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# A Review on an Electric Grid Stability in the Presence of Distributed Generation

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***Abstract: As renewable energy sources are becoming more popular, the implementation of distributed generation rather than a centralized generation has increased. Hence microgrids are also becoming an essential part of the smart grid. As we move towards a shortage in the availability of shorter non-renewable resources, the penetration of distributed generations is increasing rapidly. The primary resource to implement the distributed generation is through solar PV panels and wind turbines due to their technological improvement in the research area. As we have diverse modes of power generation such as solar, wind, hydro, and thermal, it is challenging to ensure their parallel operation. When distributed generation systems penetrate the grid, several issues will occur in the existing system, which causes the system to become unstable. If the system's robustness needs to be analyzed, then the system's dynamic behavior during fault conditions should be considered. The fault current level will not be the same if distributed generation penetrates the system. The connection of distributed generation should not alter the original power flow in the system. Hence a proper control mechanism should implement when distributed generation is used in the system. This paper has gone through the overview of distributed generation, operation, stability analysis, and different control mechanisms to improve the Stability and drawbacks. These limitations present in the fuzzy controller can overcome by designing and developing a unique controller called goal representative heuristic dynamic programming controller. This controller will frequently interact between the power plant and its control strategy, has more memory capacity, and stores the data for future reference. This controller way overcomes the fuzzy controller's limitations and can successfully be implemented in a grid in distributed generation.***

***Keywords: Distributed generation, Smart grid, Micro grid, GrHDP controller. Fuzzy controller***

## 1. INTRODUCTION

A smart grid consists of many microgrids with multiple distributed generations that will use renewable energy sources. For low voltage microgrids, distributed generations will be in the form of either solar photovoltaics or rotating machines like diesel generators or wind turbines[1]. The voltage at load nodes will be increased if a consumer's load is connected to wind turbines; suppose the wind turbine generates more than 1.7 MW [2]. Even though medium voltage is distributed, generations will penetrate the high-level voltage level of dynamic loads [3]. At critical places with a lower inertia and low power consumption, say less than 1 MW, like industries, commercial buildings, and hospitals, backup supply should be there during block out times. The microgrid will get disconnected from the primary grid. It will supply the standard power to the load [4]. The remote area will get supply from the distributed generation by treating microgrids as a critical component for distributed generations; because the microgrid can operate in both islanded or grid-connected mode [5][6][7]. As the smart grid is influenced by information and digital communication technology, most distributed generation systems have been fed through smart transformers [8]. The problems raised in an electrical system due to the increase in distributed generations and microgrids can be resolved by implementing smart FACTS devices and the system's resielincy[9]. When loads like induction motors have fed from solar photovoltaics, short-term voltage instability issues will occur; during these periods, the negative sequence current must be injected into the grid to avoid this short time voltage instability issue [10]. When wind turbines were used as a source of distributed generation in a two-area system, an investigation was done on its effect on the inertia of the system, the development of fault on the rotor angle, and synchronous frequency [11][12][13]. To mitigate the instability issues occurring in the system, primarily due to penetration of solar photovoltaic's, $H_\infty$ The consensus approach has been implemented mainly in the DC microgrids by considering uncertainties[14]. The primary source for electric vehicles is the battery; hence, there must be battery charging stations (BCSs) to charge or recover the battery once the battery goes down. But when these battery charging stations are connected to any grid or any distributed generation system that is getting power from any form of renewable energy source, the system will become unstable [15]. When communication time-varying relays are present, secondary voltage restoration problems will occur in the droop-controlled inverter-based microgrid, which will work in an islanded mode[16]. A novel-based control strategy was proposed to bring the distributed voltages to a finite period's reference value [17]. A unified power quality conditioner can use as a bidirectional interface device, which will be placed in between the grid and generic loads. During this condition, an islanded mode will behave like an AC grid by forming parallel inverters.

