FOREX Publication
Open Access | Rapid and quality publishing

International Journal of
Electrical and Electronics Research (IJEER)
Research Article | Volume 12, Issue 3 | Pages 740-745 | e-ISSN: 2347-470X

Advanced Energy Management System for Hybrid AC/DC Microgrids with Electric Vehicles Using Hybridized Solution

S. Sruthi[1]*, Dr. K. Karthikumar[2] and Dr. P. ChandraSekar[3]

[1]*Research Scholar, Dept. of EEE, Veltech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Avadi, Chennai India; sruthi.seasapram91@gmail.com*
[2]*Associate Professor, Dept. of EEE, Veltech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Avadi, Chennai India; drkarthikumark@veltech.edu.in*
[3]*Professor, Dept. of EEE, Veltech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, Avadi, Chennai India; drchandrasekar@veltech.edu.in*

***Correspondence:** S.Sruthi; sruthi.seasapram91@gmail.com

ABSTRACT- The rapid expansion of the automotive sector promising this technology is going forward and deeply ingrained in human society. Without a doubt, the unpredictable and erratic charging demands of these devices would have an impact on the power grid's scheduling and optimal performance, which may be seen as a new issue. This research introduces an efficient energy management system for hybrid renewable energy in AC/DC microgrids, including electric vehicle (EV) renewable microgrids, utilizing sources such as solar and wind energy. These systems offer promising solutions for enhancing security, reliability, and efficiency in power systems, with the added benefit of reducing greenhouse gas emissions. The proposed optimization approach utilizes Honey Badger Algorithm (HBA) Golden Jackal Optimization (GJO) called Advanced HBA (AHBA) for voltage and power control in hybrid AC/DC microgrids with EVs. This approach addresses challenges faced by existing control methods, such as instability and complexity, by simplifying control through AHBA and facilitating efficient power sharing. Additionally, the suggested technique, which is intended for microgrids with different power profiles, streamlines electric car power references using separate inputs via AHBA. MATLAB simulations of a small-scale hybrid AC/DC microgrid is used to validate the proposed Energy Management System (EMS). The proposed approach achieves an efficiency of 99.023%.

Keywords: State of Charge, Energy management, Hybrid microgrids, AC grid power integration, Electric vehicle power references, varying power profiles.

ARTICLE INFORMATION

Author(s): S.Sruthi, Dr. K. Karthikumar and Dr. P. ChandraSekar;
Received: 19/05/2024; **Accepted**: 15/07/2024; **Published**: 20/07/2024;
e-ISSN: 2347-470X;
Paper Id: IJEER 1905-17;
Citation: 10.37391/ijeer.120303
Webpage-link:
https://ijeer.forexjournal.co.in/archive/volume-12/ijeer-120303.html

crossref member
CROSSREF.ORG
THE CITATION LINKING BACKBONE

1. INTRODUCTION

Hybrid AC/DC microgrids offer significant opportunities for distributed generation (DG) systems by leveraging both AC and DC technologies without the need for converters. They make it possible to directly gather energy from a variety of renewable sources, including wind turbines that provide AC power, fuel cells that also produce DC power, and solar systems that generate DC electricity. Microturbines and other dispatchable units improve the system's dependability and power quality even more. Hybrid AC/DC microgrids provide several benefits over pure AC or DC microgrids, including reduced startup costs, no need for converters, better power quality, and on-site direct power supply [1-3].

On-going analysis endeavors have tended to these difficulties through imaginative energy the board methodologies (EMS). A counterfeit brain organization (ANN)- based EMS for dealing with a DC microgrid utilizing a HESS was proposed by Ramu et al [4]. An hourly power stream (PF) study for AC/DC mixture microgrids associated by an interlinking converter (IC) in both islanded and lattice associated structures was introduced by Moradi et al. [5] inside an EMS. Beluga Whale Streamlining (BWO) was utilized by Alharbi et al. to make a proficient EMS for disseminating load in a DC microgrid. Ghasemi et al. focused on overseeing generator units, setting up a versatile burden the board plan, and charging and releasing electric vehicles. Belkhier and Oubelaid suggested a capacity framework and facilitated energy the board methodology that coordinated Hybrid Renewable Energy Resources (HRESs) to boost microgrid plan and activity.

