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Growth of Microgrids and New Possibilities: A Review in Indian Scenario

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ABSTRACT

Renewable Energy (RE) has come in the main streamline of the electrical power system as the environmentalstandards are taken seriously like never before. With the increase in several renewable sources, new modes to use them are being developed. Also, the Distributed Energy Resources (DER) of various kinds are operating to provide a reliable power supply. This gave rise to Microgrids which are serving loads with various DERs together. As energy management is getting more and more efficient and effective, these Microgrids are proving themselves a reliable source of electrical power in remote places. India focusing on RE has rapidly developed mechanisms for getting ahead in protecting the environment and simultaneously providing power supply to remote places with the mission of 100 percent electrification targets. This in turn made the Indian government draft new policies. That's the reason why India is looking forward to more Microgrids. The discussion and review of the increase in Microgrid projects and new possibilities are discussed in this work.

Key words: Renewables (RE), Distributed Energy Resources (DERs), Microgrid (MG), Networked Microgrids

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INTRODUCTION

MICROGRID (MG) is the new technological application that has been developed in the electrical power sector. MG have proved their effectivenessin various ways. Distributed Energy Recourses (DERs) are there since very long, but as the DERs operated individually may not be sufficient to serve the load, and also there may be under-utilization of these resources. It has been then found by various ways that the possibility of using DERs together can make the more reliable and stable source of power serving load if managed properly. this led to the development of MGs. One of the biggest advantages of MG is that it operates in both Islanding and Grid-connected mode. As far as India is concerned the Government looksforwardto this technological advancement and the falling prices of solar photovoltaic made it feasible technically as wellas economically.

According to Union Minister, around 63 MGs totaling 1,899 kWp have been installed in India by 2018 totaling 1,899 kWp. and Government of India, Ministry of New and Renewable Energy (MNRE) has planned 10,000 such MG projects across India. Though the Government of India looking for remote electrification with MGs in addition to that MGs possess other possibilities like supporting the main grid in case of emergency.

The discussion on the current MG development keeping Indian development towards MGs and remote electrification along with added Possible benefits of these is done. Also, a constraint discussion on MGs acrossanother part of the world is included in this work. This will help in finding new developmental approaches related to MGs for the future. one such approach of Networked Microgrid for Indian Scenario is proposed in this work.

PREVIOUS WORK

According to the U.S. Department of Energy, “a microgrid is a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity concerning the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island mode. The development of MGs in India has been rising due to the high penetration of RE sources. Various studies are done in developing MG models. These models are normally specific to the application requirement or one can say, custom models. The needfor rural electrification had limitations mainly due to inaccessible villages. Varioustechno-economic studies have been done in this area to show the economic fusibility or techno-economic feasibility of such projects.

A. Techno-Economic feasibility

A general discussion about the Techno-Economical part of MG is done in a constraint way just to give a basic awareness which is important for work. The technological feasibility related to [1] has discussed in detail the annualized life cycle costs (ALCC) of the project for the same load with load pattern, several households, length of distribution network. This enables the techno-economic choice based on such factors for MG projects. The Microgrid’s feasibility issues have been discussed by [3] so that MGs become an operationally a possible option in India. According to reports [4], the MGs in India along with Minigrids could provide a reliable and stable option for various energy needs which are generated by various schemes of the Government of India towards providing energy for the remotest part of India. Government of India panning to Provide Solar Powered Internet Access to 250,000 Villages. This program may also be deployed with RES and Solar MGs. All this is due to the new possibilities which are opened by MGs. All the discussion above is mostly related to the economic policies and economic feasibility of the Indian Governmentsimultaneously studies are done to find the technical feasibility as well. which include the Operational feasibility. A ‘Mini Grid’ is defined as a system having a RE based electricity generator (with a capacity of 10KW and above), and supplying electricity to a target set of consumers (residents for household usage, commercial, productive, industrial, and institutional setups, etc.) through a Public Distribution Network (PDN). A ‘Micro Grid’ system is similar to a mini-grid but has a RE-based generation capacity of below 10KW. Micro and mini-grids generally operate in isolation to the electricity networks of the DISCOM-grid (standalone), but can also interconnect with the grid to exchange power. If connected to a grid they are termed as grid-connected mini/micro grid [2]. The Indian models of rural MGs are discussed in detail with cost per unit, operation and maintenance cost with the overall cost of kWh per household when used with Diesel and Solar MG is shown by [16].

