical components. There are many challenges and issues in integrating the micro grid to the utility grid. Research activities are in progress to solve the issues like design of a microgrid, control techniques and operating modes such as grid connected or islanded mode. This paper extends an exploration of issues concerning microgrids and furnishes the details of solutions suggested by researchers in areas of microgrids, including microgrid architecture, operation and control, DER, microgrid controllers, converters, energy management, protection and challenges which are yet to be addressed.***

Keywords: ***Microgrids, Distributed energy resources, operation and its control, protection schemes, hybrid energy storage systems, state of charge, power sharing unit, DC/DC converter.***

I. INTRODUCTION

THE MICROGRID, as defined by IEEE JOINT TASK FORCE ON QUADRENNIAL ENERGY REVIEW 2, is “A microgrid is a group of interconnected loads and distributed energy resources within clearly defined electrical border that act as a single capable unit with respect to the grid”. Due to the depletion of fossil fuels, techniques are involved to produce power generation from the natural sources like solar, wind, biomass, ocean energy etc. Microgrid is an amalgamation of distributed energy resources, load, retrievable devices and control devices. The microgrid generates and distributes power in a small scale. Local demands can be met, by operating the microgrids in parallel with the main grid. The interconnection betwixt the microgrid and the utility grid is executed by the microgrid controllers and it is also helpful in meeting the local load demands under islanded conditions. Under islanded condition storage devices like battery can act as a storage system to compensate for the exsiting load demand. The status of microgrid is shown in fig[1] and renewable power generation across the world is shown in fig[2].



	Region	Autonomous Basic	Autonomous Full	Interconnected Community
■ Limited	Central America and the Caribbean	🟨	🟩	🟩
□ Pilots	South America	🟨	🟩	■
🟩 Emerging	Northern Africa	🟨	🟩	■
🟨 Mature	Sub-Saharan Africa	🟩 🟨	🟩	■
	Central and North Asia	□ 🟩	■	■
	East and South Asia	🟨	□ 🟩 🟨	🟩
	Middle East	■	□	■
	Oceania	🟨	🟩 🟨	□

Fig 1: Status of Microgrid [1]

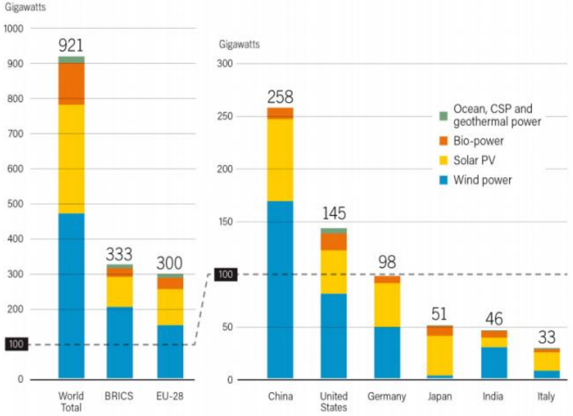


Fig 2: Renewable Power Generation across the world [1]

II. MICROGRID ARCHITECTURE

DC Microgrid architecture is discussed in paper [2]. The paper deals with the different types of DC microgrid configuration, power quality, protection and grounding systems, challenges and issues in DC microgrid. The different types of grounding systems discussed are TT, TN, IT and High resistance grounding. The power quality problems like transient voltage, harmonics, inrush current, faults in DC bus, voltage unbalance are discussed. Challenges like communication network in DC microgrid were analyzed. The efficiency of the DC microgrid can be increased by reducing the number of conversion stages and by increasing the system voltage levels. It was concluded that the non-standardization of DC microgrid acts as a barrier to make it a common grid in use

Hybrid microgrid architecture is discussed in [3]. This architecture uses Power Sharing Unit (PSU) and three numbers of single phase back to back converters (SPBTB) at the point of common coupling (PCC). The function of PSU was power exchange and load sharing. SPBTB converters are designed based on droop control and adaptive back stepping sliding mode control approach which is shown in fig 3. Back to back converters (BTB) were used in previous research

Revised Manuscript Received on March 5, 2020.