To operate fused AC/DC microgrids efficiently and pave the road for robust and sustainable energy systems, these studies emphasize the significance of sophisticated optimization techniques and integrated energy management measures. Further research is needed to addresses the defies related with renewable energy intermittency and stochasticity, as well as to develop cost-effective maximum power point tracking (MPPT) algorithms for optimal energy production and service continuity in microgrid applications. The concept of hybrid AC/DC microgrids has garnered significant attention from researchers due to the combined benefits of DC and AC structures. This study evaluates the best to operate and manage hybrid AC/DC microgrids using renewable energy sources when there are electric vehicles (EVs). This is a difficult undertaking because EV charging demand is unpredictable and complicated. Four charging options with varying market share and capacity are taken into consideration while modeling and analyzing plug-in hybrid electric vehicles (EVs) at two distinct penetration levels (80% and 40%) within the hybrid microgrid.

To optimize power flow patterns and feeder reconfiguration, an ideal switching strategy is devised to unlock the potential of portable units and renewable energy sources. As a result, the negative grid consequences of the EV charging demand will be mitigated. A point estimate approach-based stochastic technique is developed to address the stochastic nature of solar and wind energy sources and the need for EV charging.

To work on the exactness of unusualness displaying, an AI technique in light of help vectors is likewise recommended for anticipating standard deviation factors in wind and sun powered information blunders in view of conjectures. The objective capability considers not just the exchanging costs related with maturing issues yet in addition the absolute expense of the mixture microgrid for controlling burdens and electric vehicles. Owing to the optimization problem's high variability and complexity, an innovative optimization technique that utilizes the flower pollination algorithm is suggested. This kind of discrete optimization problem calls for strong optimizers, and the flower pollination technique provides an appropriate method to deal with the problem's nature.

2. OVERVIEW OF SYSTEM TO ESTABLISH ENERGY MANAGEMENT IN HYBRID MICROGRID

Figure 1 illustrates the optimal management using the proposed system architecture. The suggested control technique for the RESs in the microgrid system is demonstrated by the hybrid renewable energy source control structure and the controller that is being provided. The fuel cell and photovoltaic (PV), Micro Turbine (MT), batteries are among the RESs that supply energy to the DC bus. Furthermore, the technology continuously improves grid-side parameter and electrical energy system load evaluation. The unit structure represents Voltage Source Inverter (VSI)-based RESs control blocks for energy management in the hybrid microgrid. For the HRES and utility to manage energy quality challenges, stable real and reactive power regulation is crucial. This section outlines the control method for real power and reactive power operation modes connected to the grid. The Energy Management System (EMS) creates power reference values for converters to distribute power among solar, fuel cell, wind turbine, grid, and storage energy systems based on measurements and data that are currently accessible. It accounts for different operating aspects like battery state of charge (SOC) and weather conditions as well as changing load requirements. The energy generated by solar and wind turbines are given precedence over other sources of energy in order to meet the load needs. In the event that wind and PV power generation surpass the needs of the load, excess power is used in conjunction with the load batteries and a reference value.

$$P_{B-Re\,f} = -P_{EV} + \left(P_{pv} + P_{wind} + P_{MT}\right) \tag{1}$$

where, $P_{B-Re\,f}$ specifies reference battery power, P_{pv}, P_{wind} specifies generated power from PV and wind, P_{EV} specifies EV power, P_{MT} specifies MT power.

