Optimization of Microgrid fed from Hybrid Energy Sources using the Swarm Intelligence

Mrs. Sarika Satpute[1*], Dr. Sunil Kumar[2]

[1] PhD Scholar, Kalinga University, Raipur (CG)

Email: sarikadypiemr@gmail.com

[2] PhD Guide, Department of Electrical Engineering, Kalinga University, Raipur (CG)

Abstract - To combat the widening gap between demand and supply, it is crucial to include renewable energy sources as a Distributed Generation newline (DG). Despite their usefulness in reducing the gap, RE sources place a heavy pressure on generation scheduling, particularly wind power. Utilities are compelled to use wind curtailment due to fluctuations in wind energy output, which reduces the incentive to switch to renewable sources of power. Demand Side Management (DSM) is one approach to this problem, since it adjusts demand in real time to match generation while the grid is operating. Conventional Demand Response (DR) systems were created to minimise consumption during peak hours by arranging user loads in exchange for incentives. The Smart Grid (SG) concept provides a high-tech means of communication for keeping tabs on and managing the power grid. This motivated the creation of a sophisticated DR technique known as Demand Dispatch (DD), in which consumption is time-synchronized with electricity production. In order to deal with the fluctuations in wind power production, this thesis proposes a DD method. The entities involved in DD and the way in which data is shared between them are laid out in an operational framework. In order to find and evaluate all of the studies that have been published on a certain topic, researchers often undertake systematic literature reviews.

Keywords - Optimization Microgrid, Hybrid Energy Sources, Swarm Intelligence

- X -

1. INTRODUCTION

Since the growth of the use of renewable energy resources and the installation of new renewable-based power plants is a global focus shift towards a sustainable society, with all the preplanned new installations, it is imperative to use renewable energy with the highest efficiency and reliability that technological advances can make possible with the integration of Micro grid. It needs control and management at different levels to allow the inclusion of renewable energy sources. This area of research presents a micro-grid fed from wind and solar based renewable energy generating sources [1].

Electric power grid has been in existence and operational for more than ten decades. Thermal power plants which use coal as fuel contributes a large part of the power generated [2]. The cost incurred in transportation of coal is tremendous and an easy way to optimize this is to install thermal power plants near the coal mines. Hydro power generation too is limited to a specific location due to constrained resource availability. Even though power generation is specific to a location, the end user or the consumer is distributed throughout the country. The need for high voltage transmission lines is essential for interconnection of various generating stations and thus the conventional power system consisting of bulk generating stations at specific locations, high voltage long distance overhead transmission lines and low voltage distribution side emerged [3].

HVAC lines, and rarely HVDC too, carry the bulk power generated at one end to the other end of the country, where it is distributed to consumers at a lower voltage level. The changes in generation and consumption are reflected throughout the grid and such a system is called a synchronous network with centralized generation [4]. The advantage of a synchronous system is that the frequency of the voltage in the network is a single parameter that indicates the stability of the grid. The main strategy involved in power system control is balancing the autonomously fluctuating demand with variable generation, failing which the wastage of resources and damage on economy will be huge [5]. If generation and demand are balanced then the power system frequency will be nominal. If the demand tends to increase further keeping the generation constant, the frequency will decrease and vice versa. In traditional power system, Automatic Generation Control (AGC) and Load Frequency Control (LFC) are identified as means to balance supply and demand [6]. The frequency control schemes monitor the power system frequency and based on the deviation from its nominal value enable a control action. The control could be usually adjusting the steam pressure by burning more coal or increasing the water inlet pressure in case of a hide plant. The scheme implemented should be able to meet the fast changes in frequency deviation, but in case of thermal power plants the response is slow. During extreme conditions if the mismatch between supply and demand is widening, utility is left with no option other than load shedding [7].

The demand is time varying in nature and if the generation fails to meet it with AGC and LFC [8], the operator has to go for load shedding in order to avoid under-frequency tripping. When it comes to uncontrolled and intermittent generation schemes like wind and solar, AGC is not in the picture and even the load shedding will demand a timing and a volume that match the balancing requirements on the grid. The demand for electricity has expanded at a rate that has outpaced the increase in capacity as the power grid has developed over the years. Wind and solar power integration, among other RE technologies, shows promise. Due to their dispersed, low-power-density natural environments, all of these resources must be connected to the grid in order to have a significant effect [9]. To meet this need, the idea of distributed generation arose, which allows for the integration of renewable energy sources (RE) even at the low voltage distribution side of the power utility network. Microgrids were conceptualized in part because to distributed generation (DG) systems that could link to an existing power grid. A micro grid is a miniature power system, which has local generation and consumers spread over an area of a few 100 – 1000 km^2. The power flow in a micro grid is bidirectional when it is interfaced with the main grid, as it can aid the main grid at times with local generation in excess of local demand and absorb power from the main grid when there is a local deficit [10].This study is arranged as follows: in part 2, a description of the literature review; in section 3, a description of the research gap analysis; in section 4, an analysis of the results; and in section 5, a description of the final conclusion.