Bharathi V is a Research student in VIT University, SELECT, Vellore, India (Email: bharathivijay08@gmail.com).

M V Chilukuri is in association with the Electrical & Electronics Engineering department, SELECT, VIT University, Vellore- 632014, India (Email:mahendra.chilukuri@vit.ac.in).

M Arunachalam, is in association with the School of Electrical and Electronics Engineering REVA UNIVERSITY Bangalore, 560064, India. (Email: arunachalammalaiyandi@yahoo.co.in).

works for power flow control and it is limited for three phase microgrid systems only. PSU is used for power exchange between the phases. Therefore by using PSU, higher efficiency, reliability, utilization of power, uninterruptable power supply etc can be achieved. The PSU efficiency is calculated by observing power generation and load consumption for 30 days. It is observed that without PSU, the primary energy is wasted.

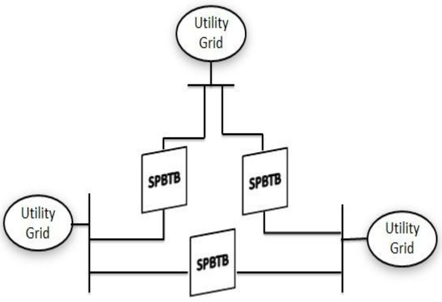


Fig 3.Microgrid Architecture with SPBTB

Hybrid microgrid architectures like single, multiple and complementary ring architectures are discussed in [4]. The design and analysis are made for all the three structures to understand the reliability and fault detection on these structures. The complementary ring formation of a DC microgrid is exhibited in fig 4. In DC microgrid there was no such problems like Voltage, frequency and synchronization. In single ring structure, two users are coupled through a DC bus and their voltage levels are same. Under this condition the two users operate independently. If there is any power failure in any one of the user, the power sharing is done to ensure continuous power supply. In complementary ring structure one arm acts as an AC distribution network, while the other arm acts as a DC distribution network through a bidirectional converter. The two arms are linked to an AC bus. The system reliability is increased and AC/DC converters are minimized and inverter capacities can be reduced.

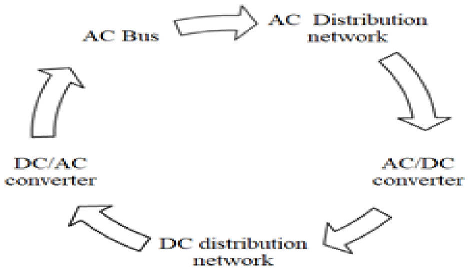


Fig 4.Complementary ring structure.

A microgrid model of power harvesting by Karun ArjunPotty, et al., explained in [5]. This microgrid model is aimed on power harvesting, bidirectional power ability and energy management utilization. The target is attained by employing smart meter and smart station (SS). In this architecture each node as a smart meter and a communication module. The smart meter collects the information from each and every node and calculates the difference in power between the nodes. The power regulation is the main function of smart station. Smart Station uses multiple access technique. The smart station communicates with each and every node at 5s, to know the status of each node. The simulation is carried on ETAP 12.0 and the results obtained from 4KW solar panel are 81%, 5KW wind turbine is 83% and 1KW battery is 81%. The results prove that excess power with good efficiency is fed back to the microgrid. The various Microgrid architecture techniques are shown in Table I.

Table I: Techniques in Microgrid Architecture

Technique	**Functions**	**Reference paper No**
Power sharing Unit (PSU)	Power exchange & load sharing	[3]
SPBTB	overcome the issue of non-linearity	[3]
Single ring architecture	They operate independently	[4]
Complementary ring structure	Reliability is increased and inverter capacity isreduced.	[4]
Smart meter and smart station	Increases the perforation of sustainable sources into the grid.	[5]

III. OPERATION AND CONTROL

In [6] self-governing operation and supervising of an coordinated AC/DC microgrid is discussed. The self-governing operation is carried with the aid of bifacial inverter which acts as an interlinking converter. The inverter used in this paper is Ʈ-Z source inverter which has peak voltage gain and overcomes the disadvantages of a standard converter. In the above mentioned paper, both AC and DC grids are considered as a source and load. The DC grid uses Multiport DC-DC converter. Power management is done with the aid of droop controller. A control strategy of the Ʈ-Z source inverter is simulated with the help of MATLAB with PV power station and a battery unit.