B. Components of a Microgrid

The major components of Microgrid are Distributed Generations (DGs), Loads, Storage devices, Control center, Point of Common Coupling.

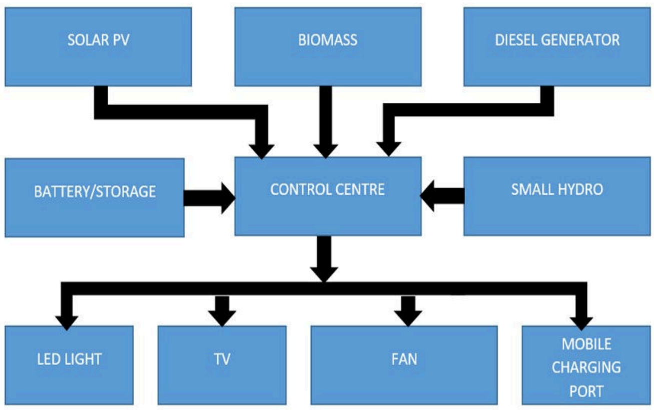


Fig. 1 Typical MicroGrid Structure

The above block diagram is as per the minimum requirement mentioned in the Rural Electrification mission of Govt. of India MNRE. It may miss some sources like Wind generators, this is because wind generation in India isn’t considered one of the most feasible options. whereas solar PVs will be employed more than any other source of power. Diesel generators are also the most used methods for power generation in non-electrified areas, wherethey may serve as emergency power supply.

Microgrids and Minigrids look almost the same the difference only is in the scale of power generate and load served. These could differ in different countries, so this kind of network will be called Microgrids unless specified. The work is in progress in the area of renewable energy is very significant from the rising penetration of Solar PV and Microgrids point of view. Microgrids provide various benefits like Resiliency, Reliability, power quality enhancement, reduced emission, also it has the islanding capability to provide reliability in case of faults and disturbances.

C. Modes of Microgrids

Various modes of Microgrid are the campus, commercial, residential or community, and military microgrids. Based on voltage and current, they can be classified as AC microgrid, DC microgrid, and hybrid microgrid.

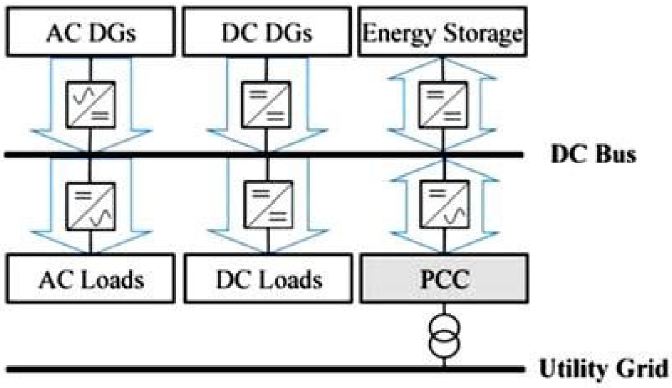


Fig. 2 DC Microgrid

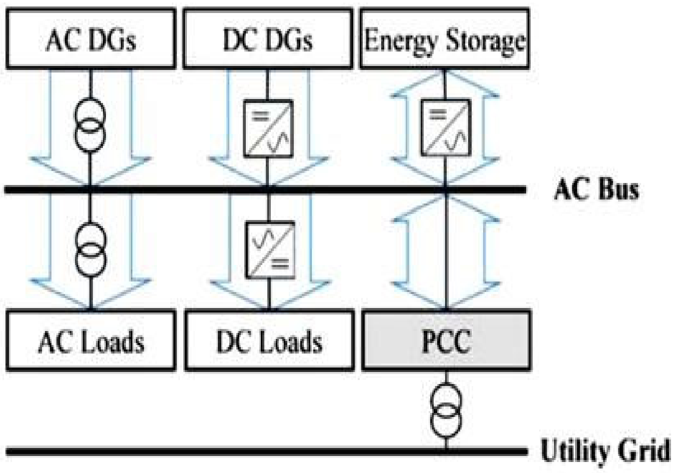


Fig. 3 AC MicroGrid

Microgrid Connection shown in the figure isthe most frequently used configuration because of the obvious nature of the mode of power used i.e. AC and DC. The figure for AC and DC microgrids are proposed by [5] seem to be simple and technically feasible models. The Hybrid model proposed by [7] gives a good option if the microgrids of different nature are to be interconnected.

