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Microgrids in Competitive Market Environment: An Indian Perspective

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***Abstract* - Microgrids are believed to be the befitting green solution to the ever-rising energy crisis in the developing nations. The resource rich nations are rapidly shifting their dependence on microgrids to meet the reduced carbon footprint target at a global level. This paper addresses this issue and presents a detailed technical review on microgrid integration in competitive electricity market scenario. An in-depth coverage of the need for and importance of microgrid deployments across India is presented in this work. The relevant literature that highlights the significance of various energy storage systems is reviewed. The authors present the perspective of microgrid integration in a competitive market scenario covering both day ahead and real time market scenarios thereby discussing the concept of maximizing social benefit in a grid integrated microgrid framework. This work also focuses on microgrid optimization techniques and outlines a detailed comparison showing merits and demerits of all the techniques implemented by the researchers so far. The authors highlight the fact that green energy holds the potential to not only outgrow the fossil fuels but it shall do so by fetching the requisite economic benefit to the investors as well.**
***Keywords:* Deregulation, Electricity Market, Microgrids, Optimization, Renewable Energy Sources, Social Benefit**

I. INTRODUCTION

The concept of microgrids is gaining importance these days, both as an economic and green solution to the ever-rising issue of energy crisis, there arises a dire need to carry out an in-depth review which covers Microgrid (MG) concept in deregulated electricity market. Indian government realized this need and a dedicated commission for alternate sources of energy was established. This marked the beginning of renewable program in India, this was back in 1981. This commission later got popularly known as the Ministry of Non-Conventional Energy Sources in the year 1992, later renamed and now popularly known as Ministry of New and Renewable Energy (MNRE) [1]. MNRE operates the largest programs which cater to promotion of green energy. India is blessed with locational advantage in terms of availability of varied green sources like hydro, wind, solar, biomass, etc. National Institute of Wind Energy (NIWE) estimates that for a 100 meters hub height, the estimated wind potential is about 300 GW. The cumulative renewable installed capacity in 2017 was around 62GW. A capacity of 27 GW was added in a time span between 2014 to 2017[2]. 20 GW solar power target is an ambitious target which needs to be fulfilled by 2022. This target was set by National Solar Mission and this target was suitably revised to 100 GW by 2022 [3]. Use of co-generation and Renewable Energy Sources (RES) for generation purpose was promoted in The Electricity Act 2003 by the State Electricity Regulatory Commission [4]. The energy produced from RES is one of the most cost beneficial solution. Though it fits into the idea of matching the rural and urban India's needs, still, the number of people receiving the benefit from RES energy remains quite low. Tania et al [5], in their review work, suggest methods for a better coordination amongst the center and state level nodal agencies in implementing RES programs.

RES is a broad category which encompasses variety of sources like solar, wind, hydro etc. Solar technology focuses on photovoltaic effect for conversion of solar energy to electrical output. Energy from sun could pose to be a key solution in bridging the energy gap, since solar energy is one of the most abundantly available resources, when compared to other sources of energy. A huge untapped market lies in off-grid solar markets which when utilized could easily meet our electricity needs as a nation. As illustrated statistically in Figure 1, installed capacity in India pertaining to RES forms about 25 percent of the total installed capacity as on 31.01.2021 [6].

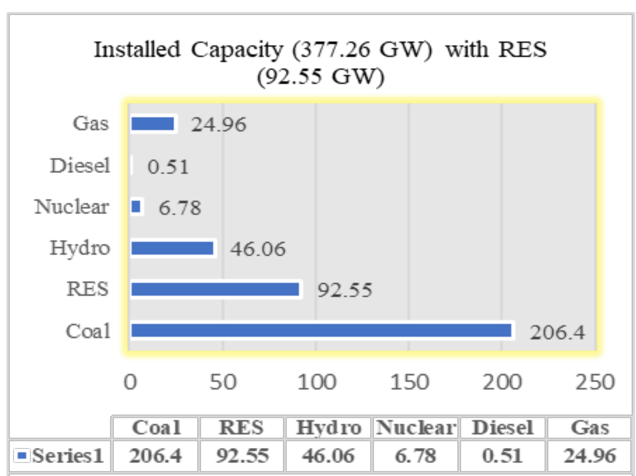

Fig. 1 Installed Capacity with RES

There is thus, a need to realize the fact that more focus needs to be laid on bringing competitiveness in solar energy market against the conventional sources [7]. Apart from solar, wind energy is another important source which has a huge share in the total installed capacity among the total RES generation in India. India is bestowed with about 7500 Km coastline which makes it fit for installing wind turbine and requires offshore region location. Kulkarni *et al.,* [8], in their work, focus on variations in wind power which are primarily caused due to meteorological changes. The main outcome of this study is focused on making better investment decisions. Latest research is focusing more on co-locating both solar and wind generation systems, thereby promoting reliability in such renewable systems [9]. Not only wind and solar, but hydro generation is also gaining all the due importance these days. Hydro generation is one of the top contributors of energy in India. It is one of the rare sources of energy which could be used both on small as well as large scale. Also, this is one of the most easily and readily available renewable source of energy. Approximately 20% of the electricity portion in India is supplied by the rivers [10]. RES are a silver lining to manage energy crisis in a sustainable manner, but selection of appropriate renewable energy sources depends on location of the feeder and voltage profile [11].

Through this extensive literature review, the authors in this work conclude some critical and vital research findings which are essential for planning a microgrid network in a deregulated or competitive electricity market. In this work, competitive electricity market scenario is reviewed considering various timelines of trading (day-ahead and real-time market). A thorough coverage of the need for and importance of microgrids, MGs deployed in India and Energy Storage System (ESS) in MGs is presented in this paper. This covers vital and relevant literature pertaining to this area of research. This detailed discussion on MGs is intended to bring the reader's interest in conceptualizing the idea of microgrids in a profit-making electricity market, i.e., the future of the microgrid concept is the fact that they are competitive with other conventional sources of generation. This review is crucial for the readers, as it encompasses a broad range of concepts related to the microgrid concept and it presents the novel idea of profit maximization by incorporating microgrid concept in a competitive electricity market scenario.

II. THE MICROGRID CONCEPT

Microgrids are an aggregation of micro-generating sources as well as controllable loads which collectively operate as a system.

A. Need and Importance

A microgrid system provides both heat and power to the neighbouring areas. Thus, the need for a central dispatch is done away with in this manner and it provides the much-needed control over distributed generation [12-13].A complete analysis on the economics and technologies employed in promotion of microgrid deployment in India is presented in [14]. A thorough research on key technologies focused on power electronic technologies, protection, etc. is carried out in [15]. Being an RES rich subcontinent, the potential for MG installation in India is quite bright. This has been validated by various researchers, one of them being through a case study for the Indian state of Maharashtra carried out in [16], which mentions how microgrids could help in reducing the energy losses and also improve power quality. It is also quintessential to schedule distributed energy resources and carry out scheduling problem from varied perspectives [17].