In contrast, during a grid operation mode, while injecting voltage from photovoltaics into the grid, it will act as an active power line conditioner [18]. Penetration of distributed generation in the grid will also lead to cause miscoordination of overcurrent relays. The protection relaying system will get distributed, and the sequence of operation of the overcurrent relay will get failed [19][20][21]. Usually, microgrids will be exposed to the actuating faults, these type of faults shows a more significant impact on the microgrids. To overcome the problems like this, a fault-tolerant secondary voltage and frequency restoration method was used by sliding mode control strategy of an islanded microgrid[22]. If we increase the dynamic load in low inertia microgrids, a more significant drop in the value of frequency will occur. In these sequences, the value of a power grid's frequency will be estimated using a phase-locked loop, and issues raised will be reloved using virtual synchronous generator control for inverters [23][24].

## 2. DISTRIBUTED GENERATION

To overcome challenges in the availability of conventional energy sources, various power generation technologies have arrived through the solar power plant, wind power plant biomass, etc. They can be used at the level of its generation, termed as distributed generation[25]. The generators' capacity in the distributed generation will be smaller than a few megawatts(10-50 MW) [25]. Modern power systems have been designed to take power from the extensive transmission network and distribute as per consumer requirement[25]. Any distributed generation can be connected with the grid in two different ways. Either it can access the grid through parallel connection or by switching mode of contact[26], as shown in Figures 1 and 2, respectively.

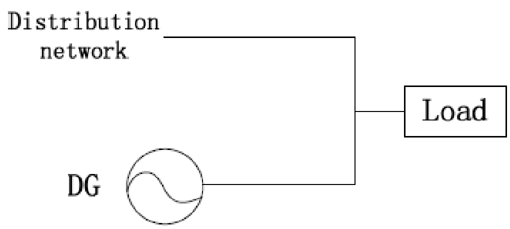


**Figure 1: grid access by DG through parallel connection**

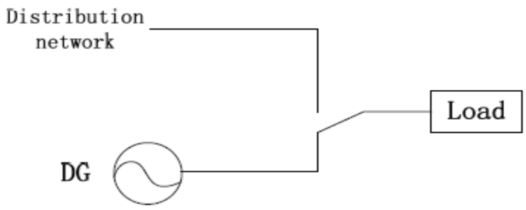


**Figure2: gird access by DG through the switch**

The most promising and largely exploring sources in a distributed generation are solar power and wind power. The installed capacity of solar energy in the world at the end of 1996 was 77MW [27]. The installation capacity of solar power by the united states increased to 40 GW at the end of 2014, and in 2017, it reached 77 GW [28]. The leading country in the implementation of wind power is Denmark; at the end of 2016, it was installed 432.882 GW[29]. At the end of 2020, it was newly installed about 127 GW of solar energy and 111 GW of wind energy in the world [36]. Figure 3 gives statistics about the variation and installation of solar, wind power, and total capacity in recent years from 2016 to 2021.

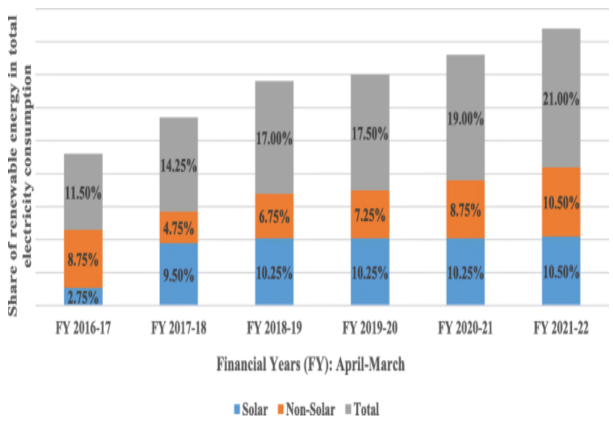


**Figure 3: Installation of renewable energies and total energy from 2016-2021**

## 3. MICROGRID

If the generator's rating is less than 10-50 MW, that generator can be treated as the distributed generator[25]. Unlike distributed generation, the installed capacity will be tens to hundreds of kilowatts in microgrids [30][31]. Power generating units will be fuel cells, microturbines, wind turbines, and solar photovoltaics[31]. These units will overcome the growing problem of electricity demand, environmentally friendly operation and become a promising option for the consumers[32].power generated by the microgrids cannot be matched instantly matched with the load during island or isolated operation mode. The compensation of unbalances between load and generation can be done by functioning the energy storage systems, the microgrids' fundamental function [33]. Either thermal or electrical load will be served by the microgrids[34]. By implementing safe and fast controlling algorithms, the primary controlling objective to control the inner units can be achieved. Output maintaining capability, power-sharing, power balancing, and island detection can be done by the primary controlling team using local parameters measurement [34][35]. Typical microgrid structures, which include renewable energy sources have shown in figure 4.