2. LITERATURE REVIEW

In [11] author considered data centers as sources of flexible demand for DR. Data centers are used by tenants on a tariff that is fixed based on the usage of the service. The strategy considered that data centre operators are participating in DR and proposed an algorithm to effectively address DR, which involved scheduling of tenants of data server.

In [12] author described for DOE suggested an advance version of DR, named as Demand Dispatch (DD). The introduction of distributed generation/resources catapulted this advancement. DD primarily focuses on demand side resources, which included consumer loads and local generation in the form of roof top solar photo voltaic (PV) and micro wind turbines.

In [13] author evaluated the true potential of DD in DSM. The authors identified DD to be an efficient adaptation of DR, facilitated by the advancements in communication technology and smart grid. Traditional DR is deployed for reduction of peak consumption, whereas DD is deployed for 24×7, throughout the year. The authors also identified a set of potential DLs. Dishwashers, cloth washers and dryers, water heaters, HVAC with thermal storage are a few among the suggested loads. The time response of these loads could be in terms of seconds to few milliseconds. The authors evaluated the scope of DD with smart charging of Plugged in Electric Vehicles (PEVs) in maintaining grid frequency. The article also emphasized on the role of smart appliances and IoT in aiding DD.

In [14] author investigated the possibilities of super capacitor based energy storage for wind power smoothening. The proposed strategy was suitable for short-term corrections in predicted wind power; however, authors suggested long term storage to be essential for huge deviations.

In [15] author evaluated the charging/discharging effects of EV using renewable sources as DG sources.

In [16] author investigated the possibilities of scheduling the charging/discharging of EVs to balance intermittent wind power generation.

In [17] author established that the co-ordinate operation of wind generators and EVs can yield primary frequency control in micro grids with high wind penetration.

In [18] author proposed a grid-to-vehicle (G2V) charging methodology incorporating optimization techniques to reduce the imbalances induced by wind.

In [19] author proposed a co-ordinate control of LFC for thermal generators and scheduled charging of EVs to maintain supply demand synergy. A power allocation layer and a control layer for BESS to reduce wind power fluctuations.

In [20] author puts serious operational restrictions like active power control on wind farms, due to un-schedulability and intermittency issues. When high wind penetration is anticipated in the near future, appropriate modifications are to be made in the grid code. One such modification could be the introduction of DD programmers and dynamic tariff. The major challenge to be addressed in DD is the customer participation. The motivation for participating in a DD or DR program is the incentives associated. For DD/DR schemes to succeed, the consumer should be aware of dynamic tariff, time, and their consumption, which is pretty hefty.

In [21], EV charge/discharge control is suggested depending on the SoC, departure time, and other features of the EV. This DR method mitigates frequency fluctuations in wind-powered microgrids.

Similarly, [22] has employed EV scheduling based on Model Predictive Control (MPC) with scenario optimization to reduce risk associated with wind power injection.

This study uses an enhanced Particle Swarm Optimization (PSO) method to tackle the large dimensionality and complex restrictions in optimal functioning of the various EV charging systems described by [23].

Wind power injection is utilized to optimize the size and operations of battery energy storage systems (BESS) for compensating wind power production changes, although BESS placement is not taken into account.

Flexibility in operation is what elasticity of an appliance amounts to in the planned household DR incorporating elastic and inelastic equipment [25]. Each home's optimal contribution to the system is communicated by the aggregator, and from there, the homeowners make operational decisions independently.

In [26]'s planned DR for homes, the loads are broken down into three groups: those that can be interrupted, those that can be adjusted, and those that can be shifted in terms of time. One of the loads that might be moved is an EV. Each load type's operating limitations are simulated so that they may be accommodated by DR in a microgrid.

Smart house energy management is suggested as part of yet another residential DR programmed in [27]. Smart home technology, cogeneration, and battery storage are all part of the energy management system. A has addressed the issue of decreasing peak loads.