Recent studies focus on importance of Solar PV technology in terms of their contribution to the process of global electrification. This study is validated in [18], through a case study for the state of Andhra Pradesh. Authors in [19], propose a benchmark meant for distributed generation studies, primarily for medium voltage rural network. Such network retains all features of a real network. Varied control schemes and microgrid architecture are reviewed in [20]. It is important to review MG test systems across continents. The authors in [21] focus on internationally installed MG test systems. This work covers a thorough review on renewable integration for generation (in microgrids), energy storage systems, connected loads and multi agent system approach where the information exchange is carried out between local controllers (LCs) and Microgrid Central Controller. A detailed description of the microgrid structure and control layout is as described in Fig. 2.

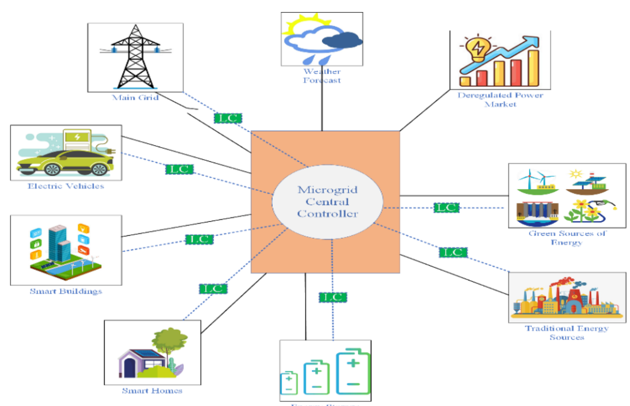

Fig. 2 Microgrid Structure and Control Layout

III. MICROGRIDS DEPLOYED IN INDIA

The Indian subcontinent being an abundant storehouse of renewable energy, is relentlessly making efforts to make full use of the available green energy in order to bridge the ever-increasing energy demand-supply gap. In present condition, already installed solar microgrids provide around 2MW of electric power. Microgrids in India have been micro-hydroelectric, the oldest one being Sidrapong Hydel Power Station, which is located at 3,600 ft, commissioned in 1897, plant consists of 65-kW single phase alternators, two in number, with rating, (2,300 V, 83.3 Hz). The plant was then upgraded to 1,000 kW in order to cater to the needs of the local residents. Biomass, wind and hydel are other vital source, but the focus has been consistently on solar photovoltaic plants. The broad layout of a Microgrid structure and its control operations are outlined in Fig.2. All the attention on solar PV can be justified in areas where grid has not yet penetrated, i.e., remote, inaccessible areas [22]. To quote a few, recently, about 2500 years old monastery located in Ladhak region nestled in Himalayas. It is a boon to the need of about 150 monks residing there, who were not even aware of electricity and its benefits before this. Such deployments of microgrids across different parts of India are presented in Table I.

TABLE I MICROGRID INSTALLATIONS IN INDIA

Sl. No.	Company	Place	Capacity	Household	Price
1	HPS	Bihar	32 kW each	3,200	INR 70/mnth per Connection (15 W)
2	Sagar Island	Sunderbans	26 kW	1,400	INR 7/kWh
3	SREDA	Sikkim	10–25-kW	----	----
4	Palm Meadows	Hyderabad	30 kW	335	----
5	SELCO foundation	Karnataka	1–14-kWp	5	----
6	OREDA	Orissa	2–4.5 kW each	27	INR 10–30/mnth with no initial cost
7	UPNEDA	Uttar Pradesh	1.2-kWp	27 districts	INR 50/month
8	Alamprabhu Pathar	Maharashtra	12,000 Kw	50	----
9	Dharnai	Bihar	100 kW	350	INR 12–14/kWh
10	DESI Power	Bihar (4) Madhya Pradesh (1)	260-Kw	450	INR 5–12/kWh
11	Amrita self-reliant	Kerala	8 kW	30–40	---
12	MGP	Uttar Pradesh	240-Wp	250	INR 25/week
13	CREDA	Chhattisgarh	500 PV	30,000	INR 1–2/kWh
14	Gram Oorja	Maharashtra, Karnataka	5–30-kWp	30–40	INR 20/kWh
15	WBREDA	West Bengal	25–500 Kw each	50	INR 6–30/kWh

India, been bestowed with ample green resources, is leading in the policy formation for rural electrification [24]. One of the popular rural electrification programs worth US$11 billion called Deen Dayal Upadhyaya Gram Jyoti Yojna is intended to deliver power to about 18000 villages. Out of these, about 14000 are served through grid extensions while the remaining 3000 villages need off grid power. Overall, the past decade was significant in increasing the rate of deployment of AC microgrids which act as small and isolated power systems using local green resources. The whole idea of a green microgrid [25-26] seems quite optimistic and promising, given the nature of it, providing green power at the same time significantly reducing the overall grid burden. On the other hand, a major drawback that renewable power suffers is the reliability issue since it is entirely climate dependent. One widely used solution to this intermittency issue is the energy storage system.

A. Energy Storage Systems in Microgrids

Energy storage systems (ESS) are a great help in improvising the overall reliability of the system. This issue has been addressed in a variety of literature available. Physical modelling of RES systems presenting various optimizations methods and principles is presented in [27]. Few other remedies include putting into use real time algorithms for load forecasting [28]. Renewable integration is believed to hamper the technical parameters of a microgrid, various power electronic converters are designed and implemented to tackle this issue [29].

ESS employing battery storage have been quite popular since long. Various improvisations have been noticed in this area, like, Lithium ion being replaced by lead acid ones. Also, numerous options are available for this purpose like ultracapacitors, flywheels, pump hydro storage system etc. [30-31]. The authors in [32] present an in-depth review of all suitable ESS which are meant to store excess green energy. Various improvisations have been made in the existing storage techniques, for example, use of solar powered heat pump meant to store solar energy [33]. It was realized that there is a dire need to control the charging cycles as well, i.e., charge and discharge cycles in an ESS. ESS is a vital pillar in managing reliability of an RES dependent microgrid [34].

Mechanical ESS employ pressurized gas, kinetic and potential energy for their working. Such systems are further classified into various categories such as Flywheel ESS, Pumped Hydro ESS and Compressed Air ESS. The Flywheel system is primarily relevant to speed and inertia, faster the rotation of flywheel, more energy it can store [35]. The Compressed Air system uses and converts compressed gas to mechanical energy. Pumped Hydro, as the name suggests employs pumping and generating action of water, depending on the peak and off-peak demand intervals.