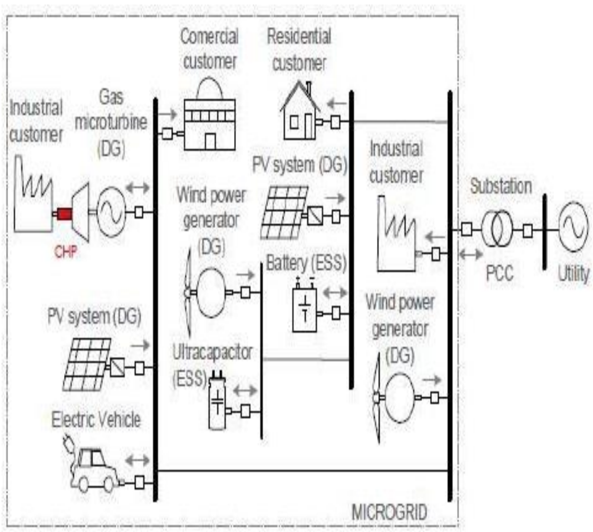


**Figure 4: Microgrid structure**

## 4. CHALLENGES TO CONNECT DISTRIBUTED GENERATION SYSTEMS TO GRID

Even though massive changes in power generation modes and structural modifications in power systems due to the adoption of distributed generation, many changes are raising for control engineers over stability issues once DGs enter the system. Usage of diesel generators is increasing rapidly in hybrid microgrids. Such microgrids' Stability will get affected due to their low inertia constant devices[37]. A microgrid has a wind turbine connected to the grid through an inverter, in islanded mode; these are significantly less sensitive to the system's frequency change, which will affect the transient Stability of the system. Most of the low voltage microgrids in the radial type of distribution system. in these types of structures, load shedding and line tripping will occur once a short circuit occurs on the network[1][3][4]. There is diversity in power generation due to the availability and adoption of various sources like solar, wind, thermal, hydro, etc. It is challenging to ensure their parallel operation and synchronization because many consumers will face power interruption problems [2][5][6]. When any fault occurs in a power system, the system will undergo its maximum stress. This stress may be electromagnetic or electromechanical, and it will reflect primarily on the switchgear and protection system. If the system has been modified with distributed generation implementation, it is challenging to judge the current fault level. The insulation of equipment may get breakdown due to an increase in the estimated fault current level[7][8][12]. Once Dg enters into the system, the overcurrent relay coordination will get mismatched, and its sequence of operation will get collapsed[13]. These issues will arise due to the usage and adoption of distributed generation through renewable energy sources, even though modern technologies enable the system to adopt distributed energy resources despite their difficulties and challenges. Figure 5 shows us the interest that the US government has offered to implement the distributed energy sources to increase its bulk power generation capacity[38][39][40].