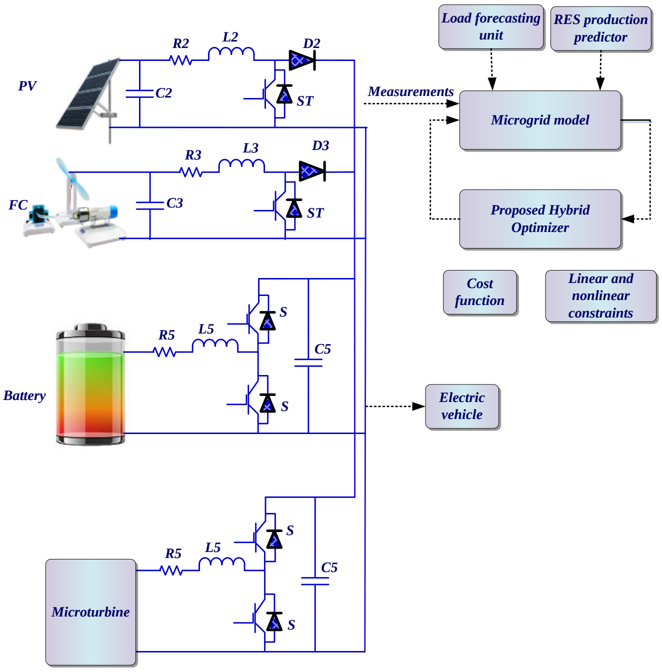


Figure 1. Optimal management using proposed system architecture

A sufficient charge is achieved if the load's requirements exceed the power generated by wind and photovoltaic systems, contingent on battery state of charge. In this case, the load is supplied with power through the battery in relation to its battery power reference.

$$P_{B-Re\,f} = -P_{EV} - (P_{pv} + P_{wind} + P_{MT}) \tag{2}$$

In situations where the battery cannot provide the required load, energy generated by FC is utilized.

$$P_{FC-Re\,f} = -P_{EV} - (P_{pv} + P_{wind} + P_{MT}) - P_{Battery} \tag{3}$$

where, $P_{FC-Re\,f}$ denotes reference power of the FC and$P_{Battery}$denotes power through battery. Operating costs is calculated as,

$$MinJ_1 = \overset{\overset{K=1}{T}}{\sum} Pr\,ice_{(k)} \begin{pmatrix} P_{EV(k)} - P_{wind(k)} - P_{pv(k)} \\ P_{FC(k)} \pm P_{B(K)} \pm P_{Grid(K)} \end{pmatrix} \tag{4}$$

where T stands for time, $Pr\,i\,ce(k)$ shows how the price of electricity changes over time, P_{FC} represents FC power, and P_{Grid} shows how utility grid power is used and distributed to various components via the smart grid.

2.1. Proposed Technique Based Optimal Energy Management in Hybrid Microgrid

Honey Badger Algorithm (HBA) is a metaheuristic optimization methodology that draws inspiration from HB's astute foraging strategies. Using their honey-seeking and excavating methods, honey badgers' dynamic search behavior serves as the basis for the development of the HBA's exploration and exploitation stages [8]. This technique uses the HBA to solve optimization problems in this manuscript. It is inspired by honey badgers, who find food sources by tunneling or by following the scent of honeydew birds. The updating behavior of HBA is enhanced by Golden Jackal Optimization (GJO) [9]. Hence it is called as Advanced HBA (AHBA).

Step 1: In step 1, the number of HBs, population, and size are initialized. In this process, the parameters, including voltage and current, are initialized as follows:

$$X_I = L_{BI} + R_1 \times (U_{BI} - L_{BI}) \tag{5}$$

Step 2: The following random generating procedure is used to produce the initial populations at random:

$$F_i = \begin{bmatrix} (V,I)_i{}^{11} & (V,I)_i{}^{12} & \cdots & (V,I)_i{}^{1n} \\ (V,I)_i{}^{21} & (V,I)_i{}^{22} & \cdots & (V,I)_i{}^{2n} \\ \vdots & \vdots & \vdots & \vdots \\ (V,I)_i{}^{m1} & (V,I)_i{}^{m2} & \cdots & (V,I)_i{}^{mn} \end{bmatrix} \tag{6}$$