In [7], the operation of a DC microgrid and electric vehicle (EV) as a storage system is performed by Kai Wei Hu, et al., is discussed. The permanent magnet synchronous generator (PMSG), dc supply source, energy management and storage system and grid connected bifacial inverter forms a microgrid. PMSG is most widely used because of its power density, efficiency and torque are higher. The EV process and operation control is explained in fig 5. EV acts as a storage device in order to perform grid to vehicle (G2V) for receiving

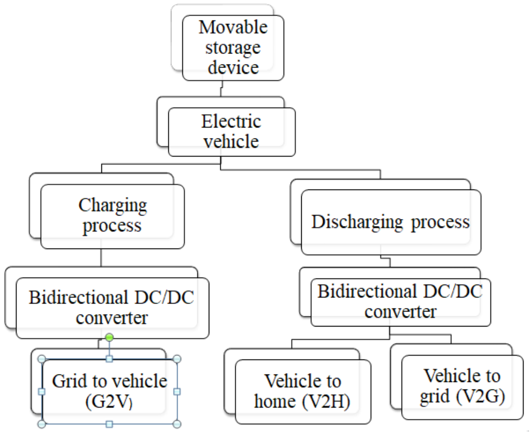


Fig 5. Electric Vehicle (EV) control

electricity and vehicle to home (V2H)/ vehicle to grid (V2G) for delivering electricity operation at idle condition. Charging and discharging operations are performed by bidirectional DC/DC converters.Wind PMSG can be interfaced to a DC microgrid by means of switch mode rectifier (SMR). Vienna rectifier is used because its voltage stress is only half of the other standard SMR, leading to reduction in switching losses. Vienna rectifier holds good for wind generation systems and distributed AC generation system because of i) minimum number of switches ii) voltage stress is less. The tracking error is minimized by the utilization of a control technique known as unified robust tracking error cancellation control (RECC) by inserting a modified command. RECC is used to enhance the robustness of the system.

Different micro source inverter control methods are explained in [8] by WenmingGuo, et al., The different types of micro source inverters are grid feeding inverters(GFD), grid forminginverters (GFM) and grid supporting inverters(GS). The different control methods of an inverter are explained in fig 6. The different microgrid operation and control are explained in Table II.

Table II: Microgrid operation and control

Components	**Functions**	**Reference Paper No**
Electric Vehicle (EV)	Energy storage device	[7]
Vienna Rectifier	Reduce the voltage stress	[7]
GFD	Track the specified power reference	[8]
GFM	Maintain the stability in AC microgrid	[8]
GS	Controlled power and voltage source	[8]
SPLL	To achieve synchronization	[9]
SVPWM	Modulates the output voltage	[9]

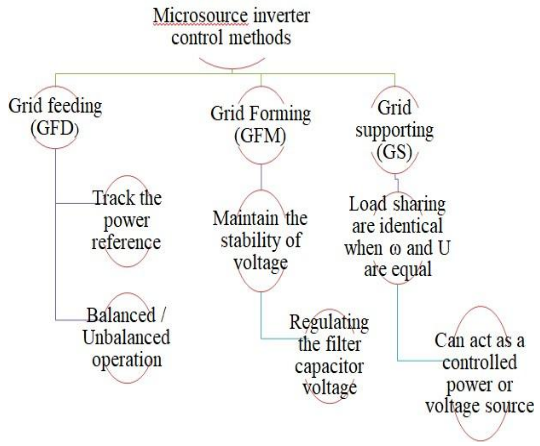


Fig 6. Inverter control methods.