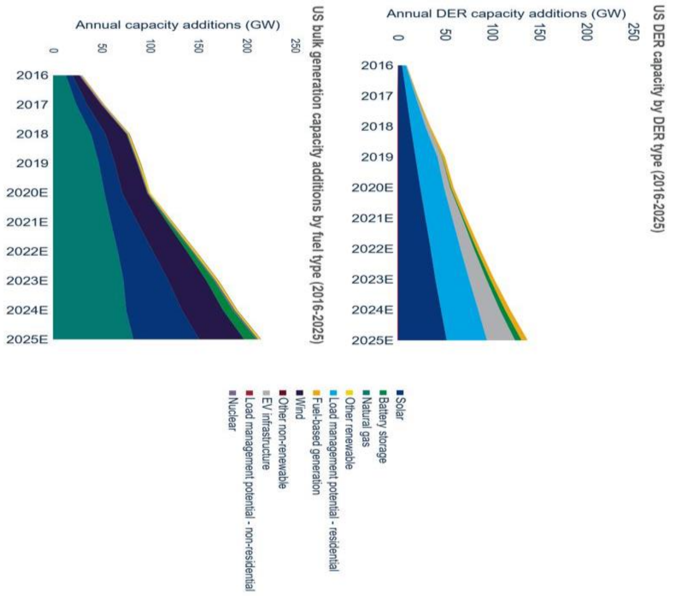


**Figure 5: usage of renewable energy resources over 2016 to 2025 in the US**

## 5. CONTROL STRATEGIES TO MAINTAIN THE STABILITY OF THE GRID

To study the system behaviors under fault conditions, especially during short circuit conditions, transients looking for a more extended period is very needful. During the islanded mode of operation of a low voltage microgrid, if an inverter is fed through photovoltaics, a special attanetiooon has to disconnect the grid's wind generators. When loads were changing abruptly, the short circuit clearing time will be the same as that of the traditional grid[1]. In [2], the Kaliningrad grid section includes the ushakhovo wind power plant. The study and analysis have been carried out by developing a proper mathematical model. A new option can transmit the power from the ushakhovo plant to the grid by creating a new transmission line. Instability occurs in the system due to non-linear loads like induction motor can be studied by comprehensive, integrated modeling, low voltage ride-through (LIRT) performance improving methods, stability studies for grid connect converter(GCC) based DG units, and also to determine the effect of the line from DG unit to the non-linear load's sensitivity analysis also carried out[3][4][5]. In the present era, distributed generation systems, smart grids, and microgrids work in automated mode, increasing cybersecurity threats. These issues can overcome by adopting a cooperative voltage control algorithm where the virtual system is introduced that will be interconnected with an original system whose operating voltage is maintained under predetermined values under attacking conditions [6]. A solid-state transformer known as a smart transformer can determine any network's low voltage value with control and communication functionalities. These features of the intelligent transformer can be used to control the low voltage converter[8]. FACTS device plays a crucial role in maintaining the system's Stability in the presence of distributed generation feeding through renewable energy sources. These FACTS devices, especially DSTATCOM, deal with a tremendous amount of dynamic loads during the transition of the grid's isolated operation mode [9][10][21]. Penetration of distributed generation in a two-area system affects the system stability. These may arise due to rotor angle swings and changes in the system's synchronous frequency when a short circuit occurs. These problems may suppress due to the proper location of the fast current limiters[11][12][13]. The distributed generator voltages will be restored within a finite time by using a novel distributed robust limited control strategy with proper delay communication technologies that will, whose solution determines fine-tuning for control gains. This will help to avoid blackouts, power interruption, and instability issues and helps to improve the transient and steady-state analysis[16][17]19]. By addressing consensus problems, sharing stringent real power in actuation or propulsion faults for frequency and voltage restoration of microgrids, the difficulties raised to activation of distributed generation can be eliminated[21]. With the adoption of a load angle-based optimal reclosing technique, it will help to enhance the system stability and determines the optimal reclosing time of circuit breakers[41]. A distributed control scheme to maintain dc micro grids' operation under various scenarios will implement a control scheme to ensure that the system is appropriately regulated. It will help to improve the transient stability of the system[42]. By applying a superconducting fast current limiter transient current rush, the power balancing and microgrids frequency stability can be improved, helping operate the protective relaying system effectively[43]. By implementing a self-adaptive virtual inertia-based fuzzy control strategy, the system's dynamic response will be improved. It will also help suppress the changes or disturbances of low inertia devices present in the microgridid[44]. A fuzzy logic system called Mamdani fuzzy set is developed to an adaptive method that will better inertial response against other time-consuming processes. This method measures and tunes the parameters online[45]. A current injector power buffer was designed, which works on a reset gain scheduling controller to stabilize the system[46]. One-off, the system’s source side controller will be replaced by aaa fast state plane controller to resiliency, microgrid operation, and load transient regulation[47]. A system consisting of multiple modular pulse width modulations and pulse phase shift controllers used for soft switching and low voltage stress purposes will help balance the voltages at the system's high voltage output side [48]. For a fixed frequency hybrid AC/DC microgrid, a dynamic voltage control technique was proposed; this will not only reduces the stress in the central system and helps in demonstrating extended operation also helps in improving transient stability of the system[49]. For management and control over the distributed power facilities and fault tolerance, the modern automated process control system was used; this will help to improve the reliability of the and fault tolerance system[50]. The injection of distributed generations into the grid causes severe issues on the protective relaying system. this will lead to mis coordination of overcurrent relays. As mentioned earlier, using the multiple numbers of fast current limiters can be resolved. Primary relays and their operating time with DG, without DG and both, are shown in figure 6.