The authors of [28] took into account data centers as adaptable demand generators for DR. Tenants pay a flat rate for using data centers regardless of how much data they store. Data centre operators' participation in DR was taken into account, and a suggested method for efficiently addressing DR was presented; this algorithm required the scheduling of data server tenants.

An improved form of DR called Demand Dispatch (DD) was proposed by DOE in [29]. This progress was propelled by the use of distributed generation and resources. Demand response prioritizes demand side resources such rooftop solar photovoltaic (PV) and micro wind turbines for local generation in addition to consumer loads.

The real potential of DD in DSM was assessed in [30]. Because of developments in communication technology and the smart grid, the authors found that DD is an efficient adaption of DR. While traditional DR is used to mitigate consumption spikes, DD is operational around the clock, all year long. A group of possible DLs was also found by the authors. Recommended loads include dishwashers, clothes washers and dryers, water heaters, and heating, ventilation, and air conditioning systems with thermal storage.

3. RESEARCH GAP ANALYSIS

Ref. No	Year	Title	Research gap and methodology	Dataset
31	2022	"Sustainable Solutions for Advanced Energy Management System of Campus Microgrids: Model Opportunities and Future Challenges"	In this article, there is a presentation of a complete evaluation of the energy management system that is used in campus microgrids. This study also includes a review of the available literature concerning various goal functions, renewable energy resources, and solution tools. In addition, the study directions and associated difficulties that need to be taken into consideration for further studies on microgrid scheduling are discussed as well.	NA
32	2019	"Performance Enhancement of an Inverter-Based Decentralized energy generation System Using Evaporation Rate Based Water Cycle Algorithm"	This article shows an example of a new Metaheuristic application called the Evaporation Rate, based Water Cycle Algorithm (ER-WCA), which is used to make an inverter-based (DEG) system work better. The way the inverter is controlled is through the vector cascaded control technique, which depends on the Proportional-Integral (PI) controller. The ER-WCA method is used to figure out how to make the PI controller factors work best.	DEG, Line, Supply
33	2022	"A Comprehensive Review on Integration Challenges, Optimization Techniques and Control Strategies of Hybrid AC/DC Microgrid"	This paper answers some of the most important questions about hybrid microgrids, such as where the feeds should be placed, how to handle them in the most cost-effective way, and how to deal with uncertainty in green energy sources. It also talks about the combination of AC and DC microgrids, security, and dependability.	Imbalanced data sets

The issues associated with high wind power injection and solutions suggested in published literature are thoroughly studied. It is observed that majority of the DSM schemes do not embrace the concept of DD effectively. The scope of DD in smoothening the variations in RE sources is potentially high. The operation of DLs leading to efficient DD operation is another task that needs to be resolved. Optimizing DL control without sacrificing the operational constraints of grid is yet another challenge [36-49].

Maximizing RE utilization is the prime goal for utilities in realizing green energy concept. However the uncertainties in RE generation force utilities to employ RE curtailment which weakens green energy initiatives. DD can ensure smooth operation of RE sources, as the instabilities in generation can be balanced through DLs. On the demand side, a few large residential consumer appliances, several commercial equipment and certain industrial ancillary units have deferrable duty in effect and thus form units of DL, to be identified with DD. Dishwashers, washing machines, huge battery chargers, plug-in electric cars, water heaters, etc., all qualify as heavy loads. Unless the appliance itself is a smart appliance, DD on appliances/DLs requires a smart controller. There are plenty of the DLs described above, but they don't pack much of a punch. In addition, the accessible DLs will be widely spread over the grid, since DD is still a novel method for which no established frameworks exist. It will be difficult for utilities to find and choose suitable DLs for DD. When deciding which DLs to use, it's important to think about things like distribution feeder capabilities, bus voltage caps, etc.

4. RESULTS

With an ever-increasing frequency, utilities are incorporating microgrids into their LV distribution networks. There will be several difficulties encountered by an islanded microgrid during operation due to the growing number of DG (Distributed generation). The suggested approach may help solve the problems associated with integrating renewable energy sources with microgrid control. The planned research will examine the effects of various controllers on the microgrid's voltage in an effort to optimize its performance. Controller performance will also be studied with the use of MATLAB/Simulink Sim Power Systems. Protection zone and operating speed of LV microgrid provide significant difficulties during microgrid operation. The suggested approach allows for the right design of a converter that meets future-ride-through (FRT) standards, hence overcoming these difficulties.