Pump hydro storage (PHSS) stands out in terms of being the most readily available. Water is the main and freely available resource for a pump hydro system. PHSS may range from a few tens of GW to some hundreds of MW [36]. The research carried out in [37], employs a genetic algorithm-based method for optimal sizing of an ESS. The results compare various batteries amongst each other. Most of the renewable integrated ESS systems suffer inaccurate forecast issues. The vital parameters that need to be addressed to solve this issue are descriptively mentioned in [38], these include energy storage capacity and error magnitude. The usage of a pump storage system as a turbine saves significant diesel oil [39]. PHSS is quite promising typically for remote areas. Appropriate mathematical models may be developed for PHSS, aimed at improving system reliability [40]. N. Sivakumar et al. [41], in their work, review the existing operation of a PHSS plant in Kadamparai (Tamil Nadu) state. Through this work, both peak and shortage can be managed. PHSS are an attractive option for nations like India, given their flexibility in operation over other storage systems [41-42]. The journey of development of PHSS in varied market platforms is presented in [43] and it is verified that undoubtedly, hydro power is most flexible as far as grid stability, flexibility and reliable maintenance of power is concerned RES [44-45].

It may be concluded that under following circumstances, ESS would play a significant part in helping the modern power system network rebuild its reliability:

1. Generation and Demand Fluctuation Condition

ESS acts as load, during excess energy availabilities and shall serve as a generator during peak demand intervals. Such methodology has already been implemented in the recent research pertaining to this area [46-50].

2. Intermediate RES Penetration

In order to make output power continuously available, ESS is meant to store as well as discharge the energy. Overall, ESS is a buffer to minimize the grid intermittencies [51].

3. Reduction of Main Grid Burden

By providing the power system utility grid the required stored energy during peak hours, the transmission congestion is reduced to a great extent.

4. Scheduling Flexibility During Peak Hours

ESS are major contributors of serving the load during peak hours, due to which the generation companies get a flexibility in scheduling their load and are not overburdened. It is realized that the significance of distributed generation in the form of microgrids is instrumental in bridging the demand-supply gap and reducing the overall carbon footprint of the generation sector.

IV. COMPETITIVE ELECTRICITY MARKET SCENARIO

This section caters to the historical perspective of the electricity market scenario, covering both the market timelines, i.e., the day-ahead and real-time markets.

A. Historical Perspective

The last ten years have witnessed a marginal shift in the operation of electricity industry as it shifted towards deregulation in most part of the world. The primary aim of introducing this was to promote economic efficiency [52-53]. A typical structure of a deregulated market has both negotiable multilateral or bilateral contracts and a pool system. A generalized model which comprises of varied types of transactions like bilateral, multi-lateral, firm and non-firm transactions is discussed in [54]. In order to cut main grid’s cost, a variety of small-scale generation systems may be used like wind energy, solar PV, small hydro and micro turbines. These alternative green sources are a befitting solution which is both economical and feasible. This has encouraged generation at the consumption site itself [55]. This deregulated system of electricity market brings with it, unwanted price fluctuations similar to stock market fluctuations. Thus, the concept of price forecasting came into existence and various price forecasting techniques came into practice. A thorough survey of the same is presented in [56]. Tak et al. [57], propose a model which employs fuzzy based logic which considers relation between electricity demand and price in the competitive/deregulated market scenario. Long ago, about 20 years ago, Verbruggen et al brought about a comparison of his model designed for European electricity industry with that of a conventional integrated market structure [58]. The overall mechanism of power trading and evolution of electricity market is reviewed in [59]. Umesh et al. [60], in their work analyze the competition in the market structure and the wholesale market concept. The Government of India in 2003, through enactment of Electricity Act, initiated various electricity reforms in order to promote competition in India.

B. Day Ahead Market Scenario

Day Ahead Markets (DAM) are a major platform for power trading. In a DAM, the trade is done after setting prices. This is done via a contract between both buyers and sellers. The delivery of electricity is scheduled for the following day. The bidding strategies concerning DAM of a microgrid are proposed in [61, 62], the renewable power is used for power generation along with storage and dispatchable loads. A methodology where the production of a firm is less than the quantity committed in DAM is proposed in [63]. Such firms are liable for penalty such that its undersupply is proportional to the underproduction. In [64], the authors present various techniques which could be put to use in order to forecast market clearing prices 24-hour ahead of the dispatch time.

C. Real Time Market

The commitments done a day before are balanced optimally in the real time market as well. The load of a particular customer is adjusted in accordance with the electricity prices which vary hourly, an optimization model of the same is proposed in [65]. There needs to be a balance between the true demand and the constraints of system. Complete timeline descriptively explaining the day ahead and real time market scheduling is presented in Fig. 3.

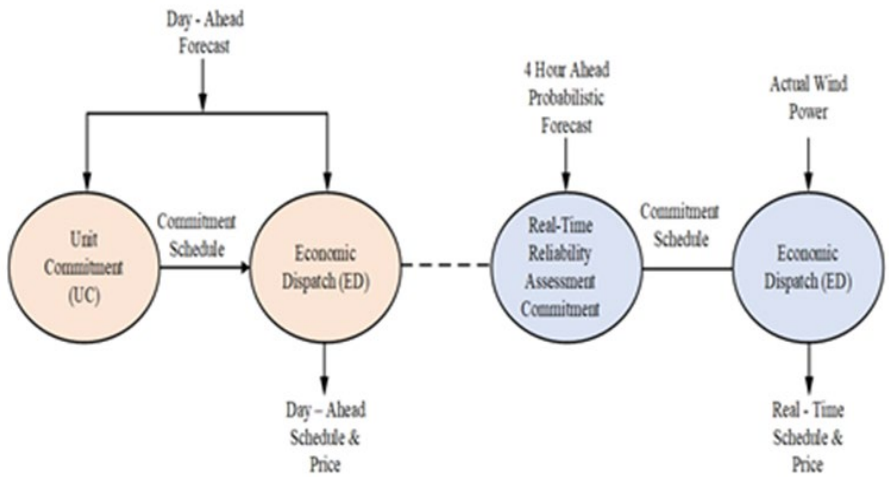

Fig. 3 Day Ahead Market and Real Time Market Timeline

Hongming *et al.,* [66], in their research, propose a model based on optimal bidding model aimed at a worst-case analysis of conditional expectation of purchase cost of electricity. If a market has high renewable penetration, the relation between electricity prices and the production cost affects the strategies of generators. The research carried out in [67], considers both wind power and real time prices information and an offer curve is built. The authors in [68], lay focus on real time electricity scheduling and develop an optimization technique which would deal with continuous uncertainty. The characteristics of real time are analyzed in [69], primarily for industrial customers which is based on information available publicly. In this work, the savings from real time pricing scheme are compared with dynamic pricing. There is a need to update power system education since the power system industry is moving to a completely deregulated system [70].