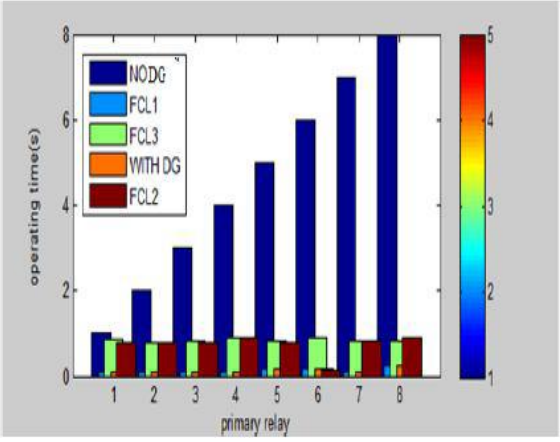


**Figure6: primary relays and their operating time in the presence of DG, without DG, and with FCLs.**

## 6. RESEARCH GAP and SOLUTION

Several control strategies have been developed to maintain the system's stability when distributed generation systems enter through the renewable energy sources system. A trending control strategy to support the grid's transient stability, especially in the presence of distributed generation, is the application of fuzzy logic controller [45]. The fuzzy controller has overcome the disadvantages and limitations of other controllers [43][44][45]. Even though it improves the system's transient stability, it requires many parameters that need to be tuned. It also has lesser memory capability, and we cannot get the data for future reference [45]. These limitations present in the fuzzy controller can overcome by designing and developing a unique controller called goal representative heuristic dynamic programming controller. This controller will frequently interact between the power plant and its control strategy, has more memory capacity, and stores the data for future reference. This controller way overcomes the fuzzy controller's limitations and can successfully be implemented in a grid in distributed generation.

## 7. CONCLUSION

Future energy demand in the world will depend on renewable energy sources. The concept of centralized power generation will no longer exist. The generated power has to use at the point of generation only, through distributed generation. But there will be many challenges to maintain the grid stability once DGs enter into the system. Hence an adaptive controller needs to be designed, which overcomes the limitations of existing controllers.

## REFERENCES

[1] Binh Phan, Hai Nguyen, Phuc Le, Hung Nguyen, Nghia Le 2019 Transient Stability of Low Voltage Micro Grid International Conference on System Science and Engineering (ICSSE).

[2] Andryushanov, D.A. and Kovalchuk, M.S., 2020, January. Research of the Stability of the Electrical System with Distributed Generation. In 2020 IEEE Conference of

Russian Young Researchers in Electrical and Electronic Engineering (EIConRus) (pp. 589-593). IEEE.

[3] Mortazavian, S. and Mohamed, Y.A.R.I., 2020. Investigation and enhancement of stability in grid-connected converter-based distributed generation units with dynamic loads. IEEE Access, 8, pp.93426-93443.

[4] Nazari, S., Amjadifard, R., Shokoohi, S. and Nateghi, A., 2018, November. Application of Kharitonov's Theorem in Robust Stability of Voltage and Frequency of an Islanded Microgrid. In 2018 Smart Grid Conference (SGC) (pp. 1-6). IEEE.

[5] babu Thogaru, R. and Mitra, A., 2019, March. Voltage Stability and Loadability Improvement of DC Microgrid Connected with Static and Dynamic Loads. In 2019 IEEE 5th International Conference for Convergence in Technology (I2CT) (pp. 1-5). IEEE.