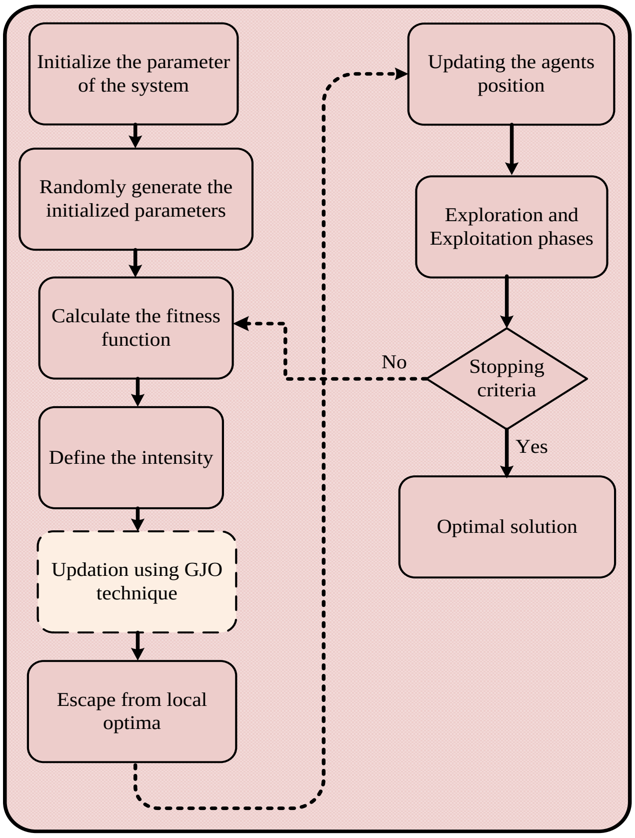


Figure 2. Flowchart of the proposed AHBA approach

Step 3: The fitness of the system is determined by the objective function which is derived as follows:

$$F = Min\{error\} \tag{7}$$

Step 4: Based on the prey's strength and the distance between them, calculate the intensity of the solution. It is explained as follows:

$$Intensity_I = R_2 \times \frac{s}{4\pi d_I^2} \tag{8}$$

Step 5: The calculation for density factor is explained as follows:

$$\beta = e \times exp\left(\frac{-t}{t_{MAX}}\right) \tag{9}$$

Step 6: To prevent the local optimum value, this step is taken in conjunction with the flag 'F'.

Step 7: The female jackals follow their male counterparts into the search area, where they wait and look for more victims.

Step 8: Check termination criterion; if the requirement is satisfied, the best possible result is indicated. If not, carry out the procedure again [35]. *Figure 2* shows the flowchart for the AHBA technique.

3. OUTCOMES AND ANALYSIS

This section demonstrates how the suggested process, which aims to improve the power quality in hybrid microgrids, is carried out on the MATLAB/Simulink platform. The suggested technique's performance is contrasted with that of other current methods.

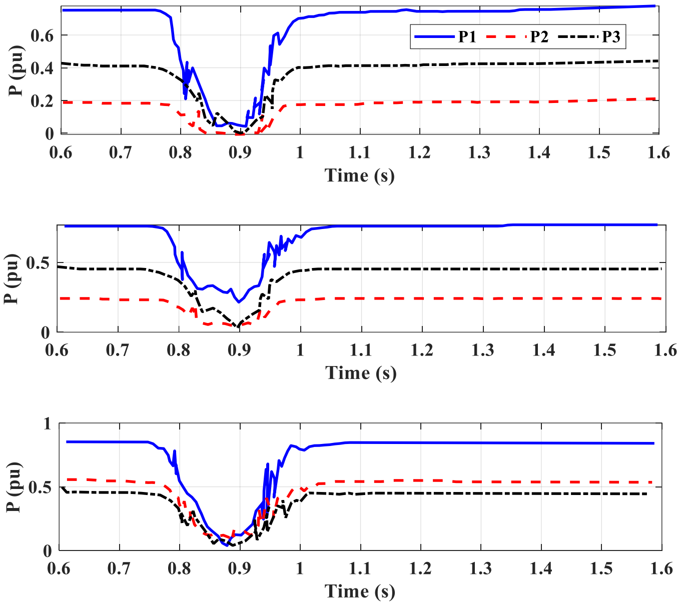


Figure 3. Three-phase fault in an islanded microgrid: time-domain simulation and microgrid active powers for the suggested method, [10] and [11]