V. MICROGRID PERSPECTIVE IN DEREGULATED MARKET

The shift of power market from a vertical to horizontal system introduced the idea of competition in the electricity market. Green microgrid acts in a self-sustainable manner i.e., green energy is put to optimal usage first, as and when available, thereafter optimal operation of MG is carried out considering maximization of social benefit of the operator.

A. Social Benefit in Microgrids

MGs could either be controllable in both grid-connected or grid isolated mode. The upcoming research in this area presents the implementation of microgrids in a deregulated/competitive power market. The idea behind is, to not only utilize green alternatives for power generation, but to also earn revenue out of it. The authors in [46], present a novel idea of MG participation in reducing main grid burden while maximizing social benefit of the main grid. Social benefit is the quantitative measure of profit earned by the grid operators [71]. A microgrid may act both as a producer and a consumer within the distributed framework of power system. Such MGs are called 'prosumers.' These aims to maximize their social benefit (SB) or social welfare [72]. Social benefit is typically defined as the difference between the willingness to pay for the load demand and the generation cost of energy. A competitive market requires trading and bidding as done in any other commodity's trading. A trading model is proposed for electricity trading is proposed in [73], where the benefit of maximizing social benefit is highlighted, for all participants. It is imperative to have a know-how of all the research carried out in this area, since social benefit maximization puts an advantage with the operator. The monetary benefit of the operator will ensure that more subsidies may be given to the vital sections like educational institutes, hospitals etc. The authors in this review have attempted to bring into a place the literature pertaining to optimization aimed at maximization of social benefit.

A multi-agent technique is implemented in [74], which optimally manages the resources in MG. This proposed framework of information exchange requires a localized network and a control strategy. One major drawback of having more buyers/ competition in the system is the decrease in social benefit [75]. Various latest techniques can be put to use for maximizing SB. The authors in [76] put to use wavelet neural network for this optimization. A unique modified auction models is put to use in [77], allowing SB of all bidding agents to be close to the price taking agents. The idea of improving SB could be brought about in many ways, managing demand or demand side management is one of the methods to do the same [78]. The problem of social benefit maximization is handled by the microgrid central controller [79]. The grid controller may also act as an auctioneer. Energy trading has been analyzed and discussed descriptively in [80], considering only green energy. Some trading models focus on energy management in microgrids [81]. The issue of optimal bidding in MGs is descriptively mentioned in [82].

B. Optimizing MG Operation

The authors in [48], present a novel dual optimization approach where optimization of both main grid and microgrid is carried out. This ensures that during power trading amongst MGs and main grid, optimal operation is ensured. The implementation of social benefit maximization requires the implementation of multi-agent system approach. Many control methods may be employed for a MG system. The authors in [83], propose a model predictive control approach using MILP. It is important to optimize and control the MG operations, in order to improvise their efficiency. Such optimization model, which is aimed at maximizing environmental benefit at the same time, minimizing the operational cost is proposed in [84]. In order to cover more objectives in the same optimization, a double-objective optimization method which is aimed at optimally planning the operation of a grid-tied microgrid is presented in [85], where maximization of customer satisfaction and minimizing of the annual cost is carried out. Many algorithms aimed at production cost minimization could be used. The research carried out in [86] aims to reduce production cost using a memory based genetic algorithm and considering smart grid scenario. Mohsen et al. [87], in their work, device a method based on MILP, which schedules both economic dispatch and commits the MG units accordingly. In order to achieve economic efficiency, it is imperative to have a model predictive control approach. Such as the one applied to an experimental microgrid in Greece [88]. The optimization methods employed in microgrid operation are thoroughly compared with descriptive remarks in Table II.

TABLE II MICROGRID INSTALLATIONS IN INDIA

Ref.	System Type	Connected Sources	Objective	Method used	Remarks
[89]	MG interfaced with grid	Wind turbine, Solar PV and battery storage	Enhancing voltage quality	A series parallel structure for grid interfaced controller	The proposed system exhibits an overall stable operation under various conditions
[90]	Islanded MG	DGs in parallel	Power sharing is improved	Adaptive method for virtual impedance control	Considerable improvement in power sharing
[91]	MG with grid connection and hybrid load	Diesel generator, solar PV, Fuel Cell, and battery bank	Minimize power loss, voltage fluctuations and total control deviation error	Multi objective particle swarm optimization Dynamic control system with (MOPSO)	Reduction in power loss and better voltage stability
[92]	Hybrid energy systems	PV array, Thermal energy storage system, generator and battery	Optimum power flow control	Particle swarm optimization	Faster convergence and reduced use of combustible fuel
[93]	AC microgrid in autonomous and grid connected mode	PV Array and Battery bank	Improve P and Q reliability of the system	Model predictive control	THD improved from 18.39% to 1.5%.
[94]	Microgrid in islanded mode	Distributed Generators	Power quality improvement and protection from overload	Model predictive control	Improved power sharing

VI. CONCLUSION

Microgrids are projected to play a significant part in future smart grid development. They may be used in the future as smart-grid testbeds. Solar photovoltaics, wind turbines, and micro-hydropower all fall under the category of microgeneration. Not only do these technologies conserve energy, but they also help reduce CO2 emissions. It is possible that energy presumption, where end-users import and export electricity, may become the rule rather than the exception due to the significant decline in solar photovoltaic generation costs and battery storage. When clean energy is readily available, combining numerous renewable energy sources with storage has a promising future ahead of it. In this comprehensive review, energy storage systems in microgrids and current research literature in the field of energy management are discussed. A thorough review of various methodologies in which renewable energy sources are optimally utilized with the primary goal of maximizing social benefits (SBs) in both the green microgrid and the main grid are presented. The idea of microgrid integration in a competitive electricity market is presented covering both day ahead and real time market scenarios. The authors have brought to focus the idea of not only augmenting microgrids in the power market but also generating profit out of the same. By thoroughly comparing the optimization techniques for a better microgrid operation, a detailed account of all merits and demerits is brought about. It is concluded after the review that the microgrids specially the ones employing green generating sources, hold a strong potential to outgrow the conventional fossil fuel generation and that too by not forgoing the profit maximization by the microgrid operators. It is thus proposed that in the years to come microgrids could replace the conventional generation not only at a national but at a global level as well.

REFERENCES

[1] ABPS Infrastructure Advisory Private Limited, "Development of Conceptual Framework for Renewable Energy Certificate Mechanism for India," *Ministry of New and Renewable Energy (Government of India),* 2009.

[2] "Power from Renewables," *Ministry of New and Renewable Energy,* 2017.