[6] Gusrialdi, A., Xu, Y., Qu, Z. and Simaan, M.A., 2020, May. Resilient Cooperative Voltage Control for Distribution Network with High Penetration Distributed Energy Resources. In 2020 European Control Conference (ECC) (pp. 1533-1539). IEEE.

[7] Essackjee, I.A., and King, R.T.A., 2019, August. Fault Level Studies in a Low Voltage Distribution Network in the Presence of Small Scale Distributed Generations–Case Study for Mauritius. In 2019 International Conference on Advances in Big Data, Computing and Data Communication Systems (icABCD) (pp. 1-5). IEEE.

[8] Zou, Z.X., Liserre, M., Wang, Z. and Cheng, M., 2020. Stability Assessment of Voltage Control Strategies for Smart Transformer-Fed Distribution Grid. IEEE Access, 8, pp.185146-185157.

[9] Paredes, L.A., Molina, M.G. and Serrano, B.R., 2020, October. Improvements in the Voltage Stability of a Microgrid due to Smart FACTS–an Approach from Resilience. In 2020 IEEE ANDESCON (pp. 1-6). IEEE.

[10] Islam, M., Mithulananthan, N., Hossain, J. and Bhumkittipich, K., 2019, March. Short-term voltage stability of distribution grids with medium-scale PV plants due to asymmetrical faults. In 2019 IEEE PES GTD Grand International Conference and Exposition Asia (GTD Asia) (pp. 130-135). IEEE.

[11] Niazi, M.T.K., Mughal, M.A., and Hussain, A., 2019, April. Influence of DDSG Wind Turbine and Fault on Stability of Two Area Power System. In 2019 8th International Conference on Modeling Simulation and Applied Optimization (ICMSAO) (pp. 1-5). IEEE.

[12] Zhou, J., Xu, Y., Sun, H., Wang, L. and Chow, M.Y., 2019. Distributed Event-Triggered $ H_\infty $ Consensus-Based Current Sharing Control of DC Microgrids Considering Uncertainties. IEEE Transactions on Industrial Informatics, 16(12), pp.7413-7425.

[13] Gumilar, L., Sholeh, M., Rumokoy, S.N. and Monika, D., 2020, October. Analysis Voltage Stability in the Interconnection of Battery Charging Station and Renewable Energy. In 2020 2nd International Conference on Cybernetics and Intelligent System (ICORIS) (pp. 1-6). IEEE.

[14] Pandey, S.K. and Singh, B., 2020, October. Grid-Tied PV-BES System with Multitasking Voltage Source Converter. In 2020 IEEE 5th International Conference on Computing Communication and Automation (ICCCA) (pp. 12-17). IEEE.

[15] Narasimhan, A., 2020, July. DC and AC Active Power filters for Distributed Photovoltaic Grid System. In 2020 IEEE International Conference on Electronics, Computing and Communication Technologies (CONECCT) (pp. 1-5). IEEE.

[16] Andreotti, A., Caiazzo, B., Petrillo, A., Santini, S. and Vaccaro, A., 2020, June. Robust Finite-time Voltage Restoration in Inverter-Based Microgrids via Distributed Cooperative Control in the presence of communication time-varying delays. In 2020 IEEE International Conference on Environment and Electrical Engineering and 2020 IEEE Industrial and Commercial Power Systems Europe (EEEIC/I&CPS Europe) (pp. 1-6). IEEE.

[17] Ahmed, M.A., Ibrahim, D.K. and Gilany, M., 2019, December. Electric Spring Technology in Small Scale Residential Microgrid. In 2019 21st International Middle East Power Systems Conference (MEPCON) (pp. 392-398). IEEE.

[18] Campanhol, L.B.G., da Silva, S.A.O., de Oliveira, A.A. and Bacon, V.D., 2018. Power flow and stability analyses of a multifunctional distributed generation system integrating a photovoltaic system with a unified power quality conditioner. IEEE Transactions on Power Electronics, 34(7), pp.6241-6256.

[19] Gupta, N. and Seethalekshmi, K., 2018, November. A review on key issues and challenges in integration of distributed generation system. In 2018 5th IEEE Uttar Pradesh Section International Conference on Electrical, Electronics and Computer Engineering (UPCON) (pp. 1-7). IEEE.