In order to quantify the value of opinion mining systems and provide context for how they have evolved practically, an assessment metric is used. Included are criteria that fall below the industry standard of secretive assessment techniques. Recall, Precision, and Accuracy are some of the metrics used for this purpose. Calculating the values of these metrics is necessary for using the suggested approach to efficiently classify reviews using mining.

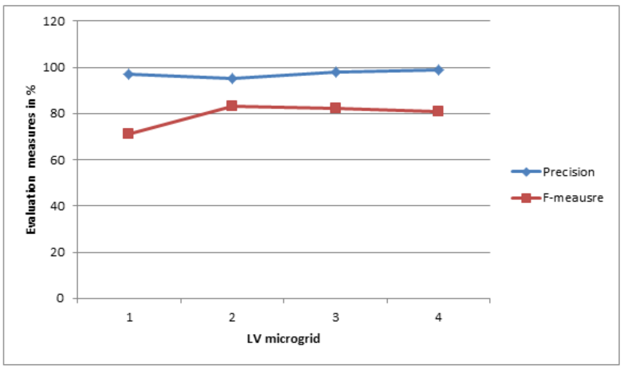

Figure 1: Evaluation Measures for precision and F-Measure

Figure 1 displays the results of a performance analysis using the Precision and F-Measure measures.

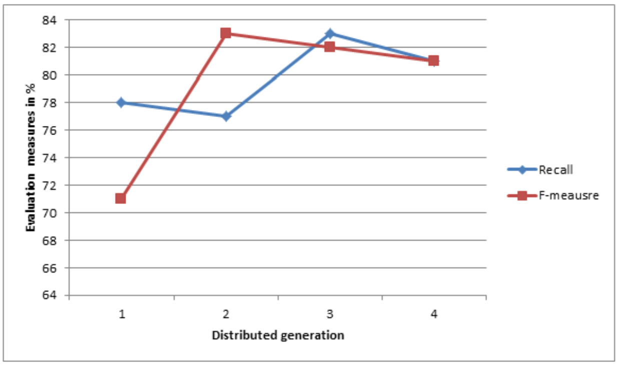

Figure 2: Evaluation Measures for Recall and F-Measure

The performance analysis with the evaluation metrics Precision and F-Measure are given in Figure 2.

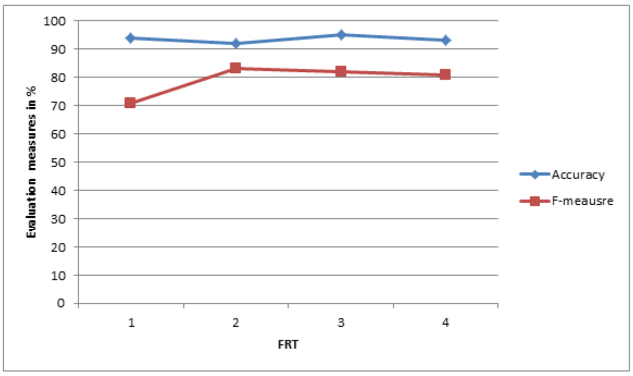

Figure 3: Accuracy Measures of Various Products

The measure of accuracy is given in Figure 3 along with the pictorial representation. In conjunction with the product reviews, the performance was analysed. These reviews were evaluated based on their precision, recall, accuracy, and F-measure scores. This demonstrates how useful opinion and classification methods may be when using sentiment analysis.

5. CONCLUSION

The investigation of literature review carried out for the paper addressed the above issues, and used DD as a means to absorb the variations in RE generation. A framework similar to DR is proposed for DD and is evaluated considering numerous Demand Side Response (DSR) aggregators. DSR aggregators help utilities in the identification and control of DLs. On a distribution network RE is manifested mostly as DG and there is scope for power balance management when the DG capacity is within the limits of distribution network. To address the issues on a distribution network, laboratory emulator based study is helpful besides simulation study. Advanced measurement and control modules necessary for deploying DD have been designed and developed as a part of the investigation. It is found that DD is effective in addressing the issues related to high wind power injection in a large utility grid. The investigation carried out used the concept of Internet of Things (IoT) for data exchange and controlling DLs for efficient DD operation.