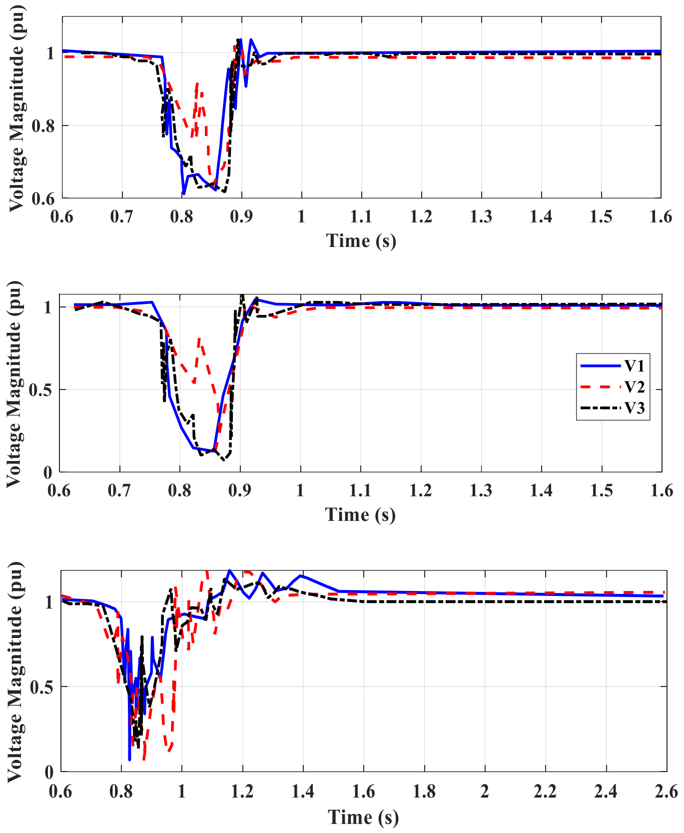
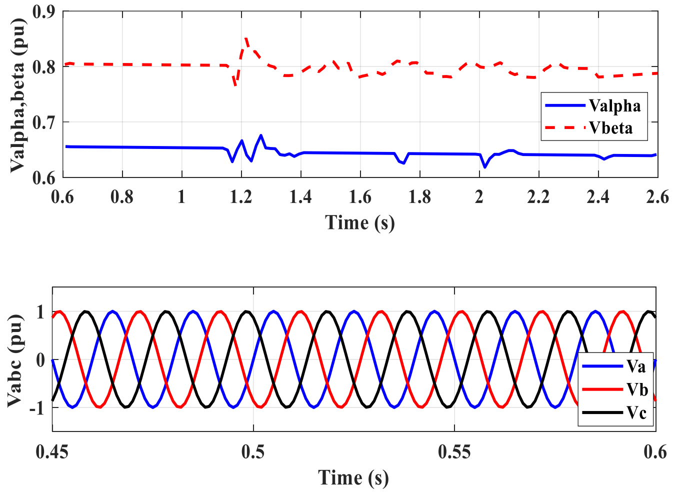


Figure 4. Three-phase failure in an islanded microgrid: time-domain simulation and microgrid voltages for the suggested method, [10] and [11].

A three-phase failure in an islanded microgrid utilizing the microgrid active powers for the recommended approaches [10] and [11] is shown in the time-domain simulation in *figures 3* and *4*. When the suggested robust nonlinear control scheme is applied, it is observed that voltage stabilizes after fault clearing; however, when the microgrid does not have the proposed robust nonlinear controller and instead uses conventional droop based control, voltage magnitude becomes unstable and power sharing is undesirable.