[3] "National Solar Mission," *Ministry of New and Renewable Energy,* 2017

[4] R. Singh and Y. Sood, "ABPS Infrastructure Advisory Private Limited, "Development of Conceptual Framework for Renewable Energy Certificate Mechanism for India," *Ministry of New and Renewable Energy (Government of India),* 2009.

[5] S. K. Sahoo, "Renewable and sustainable energy reviews solar photovoltaic energy progress in India: A review," *Renewable and Sustainable Energy Reviews*, Vol. 59, pp. 927-939, 2016, DOI: 10.1016/j.rser.2016.01.049.

[6] T. Urmee, D. Harries and A. Schlapfer, "Issues related to rural electrification using renewable energy in developing countries of Asia and Pacific," *Renewable Energy*, Vol. 34, No. 2, pp. 354-357, 2009, DOI:10.1016/j.renene.2008.05.004.

[7] Monthly Renewable Energy Generation Report [Ministry of Power, Central electricity authority].

[8] E. Kabir, P. Kumar, S. Kumar, A. Adelodun and K. Kim, "Solar energy: Potential and future prospects," *Renewable and Sustainable Energy Reviews*, Vol. 82, pp. 894-900, 2018, DOI: 10.1016/j.rser.2017.09.094.

[9] S. Kulkarni, M. Deo and S. Ghosh, "Impact of active and break wind spells on the demand - supply balance in wind energy in India," *Meteorology and Atmospheric Physics*, Vol. 130, No. 1, pp. 81-97, 2017, DOI: 10.1007/s00703-017-0501-5.

[10] S. Venkataraman, C. Ziesler, P. Johnson and S. Kempen, "Integrated Wind, Solar, and Energy Storage," *IEEE Power & Energy Magazine*, No. 3, pp. 74-83, 2018, DOI: 10.1109/MPE.2018.2793478.

[11] N. Sharma, P. Tiwari and Y. Sood, "A comprehensive analysis of strategies, policies and development of hydropower in India: Special emphasis on small hydro power," *Renewable and Sustainable Energy Reviews*, Vol. 18, pp. 460-470, 2013, DOI: 10.1016/j.rser.2012.10.017.

[12] G. Mufti, A. Basit, M. Rehman, S. Hassan and R. Khan, "Comparative Analysis of the Effects of Renewable Energy Integration on the Utility Grid System," *in International Conference on Computing, Mathematics and Engineering Technologies*, pp. 1-5, 2018, DOI: 10.1109/ICOMET.2018.8346415.

[13] R. H. Lasseter, "MicroGrids," *2002 IEEE Power Engineering Society Winter Meeting. Conference Proceedings (Cat. No.02CH37309)*, Vol.1, pp. 305-308, 2002, DOI: 10.1109/PESW.2002.985003.

[14] R. H. Lasseter and P. Paigi, "Microgrid: a conceptual solution," *2004 IEEE 35th Annual Power Electronics Specialists Conference (IEEE Cat. No.04CH37551)*, Vol. 6, pp. 4285-4290, 2004, DOI: 10.1109/PESC.2004.1354758.

[15] V. S. K. Murthy Balijepalli, S. A. Khaparde and C. V. Dobariya, "Deployment of MicroGrids in India," *IEEE PES General Meeting*, pp. 1-7, 2010, DOI: 10.1109/PES.2010.5589956.

[16] M. Ding, Y. Zhang and M. Mao, "Key technologies for microgrids-a review," *2009 International Conference on Sustainable Power Generation and Supply*, pp. 1-5, 2009, DOI: 10.1109/SUPERGEN.2009.5348218.

[17] R. Bhoyar and S. Bharatkar, "Potential of MicroSources, Renewable Energy sources and Application of Microgrids in Rural areas of Maharashtra State India," *Energy Procedia*, Vol. 14, pp. 2012-2018, 2012, doi.org/10.1016/j.egypro.2011.12.1202.

[18] S. Nosratabadi, R. Hooshmand and E. Gholipour, "A comprehensive review on microgrid and virtual power plant concepts employed for distributed energy resources scheduling in power systems," *Renewable and Sustainable Energy Reviews*, Vol. 67, pp. 341-363, 2017, DOI: 10.1016/j.rser.2016.09.025.

[19] P. Loka, S. Moola, K. Polsani, S. Reddy, S. Fulton and A. Skumanich, "A case study for micro-grid PV: lessons learned from a rural electrification project in India.," *in Progress in Photovoltaics: Research and Applications*, pp. 733-743, 2014, DOI: 10.1002/pip.2429

[20] K. Rudion, A. Orths, Z. A. Styczynski and K. Strunz, "Design of benchmark of medium voltage distribution network for investigation of DG integration," *2006 IEEE Power Engineering Society General Meeting*, pp. 1-6, 2006, DOI: 10.1109/PES.2006.1709447.

[21] T. Ustun, C. Ozansoy and A. Zayegh, "Recent developments in microgrids and example cases around the world - A review," *Renewable and Sustainable Energy Reviews*, Vol. 15, No. 8, pp. 4030-4041, 2011, DOI: 10.1016/j.rser.2011.07.033.

[22] N. Lidula and A. Rajapakse, "Microgrids research: A review of experimental microgrids and test systems," *Renewable and Sustainable Energy Reviews*, Vol. 15, No. 1, pp. 186-202, 2011, DOI: 10.1016/j.rser.2010.09.041.

[23] J. Jithendranath and Debapriya Das, "Multi-Objective Optimal Power Flow in Islanded Microgrids with Solar PV Generation by NLTV-MOPSO," *IETE Journal of Research*, pp. 1-14, 2021, DOI: 10.1080/03772063.2021.1886609.

[24] V. A. Suryad, S. Doolla and M. Chandorkar, "Microgrids in India: Possibilities and Challenges," *in IEEE Electrification Magazine*, Vol. 5, No. 2, pp. 47-55, June 2017, DOI: 10.1109/MELE.2017.2685880.

[25] Lim, Yujin, Jaesung Park, Hak-Man Kim, and Tetsuo Kinoshita, "A Bargaining approach to optimizing load shedding in islanded microgrid operation," *IETE Technical Review*, Vol. 30, No. 6, pp. 483-489, 2013, DOI: 10.4103/0256-4602.125669

[26] J. Kaur Saini, Y. Raj Sood, and R. Shrivastava, "Optimal resource management of microgrids in a competitive market environment using dual layer control approach," *Electr. Power Compon. Syst.*, Vol. 47, No. 14-15, pp. 1274-1286, 2019, DOI: 10.1080/15325008.2019.1666438.

[27] J. Kaur, Y. R. Sood, and R. Shrivastava, "Optimal resource utilization in a multi-microgrid network for Tamil Nadu state in India," *IETE J. Res.*, pp. 1-11, 2019, DOI: 10.1080/03772063.2019.1595182.