The different droop control methods are PQ droop and ωU droop. ω_0 represents the frequency under no load condition and U_0 represents the voltage under no load condition. ωU droop can act independently while PQ droop cannot. Some problems in ωU droop are line impedance; voltages at point of connection (PC) are not completely equal at each inverter. The above specified issues can be minimized by any one of the following methods such as i) decoupling transformation method ii) virtual impedance method and iii) reactive power sharing method on communication. In ωU droop method, the accuracy of the reactive loading can be improved by reducing the communication requirements.

Two control strategies for different operation modes of a microgridare explained in [9]. When it is grid connection, PQ control strategy is employed for balancing the power. V/f droop control strategy is implemented in islanding mode operation for balancing the voltage and frequency. The voltage of the utility grid is tracked by software phase locked loop (SPLL). The controller in PQ control is a double loop control; reference current loop signal is produced by outer loop control based on power target. Fine tuning is done by the current inner loop. Space vector pulse width modulation technique (SVPWM) modulates the output voltage of current controller to get a modulated sinusoidal signal. Improved V/f control method increases the tracking speed when compared to the traditional V/f droop control. Generally droop control is appertaining to “power frequency static characteristics”. The current controller output varies according to the load, therefore to get a stable output; the voltage controller output is fed as input to the current controller. SPLL is used to achieve synchronization by measuring the angle between the phases and frequency of the microgrid voltage and utility grid voltage.

In [10], the integration of various sources of energy and devices of storage in smart grid is discussed.The detailed generation and storage devices are discussed in Table III.

Table III: Microgrids – Generation and storage

Generation/ Storage	**Pros**	**Cons**
Diesel, Combustion Engine [11]	Start up is fast, load demand satisfied	Noise pollution, emission of harmful gases.
Microturbines [12]	Combined heat and power, less space	Noise pollution.
Fuel Cell [13 – 15]	Power output can be adjusted, Turned on/off.	Expensive, life time is less.
Batteries [16]	Compensates the power requirement	Carbon emission, life time is less.
Regenerative fuel cell [16]	Continuous supply	High losses
Flywheels [17]	Efficiency is high, response is fast.	High losses

Three kinds of power grid systems are modeled and analyzed by developing a theoretical framework. Three systems analyzed are i) System I – power grid with bulk generators ii) System II – power grid with DERs and iii) System III – power grid with DERs and storage devices. Integrating DER to grid can impart an increase in generation of power and reliability, reduce losses during transmission and distribution and are cost effective. Major disadvantage of DER is their uncertainties. The power fluctuation of DER due to uncertainties is compensated by integrating the DER and storage devices. The storage devices act as buffering pools to reduce the power fluctuations increases the reliability and meet the peak load demand.

In [18], the network topology and coordinated planning of various energy resources capacity is discussed. DERs capacity sub-problem can be solved by Adaptive Particle Swarm Optimization (DPSO) algorithm, while the network planning sub-problem can be solved by improved Genetic Algorithm (GA). Planning problems addressed in previous studies are i) DERs capacity planning which deals with siting and sizing ii) network topology planning. The limitation of individual planning (IP) is that, it is not suitable for optimized design. In coordinated planning (CP) the two planning techniques act as an interactive strategy for coordinated optimization. In CP both the DERs potential and network architecture are considered as a resolution variables and combine them under certain curtailment. The major disadvantage of CP are i) unknown factors are more ii) occurrence of frequent power flow variation. Separate algorithms are applied for individual sub-problems to overcome the drawbacks. A case study was performed to compare the strategy between the IP and CP. Results proved that penetration level of DERs is 10.2 MW in CP while it is 9.3 MW in IP. Compared to IP, CP has saved 115 thousand dollars.

Energy storage system like batteries, ultra capacitors or fuel cells for a movable energy storage system along with different power electronics based energy management converters are discussed in [19]. It also explains about the battery and ultra-capacitor (UC) characteristics and a comparison study of various control strategies. In this a battery and UC are considered as a parallel combination and and discussed. UC and battery combined together is called as hybrid energy storage system (HESS). Usually HESS is used because of their reduced size. HESS grouping can be connected either in passive or active. Actively connected HESS configuration is costly since it utilizes power electronic devices and regulates the transfer of energy. Battery storage unit is required for balancing load power requirement. DC/DC converter controls the UC which receives a power demand from vehicle. Functions of converter components are briefly explained in Table IV.