In ac microgrids, all DERs and loads are connected to a common ac bus. DC generating units, as well as energy storage, will be connected to the ac bus via dc-to-ac inverters, and further, ac-to-dc rectifiers are used for supplying dc loads. In dc microgrids, however, the common bus is dc, where ac-to-dc rectifiers are used for connecting ac generating units, and dc-to-ac inverters are used for supplying ac loads. In hybrid microgrids, which could be considered as a combination of a.c and dc microgrids, both types of buses exist, where the type of connection to each bus depends on the proximity of the DER/load to the bus.

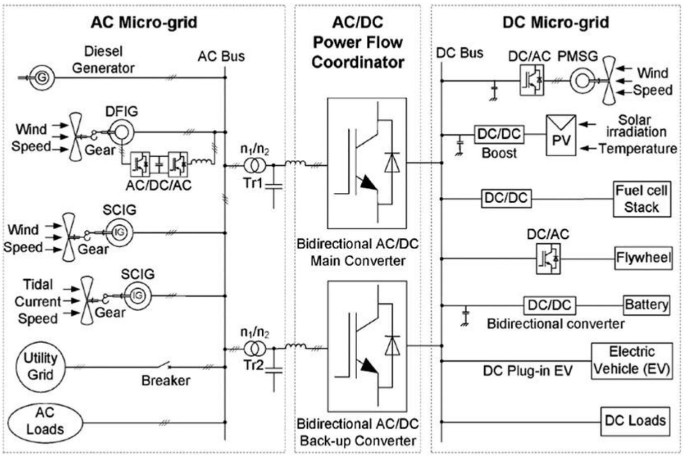


Fig. 4 Hybrid Microgrid [7]

Various studies are being done on microgrids so far. The microgrids their interconnection are also studied separately. The studies on the connection of microgrid to the AC grid are also available in the literature. DC microgrids have some advantages compared to ac microgrids these are- increased efficiency and fewer losses because of reduction in converters used for dc loads, DC microgrids can be easily integrated dc DERs to the common bus with simplified interfaces, also it can supply more efficient to dc loads, electric vehicles and LED lights, No need for synchronizing of generators [7].

METHODOLOGY: NETWORKED MICROGRID SYSTEM

The operation of multiple microgrids in coordination with the distribution system enables high penetration of locally available distributed energy resources. This approach enhances the reliability and resiliency of the power supply significantly. Also, the overall cost of energy gets reduced because of the integration of cost-free power from PV panels and wind turbines. The most effective utilization of distributed energy resources can be achieved through networked Microgrids. However, the implementation of the concepts of networked microgrids requires extensive research [6]. Interconnection of multiple self-governed microgrids is emerging as one of the best alternatives to improve the resiliency and reliability of power system networks. It can provide suitable electric infrastructure to utilize cost-effective and environmental-friendly electric power generated from distributed energy resources [7]. Microgrids are designed as entities to integrate clusters of renewable and non-renewable distributed generations to supply loads within a clearly defined electrical boundary. These MGs can sell their excess power to the distribution grid in grid-connected mode or operate automatically in islanded mode [8]. Renewable DGs include solar PV panels and wind turbines (WTs), whereas non-renewable DGs include diesel engines (DEs), Micro-Turbines (MTs), fuel cells (FCs), and combined heat and power plants [9]. Advanced control and communication technologies enable the operation of multiple MGs in coordination with the distribution system to supply day-to-day growing electrical energy requirements efficiently. Networking of multiple Microgridseither to the grid or another grid-connected or isolated MG can enable a more reliable and economic power supply to the consumers [10]. A study by [11] shows that the interconnected mode can also be cost-effective. In case of emergencies, the interconnected and networked microgrids can support the conventional power stations, giving increased resiliency to the system [12].

A simple example of a typical Distributed System with networked MGs is shown in figure 5 (an IEEE 33 Bus system). The MGs shown are capable of operating separately as paper their nature and also in the interconnected modes if the switches provided are worked out. This is only a hypothetical connection of MGs but itsurely can be worked out. As this can be seen from figure 4 that the MGs if operated with proper management can be an advanced network that will not only provide green power supply but also the in case of fault or abnormal condition. The system below is a primary network worked out in the initial stage of studies.