[28] J. Kaur, Y. R. Sood, and R. Shrivastava, "A two-layer optimization approach for renewable energy management of green microgrid in deregulated power sector," *J. Renew. Sustain. Energy*, Vol. 9, No. 6, pp. 065905, 2017, DOI: 10.1063/1.4986342.

[29] P. A. Jaboulay, W. Zhu, X. Niu, X. Pan and S. Gao, "Real-Time Energy Management Optimization Using Model Predictive Control on a Microgrid Demonstrator," 2017 *IEEE International Conference on Energy Internet (ICEI)*, pp. 226-231, 2017, DOI: 10.1109/ICEI.2017.47.

[30] F. S. Tidjani, A. Hamadi, A. Chandra, P. Pillay and A. Ndtoungou, "Optimization of Standalone Microgrid Considering Active Damping Technique and Smart Power Management Using Fuzzy Logic Supervisor," *in IEEE Transactions on Smart Grid*, Vol. 8, No. 1, pp. 475-484, Jan. 2017, DOI: 10.1109/TSG.2016.2610971.

[31] Y. Sun, X. Tang, X. Sun, D. Jia, and G. Zhang, "Microgrid tie-line power fluctuation mitigation with virtual energy storage," *J. Eng. (Stevenage)*, Vol. 2019, No. 16, pp. 1001-1004, 2019, DOI: 10.1049/joe.2018.8553.

[32] A. Dehamna and P. Asmus, "Energy Storage for Microgrids," *Navigant Research*, 2014.

[33] M. Jarnut, S. Wermiński and B. Waśkowicz, "Comparative analysis of selected energy storage technologies for prosumer-owned microgrids," *Renewable and Sustainable Energy Reviews*, Vol. 74, pp. 925-937, 2017, DOI: 10.1016/j.rser.2017.02.084.

[34] V. Verma and K. Murugesan, "Experimental study of solar energy storage and space heating using solar assisted ground source heat