Table IV: Task performed by the converter elements.

Component	Functions	Reference paper no
Flyback DC-DC converter	Bifacial power transition between grid and energy storage device takes place in only one step	[20]
Gate assisted circuit (GAC)	Switching losses is reduced and parasitic parameters can also be mitigated	[21]
LCL inverter	Less device and switching loss, high switching speed and temperature stability	[22]

There are three modes of operation of DC/DC converter.They are i) battery and UC – if power demand is not met by UC then the remaining power is supplied by the battery. ii) At low loads the battery supplies the power to the load while the UC is getting charged. iii) During regenerative mode (braking), UC is getting charged to the full capacity and the power which is in excess is used to charge the battery. Efficiency can be increased by the use of small size battery with lower peak power output. UC are used for increasing the acceleration and regenerative braking. In future, steps can be initiated to minimize the size and cost by comparing the different combinations of battery and UC.

IV. MICROGRID CONTROLLER

Microgrid controller requirement, performance evaluation, integration with DERs and distributed management systems is discussed in [23]. Microgrid controller provides two main objectives. They are i) by means of resiliency it provides continuous power to critical loads during islanded mode ii) it reduces operating costs, increases penetration level, reduces greenhouse gas emission and grid reliability is improved. Microgrid controller performance is tested in laboratory. Laboratory evaluation is done for two goals. First goal is to verify whether the microgrid controller performs as specified. IEEE standard P2030.8 focuses on testing of microgrid controllers. IEEE P2030.7 focuses on control functions. Second goal is to undergo several microgrid controllers for the same test. Purpose of this evaluation is to provide the information about their product's performance. Third goal is the site specific microgrid performance evaluation. There are several approaches to carry out this site specific microgrid performance evaluation. First approach is the simulation. Simulation software is Controller- HIL (CHIL), where the hardware is interfaced with the simulated microgrid. Limitation of CHIL is that, depending on the real time simulator capability and capacity, the electric power system must be simplified. Second approach is the power-HIL (PHIL). It uses the actual hardware or a representative model with similar characteristics. This method reduces the inaccuracies. Limitation is, PV inverters cannot be modeled accurately and interfacing power hardware has more complexities.

GridSTAR microgrid is explained in [24]. It constitutes critical loads and DERs. It can be intervened as a standalone or it can be connected to grid. GridSTAR microgrid has a Grid Network Operating Center. In GridSTAR microgrid, all power supply resources are inverter dependent units so that it may operate in standalone mode with the accessible DERs. In islanded mode, energy storage facility acts as a primary source of power. Energy storage equipment incorporates batteries, inverter and an energy management system. Facilities like real time monitoring and control are included in GridSTAR microgrid. This enables excessive speed transition to islanded mode. A digital relay is used to isolate the faulted system grid connected mode and provides information such as loading in line, microgrid voltage controller output is fed as input to current controller. SPLL is used to achieve grid synchronization. Reconnection and resynchronization is ensured by microgrid control system,when the difference in frequency is within limit and when magnitude of voltage and variations in phase angle are bounded by limits. Cost optimization and control is accomplished by microgrid automation controller.

Networked microgridsare explained in [25]. Interconnection of adjacent microgrids is called as networked microgrid. Benefits of installing networked microgrids are i) provide additional operational flexibility ii) utilization of DERs more effectively iii) reduction in generation capacity iv) loads can be optimized more comprehensively v) reliability & resilience of power services are boosted. ICM and BCM are connected to the utility grid through the switches which acts as a PCC. Disconnection of these switches results in islanded mode. ICM & BCM are integrated through a interlinking converter (IC), which provides bidirectional power flow and is parallel to distribution feeders. Each microgrid has a master controller (MC) which communicates with each other through the communication links. If microgrid frequencies are same, IC simply acts as a tie trunk, interconnecting the two microgrids.The MC operation and control objectives are achieved by OSI soft PI system is a system which pulls together and harmonize the real time information with themicrogrid data.