[20] Fazli, N., Gierschner, S., Eckel, H.G. and Cai, L., 2019, September. Island Mode Operation of Rotating-Voltage-Vector Control for Wind Power Plants. In 2019 21st European Conference on Power Electronics and Applications (EPE'19 ECCE Europe) (pp. P-1). IEEE.

[21] Magadum, R.B. and Kulkarni, D.B., 2020, March. Performance Enrichment of Distribution Network with DG in the presence of STATCOM. In 2020 6th International Conference on Advanced Computing and Communication Systems (ICACCS) (pp. 701-705). IEEE.

[22] Shahab, M.A., Mozafari, B., Soleymani, S., Dehkordi, N.M., Shourkaei, H.M. and Guerrero, J.M., 2019. Distributed consensus-based fault-tolerant control of islanded microgrids. IEEE Transactions on Smart Grid, 11(1), pp.37-47...

[23] Afshar, Z., Zadeh, M.M., Bathaee, S.M.T., Mehrizi-Sani, A. and Guerrero, J.M., 2020, August. A Novel Frequency and Voltage Controller for Parallel Voltage Source Converters and Synchronous Generators Coexisting in Islanded Microgrids. In 2020 28th Iranian Conference on Electrical Engineering (ICEE) (pp. 1-7). IEEE.

[24] Machado, J.E. and Schiffer, J., 2020, December. A passivity-inspired design of power-voltage droop controllers for DC microgrids with electrical network dynamics. In 2020 59th IEEE Conference on Decision and Control (CDC) (pp. 3060-3065). IEEE.

[25] Strbac, G., 2006, June. Technical and commercial integration of distributed generation: a review of recent developments in the UK. In 2006 IEEE Power Engineering Society General Meeting (pp. 1-pp). IEEE.

[26] Hou, S. and Gao, Q., 2011, October. Review of impact of distributed generation on the distribution system. In 2011 International Conference on Advanced Power System Automation and Protection (Vol. 1, pp. 219-222). IEEE.

[27] Pillai, N., 2017, August. A study to increase 24-hour efficiency of distributed generation. In 2017 International Conference on Information, Communication, Instrumentation, and Control (ICICIC) (pp. 1-4). IEEE.

[28] Ndahepele, L. and Chowdhury, S., 2020, August. Impact of Distributed Generation on Traditional Protection in Distribution and Transmission Systems: A Review. In 2020 IEEE PES/IAS PowerAfrica (pp. 1-5). IEEE.