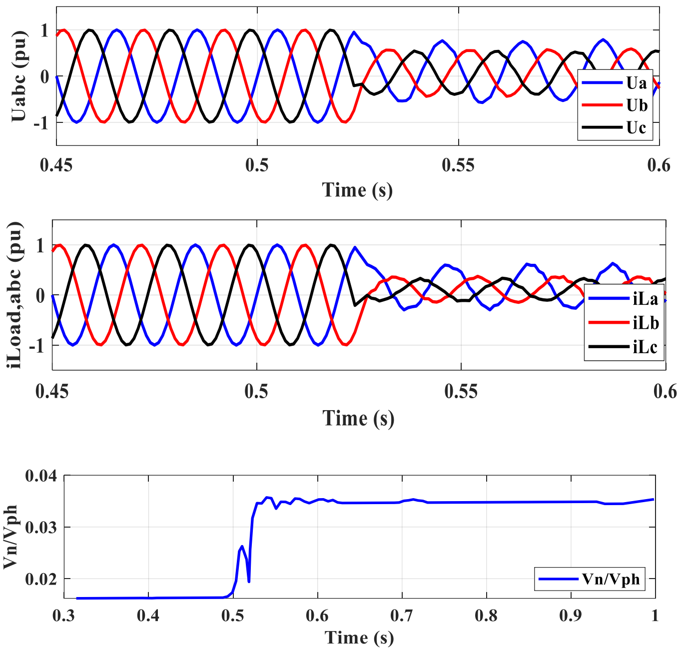


Figure 5. Simulation in the time domain to include an unbalanced load into an islanded microgrid

Time-domain simulation for adding an imbalanced load to an islanded microgrid: *Figure 5* displays microgrid voltages using the suggested control strategy. An islanded microgrid is used to demonstrate the simulation of motor starting in the time domain. The present approach and the recommended robust controller result in microgrid voltages, active powers, and reactive powers of 2.8%, which is less than the maximum value allowed by the IEEE standard.

Figure 6 displays the optimal output power of the DGs and the battery. This graph indicates that the battery is charged in the morning to reduce the cost of the microgrid during the hours of midday, or peak demand. Additionally, it is noted that because the solar panel and wind turbine are no dispatchable renewable energy sources, they are producing electricity as expected. If the cost of the more expensive units is greater than that of electricity from the main grid, it is preferable to purchase less power from them.

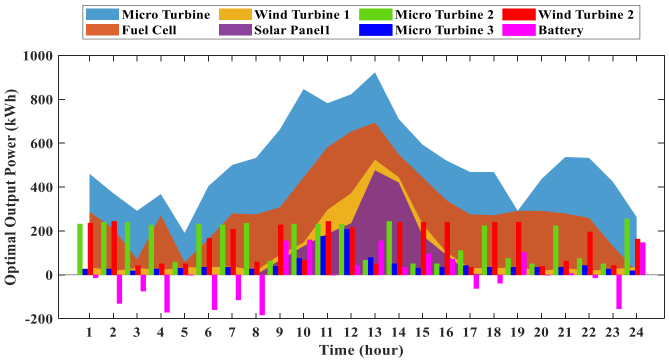


Figure 6. The units' ideal power in a coordinated charging approach (with a 40% penetration level)

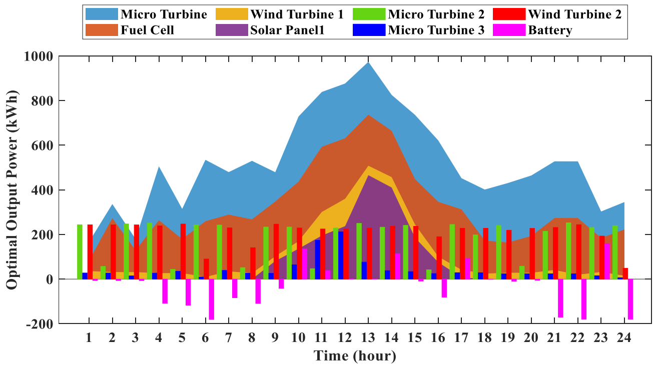


Figure 7. The units' optimal power in the smart charging approach (with a 40% penetration level)