It can be seen in figure 5 MG1 is capable of working in Islanded mode serving local load or in cooperation with the main grid when connected through PCC when SW1 is closed. Similarly, MG3 is capable of working of both Islanded or grid-connected mode and also with enhanced connection modes with proper arrangement of SW3 and SW2. There are more possible modes of connecting MGs and the number of MGs. one such arrangement is discussed by [6]. The above system is more suitable for the town or city areas.

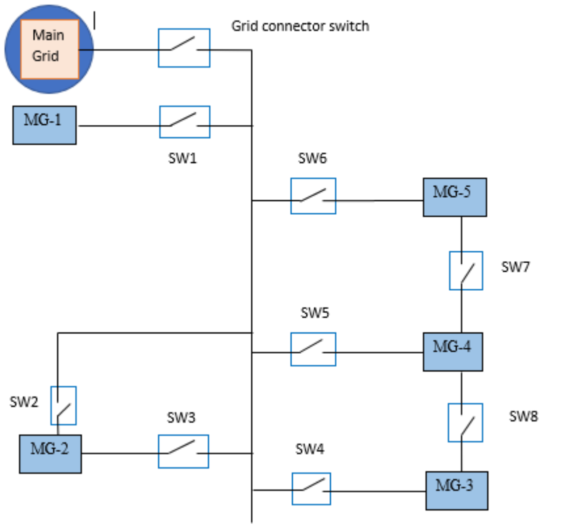


Fig. 5 Connection of Networked MGs

If one considers the Indian scenario then MGs are mostly are being installed in remote areas there may be connected in various modes shown in figure 6 below.

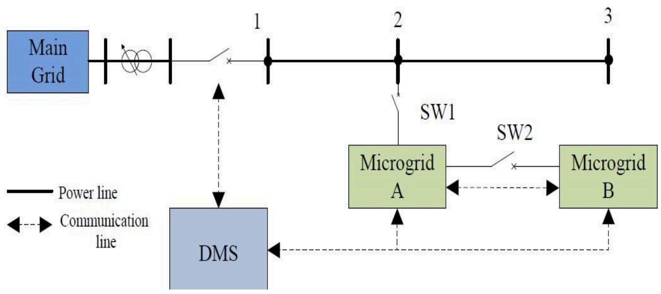
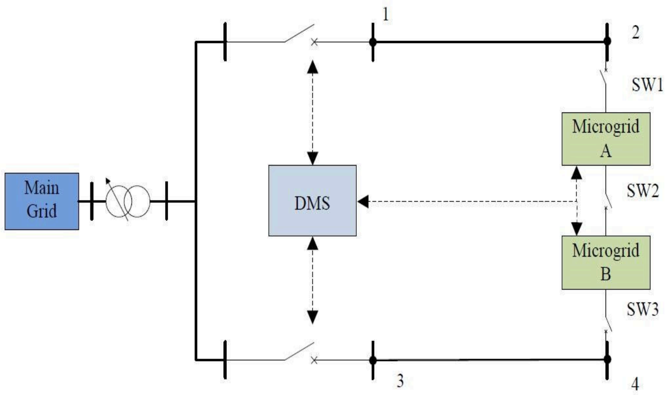
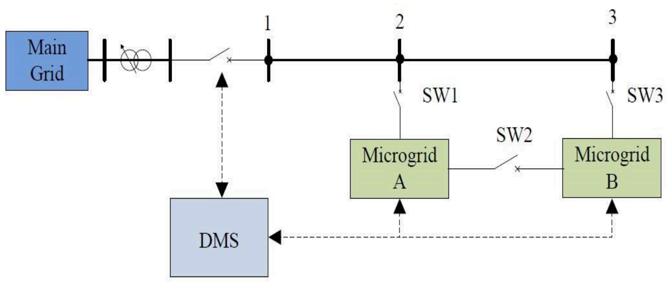