pump system for Indian climatic conditions," *Energy and Buildings*, Vol. 139, pp. 569-577, 2017, DOI: 10.1016/j.enbuild.2017.01.041.
[35] H. Chen, T. Cong, W. Yang, C. Tan, Y. Li and Y. Ding, "Progress in electrical energy storage system: A critical review," *Progress in Natural Science*, Vol. 19, No. 3, pp. 291-312, 2009, DOI: 10.1016/j.pnsc.2008.07.014.
[36] Brahmendra Kumar, G.V. and Palanisamy, K., "Review of Energy Storage System for Microgrid," *Microgrid Technologies*," pp. 57-90, 2021, DOI: 10.1002/9781119710905.ch3.
[37] H. Ibrahim, A. Ilinca and J. Perron, "Energy storage systems - Characteristics and comparisons," *Renewable and Sustainable Energy Reviews*, Vol. 12, No. 5, pp. 1221-1250, 2008, DOI: 10.1016/j.rser.2007.01.023.
[38] J. Fossati, A. Galarza, A. Martín-Villate and L. Fontán, "A method for optimal sizing energy storage systems for microgrids," *Renewable Energy*, Vol. 77, pp. 539-549, 2015, DOI: 10.1016/j.renene.2014.12.039.
[39] G. Koeppel and M. Korpas, "Using storage devices for compensating uncertainties caused by non-dispatchable generators," *2006 International Conference on Probabilistic Methods Applied to Power Systems*, pp. 1-8, 2006, DOI: 10.1109/PMAPS.2006.360269.
[40] A. Stoppato, G. Cavazzini, G. Ardizzon and A. Rossetti, "A PSO (particle swarm optimization)-based model for the optimal management of a small PV(Photovoltaic)-pump hydro energy storage in a rural dry area," *Energy*, Vol. 76, pp. 168-174, 2014, DOI: 10.1016/j.energy.2014.06.004.
[41] T. Ma, H. Yang, L. Lu and J. Peng, "Pumped storage-based standalone photovoltaic power generation system: Modeling and techno-economic optimization," *Applied Energy*, Vol. 137, pp. 649-659, 2015, DOI: 10.1016/j.apenergy.2014.06.005.
[42] N. Sivakumar, D. Das and N. Padhy, "Variable speed operation of reversible pump-turbines at Kadamparai pumped storage plant - A case study," *Energy Conversion and Management*, Vol. 78, pp. 96-104, 2014, DOI: 10.1016/j.enconman.2013.10.048.
[43] T. Sels, C. Dragu, T. Craenenbroeck and R. Belmans, "Electrical energy storage systems: existing systems versus newest systems - An overview," *in International Conference Power Generation and Sustainable Development*, Liège, Belgium, pp. 8-9, 2001, DOI: 10.1016/B978-044452745-5.00090-3.
[44] E. Barbour, I. Wilson, J. Radcliffe, Y. Ding and Y. Li, "A review of pumped hydro energy storage development in significant international electricity markets," *Renewable and Sustainable Energy Reviews*, Vol. 61, pp. 421-432, 2016, DOI: 10.1016/j.rser.2016.04.019.
[45] S. Rehman, L. Al-Hadhrami and M. Alam, "Pumped hydro energy storage system: A technological review," *Renewable and Sustainable Energy Reviews*, Vol. 44, pp. 586-598, 2015, DOI: 10.1016/j.rser.2014.12.040.
[46] B. Pali and S. Vadhera, "A novel pumped hydro-energy storage scheme with wind energy for power generation at constant voltage in rural areas," *Renewable Energy*, Vol. 127, pp. 802-810, 2018, DOI: 10.1016/j.renene.2018.05.028.
[47] J. Kaur, Y.R Sood and R. Shrivastava, "Optimal resource utilization in a multi-microgrid network for Tamil Nadu state in India," *IETE Journal of Research*, pp. 1-11, 2019, DOI: 10.1080/03772063.2019.1595182.
[48] J. K. Saini, Y.R Sood and R. Shrivastava, "Optimal Resource Management of Microgrids in a Competitive Market Environment Using Dual Layer Control Approach," *Electric Power Components and Systems*, Vol. 47, No. 14-15, pp.1274-1286, 2019.
[49] J. Kaur, Y.R Sood and R. Shrivastava, "A two-layer optimization approach for renewable energy management of green microgrid in deregulated power sector," *Journal of Renewable and Sustainable Energy*, Vol. 9, No. 6, pp. 065905, 2017, DOI: 10.1080/15325008.2019.1666438.
[50] J. Kaur, Y.R Sood and R. Shrivastava, "Optimal Operation of Self Sustainable Green Microgrid in Deregulated Power Sector," *Journal of Energy*, *Environment and Carbon Credits*, Vol. 6, No. 3, pp. 1-7, 2016.
[51] O.P. Yadav, J. Kaur, N.K. Sharma, and Y.R Sood, "Renewable Energy Management in Multi-microgrid Under Deregulated Environment of Power Sector," *In Applications of Artificial Intelligence Techniques in Engineering, Springer*, Singapore, pp. 289-302, 2019, DOI: 10.1007/978-981-13-1819-1_28.
[52] J. Kaur, R. Prashar, N.K. Sharma and A. Banshwar, "A Review on Policies and Challenges Faced in Solar PhotoVoltaic Technology: Indian Perspective," *In Computing, Networks and Renewable Energy (CNRE-2021)*, Kapurthala, August, 2021.
[53] M. Ventosa, Á. Baíllo, A. Ramos and M. Rivier, "Electricity market modeling trends," *Energy Policy*, Vol. 33, No. 7, pp. 897-913, 2005, DOI: 10.1016/j.enpol.2003.10.013.
[54] J. Kaur, A. Banshwar, N. K. Sharma, Y. Raj Sood and R. Shrivastava, "Strategic Utilization of Resources in a Microgrid in an Uncertain Electricity Market," *2018 International Conference on Power Energy, Environment and Intelligent Control (PEEIC)*, pp. 220-225, 2018, DOI: 10.1109/PEEIC.2018.8665654.
[55] G. G. Hamoud and L. Bradley, "Assessment of transmission congestion cost and locational marginal pricing in a competitive electricity market," *2001 Power Engineering Society Summer Meeting*. *Conference Proceedings (Cat. No.01CH37262)*, Vol. 3, pp. 1468-1472, 2001, DOI: 10.1109/PESS.2001.970292.
[56] L. L. Lai, Ed., *Power system restructuring and deregulation: Trading, performance and information technology,* 1st ed. Chichester, England: John Wiley & Sons, 2003.
[57] T. Niimura, "Forecasting techniques for deregulated electricity market prices-extended survey," *In IEEE PES Power Systems Conference and Exposition*, pp. 51-56, 2006.
[58] N. Padhy and Y. Sood, "Advancement in Power System Engineering Education And Research With Power Industry Moving Towards Deregulation," *in IEEE Power Engineering Society General Meeting*, pp. 71-76, 2004.
[59] A. Verbruggen, "A normative structure for the European electricity market," *Energy Policy*, Vol. 25, No. 3, pp. 281-292, 1997, DOI: doi.org/10.1016/S0301-4215(96)00138-3.
[60] P. Bajpai and S. Singh, "Electricity Trading in Competitive Power Market: An Overview And Key Issues," *in International Conference on Power Systems*, Kathmandu, Nepal, 2004.
[61] U. Shukla and A. Thampy, "Analysis of competition and market power in the wholesale electricity market in India," *Energy Policy*, Vol. 39, No. 5, pp. 2699-2710, 2011, DOI: 10.1016/j.enpol.2011.02.039
[62] G. Liu, Y. Xu and K. Tomsovic, "Bidding Strategy for Microgrid in Day-Ahead Market Based on Hybrid Stochastic/Robust Optimization," *in IEEE Transactions on Smart Grid*, Vol. 7, No. 1, pp. 227-237, Jan. 2016, DOI: 10.1109/TSG.2015.2476669.
[63] V. Madhu, B. Subramanyam and M. Surya, "Optimal Bidding strategy in South Region Day-ahead Market Model using New Aggregated Demand Model and Hybrid Technique," *International Journal of Computer Applications*, Vol. 131, No. 7, pp. 24-33, 2015, DOI: 10.5120/ijca2015907383.
[64] N. Sunar and J. Birge, "Strategic Commitment to a Production Schedule with Uncertain Supply and Demand: Renewable Energy in Day-Ahead Electricity Markets," *SSRN Electronic Journal*, 2014, DOI: 10.1287/mnsc.2017.2961.
[65] A. Conejo, J. Contreras, R. Espínola and M. Plazas, "Forecasting electricity prices for a day-ahead pool-based electric energy market," *International Journal of Forecasting*, Vol. 21, No. 3, pp. 435-462, 2005, DOI: 10.1016/j.ijforecast.2004.12.005.
[66] A. J. Conejo, J. M. Morales and L. Baringo, "Real-Time Demand Response Model," *in IEEE Transactions on Smart Grid*, Vol. 1, No. 3, pp. 236-242, Dec. 2010, DOI: 10.1109/TSG.2010.2078843.
[67] H. Yang *et al.,* "Distributionally Robust Optimal Bidding of Controllable Load Aggregators in the Electricity Market," *in IEEE Transactions on Power Systems*, Vol. 33, No. 1, pp. 1089-1091, Jan. 2018, DOI: 10.1109/TPWRS.2017.2701650.
[68] H. Shin, D. Lee and R. Baldick, "An Offer Strategy for Wind Power Producers That Considers the Correlation Between Wind Power and Real-Time Electricity Prices," *in IEEE Transactions on Sustainable Energy*, Vol. 9, No. 2, pp. 695-706, April 2018, DOI: 10.1109/TSTE.2017.2757501.
[69] Y. Ji, T. Zheng and L. Tong, "Stochastic Interchange Scheduling in the Real-Time Electricity Market," *in IEEE Transactions on Power Systems*, Vol. 32, No. 3, pp. 2017-2027, May 2017, DOI: 10.1109/TPWRS.2016.2600635.
[70] N. Nezamoddini and Y. Wang, "Real-time electricity pricing for industrial customers: Survey and case studies in the United States," *Applied Energy*, Vol. 195, pp. 1023-1037, 2017, DOI: 10.1016/j.apenergy.2017.03.102.

[71] T. Niimura and T. Nakashima, "Deregulated electricity market data representation by fuzzy regression models," *IEEE Transactions on Systems, Man and Cybernetics, Part C (Applications and Reviews)*, Vol. 31, No. 3, pp. 320-326, 2001, DOI: 10.1109/5326.971659.

[72] S. Sharma and Y. R. Sood, "Microgrids: A review of status, technologies, software tools, and issues in Indian power market," *IETE Tech. Rev.,* pp. 1-22, 2020, DOI: 10.1080/02564602. 2020.1850367.

[73] P. R. Thimmapuram and J. Kim, "Consumers' Price Elasticity of Demand Modeling With Economic Effects on Electricity Markets Using an Agent-Based Model," *in IEEE Transactions on Smart Grid*, Vol. 4, No. 1, pp. 390-397, March 2013, DOI: 10.1109/TSG.2012. 2234487.

[74] D. Roh and H. Yang, "Design of An Iterative Multi-Item Double-Auction Mechanism," *Computational Intelligence*, Vol. 24, No. 1, pp. 62-75, 2008, DOI: 10.1111/j.1467-8640.2007.00319.x.