[29] Rafique, Z., Khalid, H.M. and Muyeen, S.M., 2020. Communication Systems in Distributed Generation: A Bibliographical Review and Frameworks. IEEE Access, 8, pp.207226-207239.
[30] Saad, O. and Abdeljebbar, C., 2020. Historical Literature Review of Optimal Placement of Electrical Devices in Power Systems: Critical Analysis of Renewable Distributed Generation Efforts. IEEE Systems Journal.
[31] Abdelgawad, H. and Sood, V.K., 2019, October. A Comprehensive Review on Microgrid Architectures for Distributed Generation. In 2019 IEEE Electrical Power and Energy Conference (EPEC) (pp. 1-8). IEEE.
[32] Malleswararao, M. and Ramadas, G., 2020, February. Review on Smart Energy & Congestion Management in Distributed Generation System using IoT. In 2020 International Conference on Inventive Computation Technologies (ICICT) (pp. 1001-1006). IEEE.
[33] Vargas, M.C., Mendes, M.A., Batista, O.E. and Simonetti, D.S.L., 2018, May. A review on the protection elements required for distributed generation in Brazil. In 2018 Simposio Brasileiro de Sistemas Eletricos (SBSE) (pp. 1-6). IEEE.
[34] Santos, G.B., Lopes, F.V. and Reis, A., 2018, May. Review of technical impacts and concerns caused by distributed generation in distribution systems protection. In 2018 Simposio Brasileiro de Sistemas Eletricos (SBSE) (pp. 1-6). IEEE.
[35] Singh, D. and Seethalekshmi, K., 2020, February. A Review on Various Virtual Inertia Techniques for Distributed Generation. In 2020 International Conference on Electrical and Electronics Engineering (ICE3) (pp. 631-638). IEEE.
[36] IRENA, international renewable energy agency, https://www.irena.org/
[37] Aderibole, A., Zeineldin, H.H., El-Moursi, M.S., Peng, J.C.H. and Al Hosani, M., 2017. Domain of stability characterization for hybrid microgrids considering different power-sharing conditions. IEEE Transactions on Energy Conversion, 33(1), pp.312-323.
[38] Narayanan, K., Ganesan, R.G. and Manju, A., 2018, May. Optimal Allocation of DG units to Counteract Load Growth. In 2018 IEEE Innovative Smart Grid Technologies-Asia (ISGT Asia) (pp. 1-6). IEEE.
[39] Sahoo, S., Mishra, S., Peng, J.C.H. and Dragičević, T., 2018. A stealth cyber-attack detection strategy for DC microgrids. IEEE Transactions on Power Electronics, 34(8), pp.8162-8174.
[40] O'Keeffe, D., Riverso, S., Albiol-Tendillo, L. and Lightbody, G., 2018, June. Decentralized L 1 Adaptive Controllers for Voltage Control of DC Islanded Microgrids. In 2018 European Control Conference (ECC) (pp. 161-166). IEEE.
[41] Adly, A.R., El Sehiemy, R.A. and Abdelaziz, A.Y., 2017. Optimal reclosing time to improve transient stability in the distribution system. CIRED-Open Access Proceedings Journal, 2017(1), pp.1359-1362.
[42] Vu, T.V., Paran, S., Diaz-Franco, F., El-Mezyani, T. and Edrington, C.S., 2016. An alternative distributed control architecture for improvement in the transient response of DC microgrids. IEEE Transactions on Industrial Electronics, 64(1), pp.574-584.
[43] Zheng, F., Deng, C., Chen, L., Li, S., Liu, Y. and Liao, Y., 2015. Transient performance improvement of a microgrid by a resistive superconducting fault current limiter. IEEE Transactions on Applied Superconductivity, 25(3), pp.1-5.
[44] Kerdphol, T., Watanabe, M., Hongesombut, K. and Mitani, Y., 2019. Self-adaptive virtual inertia control-based fuzzy logic to improve frequency stability of microgrid with high renewable penetration. IEEE Access, 7, pp.76071-76083.

[45] Karimi, A., Khayat, Y., Naderi, M., Dragičević, T., Mirzaei, R., Blaabjerg, F. and Bevrani, H., 2019. Inertia response improvement in AC microgrids: A fuzzy-based virtual synchronous generator control. IEEE Transactions on Power Electronics, 35(4), pp.4321-4331.
[46] Vafamand, N., Khayatian, A. and Khooban, M.H., 2019. Stabilization and transient performance improvement of DC MGs with CPLs: non-linear reset control approach. IET Generation, Transmission & Distribution, 13(14), pp.3169-3176.
[47] Bianchi, M.A., Zurbriggen, I.G., Paz, F. and Ordonez, M., 2018. Improving dc microgrid dynamic performance using a fast state-plane-based source-end controller. IEEE Transactions on Power Electronics, 34(8), pp.8062-8078.
[48] Lu, Y., Sun, K., Wu, H., Dong, X. and Xing, Y., 2018. A three-port converter-based distributed DC grid-connected PV system with autonomous output voltage sharing control. IEEE Transactions on Power Electronics, 34(1), pp.325-339.
[49] Navarro-Rodríguez, Á., García, P., Georgious, R. and García, J., 2018. Adaptive active power sharing techniques for DC and AC voltage control in a hybrid DC/AC microgrid. IEEE Transactions on industry applications, 55(2), pp.1106-1116.
[50] Adly, A.R., El Sehiemy, R.A. and Abdelaziz, A.Y., 2017. Optimal reclosing time to improve transient stability in the distribution system. CIRED-Open Access Proceedings Journal, 2017(1), pp.1359-1362.
[51] B Venkateshnaiiik, Sudhakar G kote 2019, Optimum Coordination of Directional Overcurrent Relays By Implementing Genetic Algorithm In The Presence of Distributed Generation.