Microgrid control framework is explained in [26]. Control strategyof microgrid is classified into three layers – primary, secondary and tertiary. Primary control is performed by the droop control methods. Advantages of droop control methods – fast response, reliance on local measurements, communication link independence etc. The major disadvantage of droop control method is its frequency deviation. This leads to increase in circulating current and system instability in islanded mode. In- order to overcome the frequency deviation a secondary control is introduced is shown in fig 7. In secondary control, entire system voltage and frequency values are armed to a reference point. Tertiary control uses model based control functions which includes economic dispatch, optimal power management and power scheduling and planning.

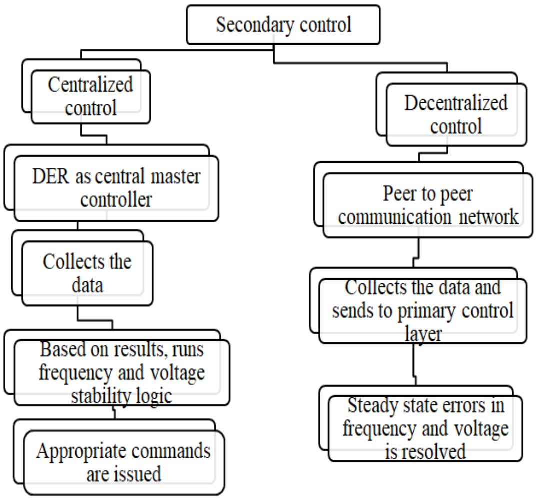


Fig7: Hierachy of secondary control

The DC microgrid stability, distributed architecture and load sharing is discussed in [27]. Stability is achieved with the help of sliding mode (SM) controller. It uses low bandwidth for communication. SM controller maintains stability throughout operation of the system, whereas conventional central controller will lose its stability at one particular instant of time during its operation. The advantages of SM controller are i) high stability ii) dynamic response is fast iii) maintain stability even when there is large variations in load. Aggressive operation of the system is modeled for under damped. Operation is carried out for damped systems also. SM controller is simulated and its performance was observed to be good compared to conventional central controller.

V. CONCLUSION

The current growing technology across the globe is the penetration of microgrids that leads to several summons and contingencies. This paper aimed to deliver an anatomization of microgrids which helps the researchers, educators and developers in acquiring knowledge about the microgrid architecture, protection, control and challenges in integrating it to the grid. In future the hybrid system may consist of bio mass and micro turbines and will play a vital role in real time applications with this energy sources. In future the generating capacity of off shore wind turbines will increase, which will increase the nation’s economic growth. In future advanced microgrid technologies such as optimization, interoperability, resilience and carbon abetment will be a risk of perception to the utilities and developers. The extent of microgrid will see a great transformation in the grid architecture.