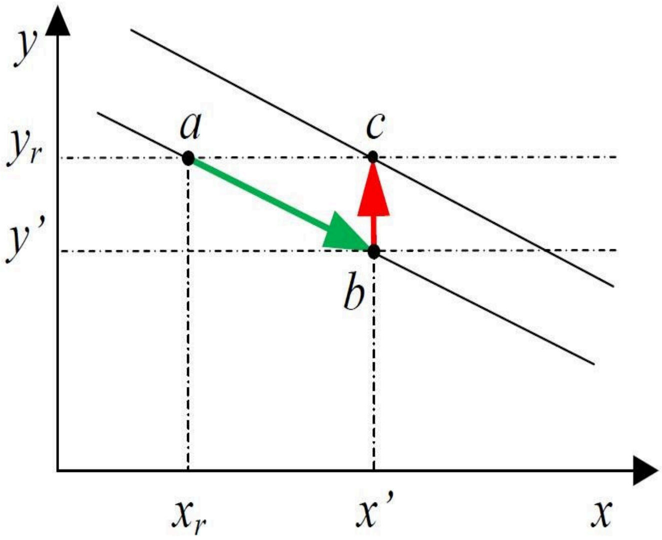
Fig. 6 Typical architecture of networked MGs**.**



(a) Serial MGs on a single feeder of DS



(b) Interconnected MGs on many feeders



(c) Interconnected MGs on many feeders

Fig. 7 (a), (b), (c) Generalized networked MGs droop characteristic

The configuration shown above can be categorized as Series connection of MGs, Parallel connection of MGs, and interconnection of MGs on more than one feeder. In the Indian scenario, there would be a group of MGs in nearby villages which can be interconnected also one or more such groups or groups of MGs with one or more MGs could also be formed. This kind of con should also be a very good enhancement of the Indian village MGs. If a village contains Hospital which is working with or without MG may need an emergency supply in case of Natural abnormalities. In such a situation theNetworked MGs could provide enhanced Reliability and Stability.

One of the major aspects of the MG is Control. Here a constraint view on control strategy is included. Mainly Hierarchical control strategy and Distributed control strategy are employed for management and control of MGs.

The islanding and grid-connected operation of each MG is another important task of the networked MGs controller. The optimal load sharing among all MGs in networked MGs and among dispatch able DERs within each MG are performed using various droop characteristics. Normally, the following four types of droopcharacteristics control are required to operate networked MGs. These characteristics are: a) Active power–frequency (Pac–f) droop, b) Reactive power– voltage (Qac–Vac) droop, c) DC power–voltage (Pdc–Vdc) droop, and d) interlinking converter droop. Mathematically generalized droop characteristics are as follows

$$y = y_r - \lambda * (x - x_r)$$

where x and y are correlated variables and y can be regulated by changing x for a control entity; xrand y_r are the reference values of x and y, respectively; and is the droop coefficient with a positive value.

As shown in figure 7 the generalized droop characteristics for networked MGs the control entity x changes from its reference value or to x' (a to b in figure 7), due to this correlated regulating variable y changes from its reference value yr to y', then corrective action is taken to restore regulating variable y to its original values yr. Thus, the operating point shifts from b to a new point c and stabilizes the performance of the system for the new value (x') of the control entity x. In networked MGs, x, y, and represent different meanings for determining droop characteristics for different control entities. Table I gives a summary of various droop characteristics used in networked MGs. The detailed description of various droop characteristics suitable for the control of entire networked MGs is thoroughly discussed in[6].

Table -1 Droop Characteristics in Networked MGS

Control Entity	x	y	L
Active power in AC MGs/section	Pac	f	kP
Reactive power in AC MGs/section	Qac	Vac	kQ
Power in DC MGs/section	Pdc	Vdc	mP
Interlinking converters	Pic	E	nic

Hierarchical Control Strategy: The hierarchical control has primary, secondary, and tertiary levels. This is a versatile tool in managing the static and dynamic operation of MGs, and same time keeps an eye on economical constraints. It involves various layers and the control center has all the control over MG operations [14].

2) Distributed Control Strategy: In distributed control strategy MGs operate and control individually, [15]. Individual MG shares information with the MG controls. This is more suitable in the case where the expansion of MGs in-network is necessary. So, the plug and play become easy and Networked grid expansion becomes less complex.

This article provides a brief discussion of increasing MGs in India. Though the work on Networked MGs is in progress still the stable and reliable Networked MGs are awaited. A small attempt of review of MGs for Indian condition is tried here, which could be a valuable asset for future in providing reliable power economically to remote villages in India. The control strategies which are thought to be the major strategies of control in future MGs are only included in the discussion so that the work about MGs could be narrowed in the proper direction.