REFERENCES

[1] Shailendra Kr. Tiwari* , Member, IEEE, Bhim Singh* , Fellow, IEEE, Puneet K. Goel "Design and Control of Micro-Grid fed by Renewable Energy Generating Sources" IEEE Transactions on Industrial Application, vol 0093-994, 2017

[2] Faisal R. Badal , Purnima Das, Subrata K. Sarker1 and Sajal K. Das" A survey on control issues in renewable energy integration and microgrid" Springer open access, 4, Article number: 8 (2019)

[3] M. Das and V. Agarwal, "Novel High-Performance Stand-Alone Solar PV System With High-Gain High-Efficiency DC–DC Converter Power Stages," IEEE Transactions on Industry Applications, vol. 51, no. 6, pp. 4718-4728, Nov.-Dec. 2015.

[4] A. B. Ataji, Y. Miura, T. Ise and H. Tanaka, "Direct Voltage Control With Slip Angle Estimation to Extend the Range of Supported Asymmetric Loads for Stand-Alone DFIG," IEEE Transactions on Power Electronics, vol. 31, no. 2, pp. 1015-1025, Feb. 2016.

[5] N.A. Orlando, M. Liserre, R.A. Mastromauro and A. Dell'Aquila, "A survey of control issues in PMSG-based small wind turbine system," IEEE Trans. Industrial Informatics, vol.9, no.3, pp 1211-1221, July 2013

[6] Z. Qi, "Coordinated Control for Independent Wind-Solar Hybrid Power System," 2012 Asia-Pacific Power and Energy Engineering Conference, Shanghai, 2012, pp. 1-4.

[7] M. Rezkallah, S. Sharma, A. Chandra and B. Singh, "Implementation and control of small-scale hybrid standalone power generation system employing wind and solar energy," 2016 IEEE Industry Applications Society Annual Meeting, Portland, OR, 2016, pp. 1-7.

[8] A. Hamadi, S. Rahmani, K. Addoweesh and K. Al-Haddad, "A modeling and control of DFIG wind and PV solar energy source generation feeding four wire isolated load," IECON 2013 - 39th Annual Conference of the IEEE Industrial Electronics Society, Vienna, 2013, pp. 7778-7783.

[9] S. K. Tiwari, B. Singh and P. K. Goel, "Design and control of autonomous wind-solar energy system with DFIG feeding 3-phase 4- wire network," 2015 Annual IEEE India Conference (INDICON), New Delhi, 2015, pp. 1-6.

[10] S. K. Tiwari, B. Singh and P. K. Goel, "Design and control of microgrid fed by renewable energy generating sources," 2016 IEEE 6th Inter. Conference on Power Systems (ICPS), New Delhi, 2016, pp. 1-6.

[11] Zhan, S. Member, M. Ghamkhari, and D. Xu, "Extending Demand Response to Tenants in Cloud Data Centers via Non-intrusive Workload Flexibility Pricing," vol. 3053, no. c, pp. 1–12, 2016.

[12] Dodrill, Keith. "Demand Dispatch—Intelligent Demand for a More Efficient Grid." 2011.

[13] A. Brooks, E. Lu, D. Reicher, C. Spirakis, and B. Weihl, "Demand dispatch," IEEE Power Energy Mag., vol. 8, no. 3, pp. 20–29, 2010.

[14] C. Abbey and G. Joos, "Supercapacitor energy storage for wind energy applications," IEEE Trans. Ind. Appl., vol. 43, no. 3, pp. 769–776, 2007.

[15] H. Fathabadi, "Utilization of electric vehicles and renewable energy sources used as distributed generators for improving characteristics of electric power distribution systems," Energy, vol. 90, pp. 1100–1110, 2015.

[16] X. Huang, Q., Jia, Q.-S., and Guan, "Robust Scheduling of EV Charging Load with Uncertain Wind Power Integration," IEEE Trans. Smart Grid, vol. PP, no. 99, pp. 1–12, 2016.

[17] M. F. M. Arani and Y. Mohamed, "Cooperative Control of Wind Power Generator and Electric Vehicles for Microgrid Primary Frequency Regulation," IEEE Trans. Smart Grid, vol. 3053, no. c, pp. 1–1, 2017.

[18] W. Leterme, F. Ruelens, B. Claessens, and R. Belmans, "A flexible stochastic optimization method for wind power balancing with PHEVs," IEEE Trans. Smart Grid, vol. 5, no. 3, pp. 1238–1245, 2014.