[75] Y. Xu and Z. Li, "Distributed Optimal Resource Management Based on the Consensus Algorithm in a Microgrid," *in IEEE Transactions on Industrial Electronics*, Vol. 62, No. 4, pp. 2584-2592, April 2015, DOI: 10.1109/TIE.2014.2356171.

[76] J. Lee, J. Guo, J. K. Choi and M. Zukerman, "Distributed Energy Trading in Microgrids: A Game-Theoretic Model and Its Equilibrium Analysis," *in IEEE Transactions on Industrial Electronics*, Vol. 62, No. 6, pp. 3524-3533, June 2015, DOI: 10.1109/TIE.2014.2387340.

[77] Z. Fu, X. He, T. Huang and H. Abu-Rub, "A distributed continuous time consensus algorithm for maximize social welfare in micro grid," *Journal of the Franklin Institute*, Vol. 353, No. 15, pp. 3966-3984, 2016, DOI: 10.1016/j.jfranklin.2016.07.009.

[78] M. N. Faqiry and S. Das, "Double-Sided Energy Auction in Microgrid: Equilibrium Under Price Anticipation," *in IEEE Access*, Vol. 4, pp. 3794-3805, 2016, DOI: 10.1109/ACCESS.2016.2591912.

[79] S. Behboodi, D. Chassin, C. Crawford and N. Djilali, "Renewable resources portfolio optimization in the presence of demand response," *Applied Energy*, Vol. 162, pp. 139-148, 2016, DOI: 10.1016/j.ap energy.2015.10.074.

[80] C. L. Chang and J. C. H. Peng, "A Decision-Making Auction Algorithm for Demand Response in Microgrids," *in IEEE Transactions on Smart Grid*, Vol. 9, No. 4, pp. 3553-3562, July 2018, DOI: 10.1109/TSG.2016.2634583.

[81] S. Park, J. Lee, G. Hwang and J. K. Choi, "Event-Driven Energy Trading System in Microgrids: Aperiodic Market Model Analysis With a Game Theoretic Approach," *in IEEE Access*, Vol. 5, pp. 26291-26302, 2017, DOI: 10.1109/ACCESS.2017.2766233.

[82] D. Vergados, I. Mamounakis, P. Makris and E. Varvarigos, "Prosumer clustering into virtual microgrids for cost reduction in renewable energy trading markets," *Sustainable Energy, Grids and Networks*, Vol. 7, pp. 90-103, 2016, DOI: 10.1016/j.segan.2016. 06.002.

[83] D. An, Q. Yang, W. Yu, X. Yang, X. Fu and W. Zhao, "Sto2Auc: A Stochastic Optimal Bidding Strategy for Microgrids," *in IEEE Internet of Things Journal*, Vol. 4, No. 6, pp. 2260-2274, Dec. 2017, DOI: 10.1109/JIOT.2017.2764879.

[84] A. Parisio, E. Rikos and L. Glielmo, "A Model Predictive Control Approach to Microgrid Operation Optimization," *in IEEE Transactions on Control Systems Technology*, Vol. 22, No. 5, pp. 1813-1827, Sept. 2014, DOI: 10.1109/TCST.2013.2295737.

[85] M. Ding, Y. Y. Zhang, M. Q. Mao, W. Yang and X. P. Liu, "Operation optimization for microgrids under centralized control," *The 2nd International Symposium on Power Electronics for Distributed Generation Systems*, pp. 984-987, 2010, DOI: 10.1109/ PEDG.2010.5545793.

[86] J. Chen *et al.,* "Optimal Sizing for Grid-Tied Microgrids With Consideration of Joint Optimization of Planning and Operation," *in IEEE Transactions on Sustainable Energy*, Vol. 9, No. 1, pp. 237-248, Jan. 2018, DOI: 10.1109/TSTE.2017.2724583.

[87] A. Askarzadeh, "A Memory-Based Genetic Algorithm for Optimization of Power Generation in a Microgrid," *in IEEE Transactions on Sustainable Energy*, Vol. 9, No. 3, pp. 1081-1089, July 2018, DOI: 10.1109/TSTE.2017.2765483.

[88] M. Nemati, M. Braun and S. Tenbohlen, "Optimization of unit commitment and economic dispatch in microgrids based on genetic algorithm and mixed integer linear programming," *Applied Energy*, Vol. 210, pp. 944-963, 2018, DOI: 10.1016/j.apenergy.2017.07.007.

[89] A. Parisio, E. Rikos, G. Tzamalis and L. Glielmo, "Use of model predictive control for experimental microgrid optimization," *Applied Energy*, Vol. 115, pp. 37-46, 2014, DOI: 10.1016/j.apenergy.2013. 10.027.

[90] F. Wang, J. L. Duarte and M. A. M. Hendrix, "Grid-Interfacing Converter Systems With Enhanced Voltage Quality for Microgrid Application - Concept and Implementation," *in IEEE Transactions on Power Electronics*, Vol. 26, No. 12, pp. 3501-3513, Dec. 2011, DOI: 10.1109/TPEL.2011.2147334.

[91] J. He, Y. W. Li and F. Blaabjerg, "An accurate autonomous islanding microgrid reactive power, imbalance power and harmonic power sharing scheme," *2013 IEEE Energy Conversion Congress and Exposition*, 2013, pp. 1337-1343, DOI: 10.1109/ECCE.2013.6646860.

[92] A. M. Sharaf and A. A. El-Gammal, "A novel efficient PSO-self regulating PID controller for hybrid PV-FC-diesel-battery micro grid scheme for village/resort electricity utilization," *2010 IEEE Electrical Power & Energy Conference*, 2010, pp. 1-6, DOI: 10.1109/EPEC. 2010.5697245.

[93] S. Ghaem Sigarchian, M. S. Orosz, H. F. Hemond, and A. Malmquist, "Optimum design of a hybrid PV–CSP–LPG microgrid with Particle Swarm Optimization technique," *Appl. Therm. Eng.*, Vol. 109, pp. 1031-1036, 2016, DOI: 10.1016/j.applthermaleng.2016.05.119.

[94] K. T. Tan, P. L. So, Y. C. Chu and M. Z. Q. Chen, "A Flexible AC Distribution System Device for a Microgrid," *in IEEE Transactions on Energy Conversion*, Vol. 28, No. 3, pp. 601-610, Sept. 2013, DOI: 10.1109/TEC.2013.2260162.

[95] M. S. Golsorkhi and D. D. Lu, "A Decentralized Control Method for Islanded Microgrids Under Unbalanced Conditions," *in IEEE Transactions on Power Delivery*, Vol. 31, No. 3, pp. 1112-1121, June 2016, DOI: 10.1109/TPWRD.2015.2453251.