CONCLUSION

Microgridsare proving their way to the future energy option. Microgrids management has made Microgrid more feasible economically and technically. As the Government of India is providing fuel to the development of more and more Microgrids by making policies in line with future energy demands. The example of NetworkedMicrogrids will be a very good choice that has been shown by an example of distribution feeders connected to Microgrids. Possible modes of operation of Microgrids like series, parallel and interconnected modes need more investigation so that microgrids in these modes perform stably and reliably. Also, some of the main control strategies are disused which will be the general choices of working with future Networked microgrids. A brief review and future strategy for Networking of Microgrids are discussed in this work.

REFERENCES

[1]. Chauncey, T. C. Kandpal, ‘A techno-economic comparison of rural electrification based on solar home systems and PV microgrids’, Energy Policy, ISSN: 0301-4215, Vol: 38, Issue: 6, Page: 3118-3129, 2010.

[2]. [Online]Available:https://www.brookings.edu/wpcontent/uploads/2018/02/impactseriesmicrogrid-folder,feb10-2.pdf

[3]. V. S. K. Murthy Balijepalli, S. A. Khaparde, C. V. Dobariy, "Deployment of Microgrids in India", Proceedings of IEEE Power and Energy Society General Meeting, pp. 1-7, July 2010.

[4]. [Online] Available: https://mercomindia.com/?s=microgrids

[5]. H. Lotfi, A. Khodaei, "AC versus DC microgrid planning", IEEE Trans. Smart Grid, vol. 8, no. 1, pp. 296-304, Jan. 2017.

[6]. M. N. Alam, S. Chakrabarti, and A. Ghosh, "Networked Microgrids: State-of-the-art and Future Prospectives," in IEEE Transactions on Industrial Informatics, 2018.

[7]. Xiong Liu; Peng Wang; Poh Chiang Loh, "A Hybrid AC/DC Microgrid and Its Coordination Control," Smart Grid, IEEE Transaction on, vol. 2, no. 2, pp. 278, 286, June. 2011.

[8]. A. R. Malekpour and A. Pahwa, “Stochastic networked microgrid energy management with correlated wind generators,” IEEE Trans. Power Syst., vol. 32, no. 5, pp. 3681–3693, Sep. 2017.

[9]. N. Nikmehr and S. N. Ravadanegh, “Optimal power dispatch of multimicrogrids at future smart distribution grids,” IEEE Trans. Smart Grid, vol. 6, no. 4, pp. 1648–1657, Jul. 2015.

[10]. F. S. Gazijahani and J. Salehi, “Stochastic multi-objective framework for optimal dynamic planning of interconnected microgrids,” IET Renew.

[11]. Power Gener., vol. 11, no. 14, pp. 1749–1759, 2017.

[12]. M. M. Esfahani, A. Hariri, and O. A. Mohammed, “A multi-agent-based game-theoretic and optimization approach for market operation of multimicrogrid systems,” IEEE Trans. Ind. Information., vol. PP, no. 99, pp. 1–1, 2018.

[13]. M. Shahidehpour, Z. Li, S. Bahramirad, Z. Li, and W. Tian, “Networked microgrids: Exploring the possibilities of the IIT-Bronzeville grid,” IEEE Power and Energy Magazine, vol. 15, no. 4, pp. 63–71, Jul. 2017.

[14]. [Online] Available: https://mnre.gov.in/file-manager/UserFiles/draftnational-Mini_Micro-Grid- Policy. pdf

[15]. A. Bidram and A. Davoudi, “Hierarchical structure of microgrids control system,” IEEE Trans. Smart Grid, vol. 3, no. 4, pp. 1963–1976, Dec. 2012.

[16]. M. S. Golsorkhi, D. J. Hill, and H. R. Karshenas, “Distributed voltage control and power management of networked microgrids,” IEEE J. Emerg. Sel. Topics Power Electron., vol. PP, no. 99, pp. 1–1, 2017.

[17]. V. S. K. Murthy Balijepalli, S. A. Khaparde, C. V. Dobariy, "Deployment of Microgrids in India", Proceedings of IEEE Power and Energy Society General Meeting, pp. 1-7, July 2010.