[19] Y. Ota, H. Taniguchi, T. Nakajima, K. M. Liyanage, J. Baba, and A. Yokoyama, "Autonomous distributed V2G (vehicle-to-grid) satisfying scheduled charging," IEEE Trans. Smart Grid, vol. 3, no. 1, pp. 559–564, 2012.

[20] Ericsson, Göran N. "Cyber security and power system communication—essential parts of a smart grid infrastructure." , IEEE Transactions on Power Delivery vol. 25, no. 3, pp.1501-1507,2010.

[21] Du, W. et al. A Comparative Study of Two Widely Used Grid-Forming Droop Controls on Microgrid Small-Signal Stability. IEEE J. Emerg. Sel. Top. Power Electron. 2020, 8, 963–975. https://doi.org/10.1109/JESTPE.2019.2942491.

[22] Tan, K.H.; Li, M.Y.; Weng, X.Y. Droop Controlled Microgrid with DSTATCOM for

Reactive Power Compensation and Power Quality Improvement. IEEE Access 2022, 10, 121602–14.

[23] Benadli, R.; Khiari, B.; Memni, M.; Bjaoui, M.; Sellami, A. An Improved Super-Twisting Sliding Mode Control for Standalone Hybrid Wind/Photovoltaic/Fuel Cell System Based on Energy Management of Battery/Hydrogen. J. Sol. Energy Eng. 2022, 144, 031003.

[24] Trivedi, R.; Khadem, S. Implementation of artificial intelligence techniques in microgrid control environment: Current progress and future scopes. Energy AI 2022, 2, 100147.

[25] Zaki, D.A.; Hasanien, H.M.; El-Amary, N.H.; Abdelaziz, A.Y. Tuning PI controllers for optimal migrogrid operation based on Artificial Neural Network. In Proceedings of the IEEE Conference on Power Electronics and Renewable Energy (CPERE), As- wan, Egypt, 23–25 October 2019; pp. 371–378.

[26] Sindi, H.F.; Alghamdi, S.; Rawa, M.; Omar, A.I.; Elmetwaly, A.H. Robust control of adaptive power quality compensator in Multi-Microgrids for power quality enhancement using puzzle optimization algorithm. Ain Shams Eng. J. 2022, 17, 102047.

[27] Saxena, N.K.; Gao, W.D.; Kumar, A.; Mekhilef, S.; Gupta, V. Frequency regulation for microgrid using genetic algorithm and particle swarm optimization tuned STATCOM. Int. J. Circuit Theory Appl. 2022, 50, 3231–3250.

[28] Guha, D.; Roy, P.K.; Banerjee, S. Performance evolution of different controllers for frequency regulation of a hybrid energy power system employing chaotic crow search algorithm. ISA Trans. 2022, 120, 128–146.

[29] Rostom, D.Z.; Hasanien, H.M.; El Amary, N.H.; Abdelaziz, A.Y. Adaptive PI Control Strategy for Microgrid Performance En- hancement. Int. J. Energy Conv. 2019, 7. https://doi.org/10.15866/irecon.v7i3.17327.

[30] Nagaraja, Y.; Devaraju, T.; Sankar, A.M.; Narasimhulu, V. PV and Wind Energy Conversion Exploration based on Grid Inte- grated Hybrid Generation Using the Cuttlefish Algorithm. Eng. Technol. Appl. Sci. Res. 2022, 12, 9670–9675

[31] Muqeet, H.A.; Javed, H.; Akhter, M.N.; Shahzad, M.; Munir, H.M.; Nadeem, M.U.; Bukhari, S.S.H.; Huba, M. Sustainable Solutions for Advanced Energy Management System of Campus Microgrids: Model Opportunities and Future Challenges. Sensors 2022, 22, 2345.

[32] D. A. Zaki, H. M. Hasanien, N. H. El-Amary and A. Y. Abdelaziz, "Performance Enhancement of an Inverter-Based Decentralized energy generation System Using Evaporation Rate Based Water Cycle Algorithm," 2019 IEEE Conference on Power Electronics and Renewable Energy (CPERE), Aswan, Egypt, 2019, pp. 270-277, doi: 10.1109/CPERE45374.2019.8980152.

[33] Xiaofei Liu, Pei Zhang, Xiaoyang Deng, Dawei Sun, Hierarchical overvoltage predictive control scheme for a DFIG-based wind farm, Electric Power Systems Research, Volume 217, 109172, ISSN 0378-7796,

[34] Chakraborty, A.; Maity, T. Integrated control algorithm for fast and accurate detection of the voltage sag with low voltage ride- through (LVRT) enhancement for doubly-fed induction generator (DFIG) based wind turbines. Control. Eng. Pract. 131, 105393.