REFERENCES

1. REN21, Renewables 2017, Global Status Report.
2. Dinesh Kumar, FiruzZare, ArindamGhosh, “ DC Microgrid Technology : System Architecture, AC Grid Interfaces, Grounding Schemes, Power Quality, Communication Networks, Applications and Standardizations Aspects”, IEEE Access Power Quality and Harmonics Issues of Future and Smart Grids, vol. 5, pp.12230-12256, June 2017.
3. Qiuye Sun, Jianguo Zhou, Josep M Guerrero, Huaguang Zhang, “Hybrid three phase/ single phase microgrid architecture with power management capabilities,” IEEE Trans. Power Electron., vol. 30, no. 10, pp. 5964-5977, Oct.2015.
4. JIA Lihu, ZHU Yongqiang, WANG Yinshun, “Architecture design for new AC-DC hybrid microgrid,” DC Microgrids (ICDCM), 2015 IEEE International conference, pp. 113-118, July2015.
5. Karun Arjun Potty, PramathKeny, Chandrasekhar Nagarajan, “An intelligent Microgrid with distributed generation”, Innovative Smart Grid Technologies – Asia (IGST Asia), 2013IEEE.
6. M. Poursmaeil ; Sh. MoradinejadDizgah ; H. Torkaman ; E. Afjei, “Autonomous control and operation of an interconnected AC/DC microgrid with Γ-Z-Source interlinking converter”, 2017 Smart Grid Conference (SGC), 08 March 2018.
7. Kai Wei Hu, Chang Ming, “Incorporated Operation control of DC microgrid and Electric Vehicle”, IEEE Trans.On Industrial Electronics. vol. 63, No 1, Jan 2016.
8. WenmingGuo, Longhua Mu, “Control principles of micro source inverters used in microgrids”, Springer, 2016.
9. Yinghui Han, Mingchao Xia, Xiaoyu Hong, Mengyun Ye, “A smooth transition control strategy for microgrid operation modes”, Elsevier, in Energy Procedia, 2014, pp.760-766.
10. GuobinXu, Wei Yu, David Griffith, Nada Golmie and Paul Moulema, “Toward Integrating Distributed Energy Resources and Storage Devices in Smart Grid”, IEEE Internet of Things Journal, vol. 4, No 1, Feb2017.
11. Akorede MF, Hizam H, Pouresmaeil E, “Distributed energy resources and benefits to the environment”, Renewable Sustainable Energy Rev, vol. 14, pp. 724–34, 2010
12. Bayindir R, Hossain E, Kabalci E, Perez R, “ A comprehensive study on microgrid technology”, Internatinal Journal of Renewable Energy Res, vol.4, pp - 1094–107,2014.

13. Kirubakaran A, Jain S, Nema RK. A review on fuel cell technologies and powerelectronic interface. Renew Sustain Energy Rev 2009;13:2430–40.
14. Mekhilef S, Saidur R, Safari A, “Comparative study of different fuel cell technologies”,Renew Sustain Energy Rev, pp. 981–988, 2012
15. Neef HJ, “International overview of hydrogen and fuel cell research”, Energy, pp. 1-5, IEEE 2016.
16. Abusharkh S, Arnold R, Kohler J, Li R, Markvart T, Ross J, “Can microgridsmake a major contribution to UK energy supply?”, Renew Sustain Energy Rev, pp. 78- 127, 2006
17. Díaz-González F, Sumper A, Gomis-Bellmunt O, Villafáfila-Robles R, “A review ofenergy storage technologies for wind power applications”, Renew Sustain EnergyRev, pp. 2154–71, 2012.
18. Xiang Guo, He Guo, Haozhong Cheng, “Coordinated planning of distributed energy resources and microgrid network”, IEEE Transmission and Distribution Conference and Exposition, July 2016.
19. Z. Amjadi, Z. and S. S. Williamson, "Power-electronics-based solutions for plug-in hybrid electric vehicle energy storage and management systems," IEEE Trans. Ind. Electron., vol.57, no.2, pp.608-616, Feb.2010.
20. Yeong-SeungJeong, Sung-Ho Lee, Seo-GwangJeong, Jung-Min Kwon and Bong-Hwan Kwon, “ High efficiency bidirectional Grid-Tied converter using single power conversion with high quality grid current”, IEEE Trans. On Industrial Electronics, May 2017.
21. Shan Yin, K.J.Tseng, RejekiSimanjorang, Yong Liu, JosepPou, “ A 50-KW High-Frequency and High-Efficiency SiC Voltage source inverter for more Electric Aircraft, IEEE Trans. On IndustrialElectronics.
22. Yang Han, Xiao GaoXie, Hao Deng, Weizhong Ma, “ Central energy management method for photovoltaic DC microgrid system based on power tracking control”, IET Renew. Power Gener., vol. 11 Iss. 8, pp. 1138-1147,2017.
23. ArindamMaitra, Annabelle Pratt, Tanguy Hubert, Dean Weng, KumaraguruPrabakar, RachnaHanda, MuraliBaggu and Mark McGranaghan, “ Microgrid Controllers”, IEEE Power & Energy magazine, pp. 41-49, July2017.
24. R.Uluski, J.Kumar, S.S.Venkata, D.Vishwakarma, K.Schneider, Ali Mehrizi-Sani, Rudy Terry and Will Agate, “Microgrid Controller Design, Implementation, and Deployment”, Microgrid Controllers”, IEEE Power & Energy magazine, pp. 50-62, July 2017.
25. Mohammad Shahidehpour, Zhiyi Li, Shay Bahramirad, Zuyi Li and Wei Tian, “Networked Microgrids”, IEEE Power & Energy magazine, pp. 63-71, July2017.
26. Alex Rojas and Tamer Rousan, “MicrogridControlStrategy”,IEEE Power & Energy magazine,pp. 72-79, July 2017.
27. Muhammad Rashad, UzairRaoof, Muhammad Ashraf, and Bilal Ashfaq Ahmed, “Proportional Load Sharing and Stability of DC Microgrid with Distributed Architecture Using SM Controller”, Hindawi Mathematical Problems in Engineering Volume 2018