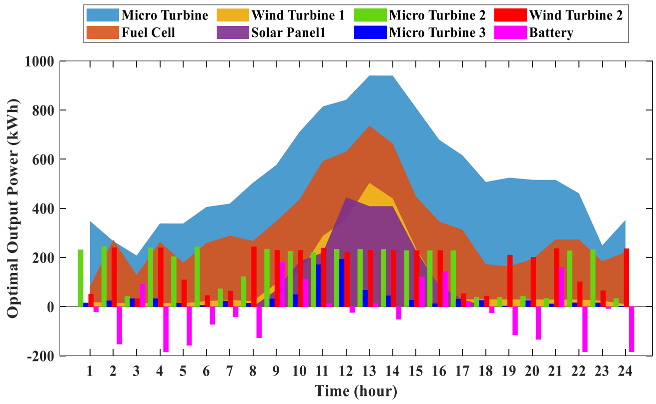


Figure 8: Impact of plug-in hybrid electric vehicle on hybrid AC/DC microgrid's overall cost

The present approach and the recommended robust controller result in microgrid voltages, active powers, and reactive powers of 2.8%, which is less than the maximum value allowed by the IEEE standard. *Figure 7* displays the units' ideal output power. For this analysis, the prior numbers are examined in a comparable way. Figure 8 shows the overall cost of the microgrid in all scenarios along with penetration levels of 40% and 80% to facilitate comparison. Additionally, it is evident that by demonstrating alternate power flow paths and thereby lowering costs, optimal switching has helped to improve the microgrid's economic position. Furthermore, it is possible to infer from this that the smart charging pattern is highly effective and efficient when compared to both coordinated and uncoordinated patterns. It is evident that the smart charging plan has the potential to lower the hybrid microgrid's overall operating costs during most of the day.

The efficiency for several path counts, such 100, 200, 500, and 100 trails, is explained in *table 1*.

The suggested technique confirms the best result in all the trails. The suggested method, which entails observing the values, performs better than previously developed techniques like Radial Basis Function Neural Network-Sparrow Search Algorithm (RBFNN-SSA), Artificial Neural Network (BFOANN) Grasshopper Optimization Algorithm and particle Swarm based neural network (GOAPSNN), and Bacterial Foraging Optimization and Ant Lion Optimizer (ALO). Overall analysis shows that the suggested method reduces the grid-connected microgrid's overall operating costs while simultaneously increasing the energy management system's accuracy.

Table 1: Effectiveness under different trail counts

Trials	**Methods**				
	Proposed	**ALO**	**RBFNN-SSA**	**GOAPSNN**	**BFOANN**
100	99.0037	75.6032	85.1948	80.3432	55.8935
200	99.2356	69.06723	88.3632	79.0342	59.84356
500	99.8363	65.32457	87.7322	77.1177	68.8362
1000	99.9373	61.03937	83.4378	79.2140	60.9273

4. CONCLUSION

This research uses a novel advanced approach to examine the best scheduling and energy management for hybrid AC/DC microgrids. Based on experimental results, the recommended hybrid EMS guarantees a balanced power distribution among the storage system and sources guaranteeing a continuous power supply. The present approach and the recommended robust controller result in microgrid voltages, active powers, and reactive powers of 2.8%, which is less than the maximum value allowed by the IEEE standard. The overall cost of the microgrid in all scenarios along with penetration levels of 40% and 80% to facilitate comparison. Due to a higher rate of adoption of electric vehicles, the hybrid microgrid will initially incur higher expenditures as a result of this number. The following efficiency numbers are listed under trails: 99.0037%, 99.2356%, 99.8363%, and 99.9373% for 100, 200, 500, and 1000. It quickly adjusts the DC bus voltage when there are variations and efficiently controls the terminal power balance of the system's components. Consequently, the following might be listed as the primary benefits of the suggested method:

- Offering a workable stochastic framework that enables hybrid microgrids to be operated while accounting for the significant levels of uncertainty associated with renewable energy sources.
- Evaluating the plug-in hybrid electric vehicle charging affects hybrid microgrid performance.
- Creating a universal optimisation technique that performs consistently and dependably outside of microgrids.
- Outlining the significant benefits of turning on the hybrid microgrids' entire operating costs.