[35] Azeem, O.; Ali, M.; Abbas, G.; Uzair, M.; Qahmash, A.; Algarni, A.; Hussain, M.R. A Comprehensive Review on Integration Challenges, Optimization Techniques and Control Strategies of Hybrid AC/DC Microgrid. Appl. Sci. 2021, 11, 6242.

[36] Badarla, A. & Junnarkar, A.A. CL-IoT: cross-layer Internet of Things protocol for intelligent manufacturing of smart farming. J Ambient Intell Human Comput 12, 7777–7791 (2021). https://doi.org/10.1007/s12652-020-02502-0

[37] Badarla, A. (2018). Application of Internet of Things for Smart Precision Farming: Solutions and Challenges. International Journal of Advanced Science and Technology, Vol. Dec. 2018, PP. 37-45.

[38] Badarla, A. (2019). Experimental Analysis of Recent Clustering Algorithms for Wireless Sensor Network: Application of IoT based Smart Precision Farming. Jour of Adv Research in Dynamical & Control Systems, Vol. 11, No. 9. 10.5373/JARDCS/V11I9/20193162.

[39] Badarla, A. (2020). Detecting HTTP Vulnerabilities in IoT-based Precision Farming Connected with Cloud Environment using Artificial Intelligence. International Journal of Advanced Science and Technology, Vol. 29, No. 3, pp. 214 - 226.

[40] Mikhail, A., Kamil, I. A. (2017). Increasing SCADA System Availability by Fault Tolerance Techniques. 2017 International Conference on Computing, Communication, Control and Automation (ICCUBEA). doi:10.1109/iccubea.2017.8463911

[41] Mikhail, A., Kareem, H. (2017). Fault Tolerance to Balance for Messaging Layers in Communication Society. 2017 International Conference on Computing, Communication, Control and Automation (ICCUBEA). doi:10.1109/iccubea.2017.8463871

[42] Alhayani, B., Abbas, S.T., Mohammed, H.J Intelligent Secured Two-Way Image Transmission Using Corvus Corone Module over WSN. Wireless Pers Commun (2021). https://doi.org/10.1007/s11277-021-08484-2.

[43] Badarla, A. A. Junnarkar Cross-Layer Protocol for WSN-Assisted IoT Smart Farming Applications Using Nature Inspired Algorithm. Wireless Pers Commun 121, 3125–3149 (2021). https://doi.org/10.1007/s11277-021-08866-6

[44] Uke, N., Pise, P. et.al. (2021). Healthcare 4.0 Enabled Lightweight Security Provisions for Medical Data Processing. Turkish Journal of Computer and Mathematics (2021), Vol. 12, No. 11. https://doi.org/10.17762/turcomat.v12i11.5858.

[45] Alhayani, B., Kwekha-Rashid, A.S., et al. 5G standards for the Industry 4.0 enabled communication systems using artificial intelligence: perspective of smart healthcare system. Appl Nanosci (2022). https://doi.org/10.1007/s13204-021-02152-4.

[46] Rashid, A.S., Junnarkar, A.A. et al. Integration of Healthcare 4.0 and blockchain into secure cloud-based electronic health records systems. Appl Nanosci (2022). https://doi.org/10.1007/s13204-021-02164-0.

[47] A.Junnarkar, Dr & Tiwari, Mohit & Tiwari, Tripti & Upadhyaya, Dr. (2022). LCIPA: Lightweight Clustering protocol for Industry 4.0 enabled Precision Agriculture. Microprocessors and Microsystems. 94. 10.1016/j.micpro.2022.104633.

[48] A.A.Junnarkar Emergence of Healthcare 4.0 and Blockchain into Secure Cloud-based Electronic Health Records Systems: Solutions, Challenges, and Future Roadmap. Wireless Pers Commun 126, 2425–2446 (2022). https://doi.org/10.1007/s11277-022-09535-y

[49] Uke, N., Pise, P. et al. Automatic robot Manoeuvres detection using computer vision and deep learning techniques: a perspective of internet of robotics things (IoRT). Multimed Tools Appl (2022). https://doi.org/10.1007/s11042-022-14253-5.

Corresponding Author

Mrs. Sarika Satpute*

PhD Scholar, Kalinga University, Raipur (CG)