AUTHORS PROFILE

Bharathi Vgraduated in BE Electrical & Electronics Engineering from St. Peter’s Engg College in the year 2004. Completed her PG in Instrumentation Engineering in the year 2011. She has a total teaching experience of 13 years. Her publications are 2 - National and International Conference, 4 – in International Journal. She is a member of IEEE from 2016. She is pursuing her PhD in VIT University, Vellore. Research topic is “Integration of microgrid with the utility grid”.

M V Chilukuri graduated with BEngg in Electrical and Electronics Engineering, MEngg in Power Systems and Automation from the Andhra University, India and PhD in Electrical Engineering from Multimedia University, Cyberjaya. He was a Lecturer at Faculty of Engineering, Malaysia from 2001-12. He was an Assistant Professor at the Department of Electrical and Electronics Engineering, University of Nottingham Malaysia Campus from 2012 – 2015. From May 2016 he is working as an Associate Professor, in School of Electrical Engineering, VIT University, Vellore, India. His fields of research include Power Quality, Partial Discharges, Condition Monitoring, Distributed Generation, Smart Microgrid, Time-Frequency Analysis, Pattern Recognition and Green ICT. He was MNC-CIGRE (2005 – 2007), MNC-CIRED (2005 – 2011), IEEE PES, IAS and PELS. Currently, he is member of IEEE P825 Working Group on Transactive Energy.

Arunachalam M graduated with B.E- Electrical Engineering from Madras University in the year 1970 and M.Sc (Engg) in Power System Engineering from Madras University in the year 1972 and PhD from IIT Kanpur in the year 1978.

He joined BHEL in Electronics Division in 1978 and continued till 2008.During his service in BHEL Electronics Division, in different capacities and was a General Manager at the time of his superannuation and he continued at BHEL as a Senior Specialist from 2008 till 2012 in the area of HVDC and FACTS. His areas of interest in research are High Power Converters and Controls for HVDC and FACTS. He is a member of various committees like National committees and International working Groups (CIGRE). He is a Senior Member IEEE and a Fellow of Indian National Academy of Engineering. He has been awarded Distinguished Visiting Professorship under AICTE-INAE DVP scheme. He received BHEL EXCEL awards in the year 2001-02, 2002-03 and 2004-05. He also received an innovative project award in the year 2013 for the project “Development of Controller for TCSC”. His publications are in national and international conferences, workshops and journals. He is co-inventor in seven patents, out of which six have been already granted. He has got about 34 years industrial experience in Product design, Engineering and Development and about 7 years in teaching. Since January 2013 Dr.Arunachalam is with RajaRajeswari college of Engineering as Professor in Electrical and Electronics Engineering Departmenttill Jan 2018. At present associated withthe School of Electrical and Electronics Engineering REVA UNIVERSITY Bangalore.