REFERENCES

[1] Nourollahi, R., Zare, K. and Nojavan, S., 2020. Energy management of hybrid AC-DC microgrid under demand response programs: real-time pricing versus time-of-use pricing. Demand Response Application in Smart Grids: Operation Issues-Volume 2, pp.75-93.

[2] Wang, P., Wang, D., Zhu, C., Yang, Y., Abdullah, H.M. and Mohamed, M.A., 2020. Stochastic management of hybrid AC/DC microgrids considering electric vehicles charging demands. Energy Reports, 6, pp.1338-1352.

[3] Gholami, K., Azizivahed, A. and Arefi, A., 2022. Risk-oriented energy management strategy for electric vehicle fleets in hybrid AC-DC microgrids. Journal of Energy Storage, 50, p.104258.

[4] Ramu, S.K., Vairavasundaram, I., Palaniyappan, B., Bragadeshwaran, A. and Aljafari, B., 2024. Enhanced energy management of DC microgrid: Artificial neural networks-driven hybrid energy storage system with integration of bidirectional DC-DC converter. Journal of Energy Storage, 88, p.111562.

[5] Moradi, S., Tinajero, G.D.A., Vasquez, J.C., Zizzo, G., Guerrero, J.M. and Sanseverino, E.R., 2024. Hierarchical-Power-Flow-Based Energy Management for Alternative/Direct Current Hybrid Microgrids. Sustainable Energy, Grids and Networks, p.101384.

[6] Simões M, Busarello T, Bubshait A, Harirchi F, Pomilio J, Blaabjerg F. Interactive smart battery storage for a PV and wind hybrid energy management control based on conservative power theory. Int J Control. 2015;89(4):850-870. doi:10.1080/00207179.2015.1102971.

[7] Ghasemi, E., Ranjbaran, A. and Pourhossein, J., 2024. Designing multi-objective electric and thermal energy management system of microgrid in the presence of controllable loads and electric vehicles. Electrical Engineering, 106(2), pp.1519-1532.

[8] Hashim, F.A., Houssein, E.H., Hussain, K., Mabrouk, M.S. and Al-Atabany, W., 2022. Honey Badger Algorithm: New metaheuristic algorithm for solving optimization problems. Mathematics and Computers in Simulation, 192, pp.84-110.

[9] Chopra, N. and Ansari, M.M., 2022. Golden jackal optimization: A novel nature-inspired optimizer for engineering applications. Expert Systems with Applications, 198, p.116924.

[10] Baghaee, H.R., Mirsalim, M. and Gharehpetian, G.B., 2016. Real-time verification of new controller to improve small/large-signal stability and fault ride-through capability of multi-DER microgrids. IET Generation, Transmission & Distribution, 10(12), pp.3068-3084.

[11] Lu, X., Guerrero, J.M., Sun, K., Vasquez, J.C., Teodorescu, R. and Huang, L., 2013. Hierarchical control of parallel AC-DC converter interfaces for hybrid microgrids. IEEE Transactions on Smart Grid, 5(2), pp.683-692.

[12] Rajesh, P., Shajin, F.H., Rajani, B. and Sharma, D., 2022. An optimal hybrid control scheme to achieve power quality enhancement in micro grid connected system. International Journal of Numerical Modelling: Electronic Networks, Devices and Fields, 35(6), p.e3019.

[13] T. Praveen Kumar, N. Subrahmanyam and M. Sydulu, "Power Flow Management of the Grid-Connected Hybrid Renewable Energy System: A PLSANN Control Approach", IETE Journal of Research, pp. 1-16, 2019. Available: 10.1080/03772063.2019.1565950.

[14] Belkhier, Y. and Oubelaid, A., 2024. Novel design and adaptive coordinated energy management of hybrid fuel-cells/tidal/wind/PV array energy systems with battery storage for microgrids. Energy Storage, p.e556.

[15] M. Suresh and R. Meenakumari, "Optimum utilization of grid connected hybrid renewable energy sources using hybrid algorithm", Transactions of the Institute of Measurement and Control, p. 014233122091374, 2020. Available: 10.1177/0142331220913740.