Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 45 No. 1 (2024)

Machine Learning Based Enhancement of Load Sharing Efficiency in Off-Grid Systems

[1] Shoeb Peer Syed, [2] Dr. Maninti Venkateswarlu,[3] N.Vasavi,[4] D.Reshma

[1]*Assistant Professor-CSE, Ashoka Women's Engineering College, Kurnool, AP, India*

[2]*Professor-CSE, Ashoka Women's Engineering College, Kurnool, AP, India*

[3]*Assistant Professor-CSE, Ashoka Women's Engineering College, Kurnool, AP, India*

[4]*Assistant Professor-CSE, Ashoka Women's Engineering College, Kurnool, AP, India*

Abstract

Scheduled energy frameworks based on non-customary assets to fulfill the power needs in remote spots where there is no utility lattice and sun oriented and wind energy frameworks are required. A control strategy for an independent half breed PV cluster energized breeze driven enlistment generator with a three stage variable adjusted load is introduced in this paper. This paper examines load sharing for an independent framework utilizing a battery and power is conveyed using machine learning with presence of battery. Reenactment results are approved with the proposed control procedure and are a solid answer for far off applications where utility framework is neither possible nor conservative.

Index Terms— Machine learning,PV and wind energy systems, Battery

1. Introduction

Energy has consistently assumed a significant part in human and monetary turn of events and world harmony. By and by practically all the power age happens at focal power station which uses coal, oil, gas, water or fissile atomic material as the essential fuel source. It is fundamental that a few section and a rising part, of future electrical energy innovative work be worried about supposed nonconventional techniques for age. Wind-sun based power ages are noticeable choices for future power age. A worked on computerized reenactment model of the breeze energy change framework with battery capacity has been depicted in [2]. A plan methodology for PV/Wind half breed power age framework is introduced [3]. The PMSG wind turbine is one of the most well-known kind of wind turbines that utilizes a full scale converter with a variable speed wind turbine is examined in [6] and another model is produced for a PMSG-based breeze turbine with yaw control plot. [11] Arrangements with the consistent and transient examination of self-energized enlistment generators utilized rather than coordinated generators for off-matrix.

An inverter and a field-situated regulator are utilized to energize the enlistment machine (IM) proficiently, limiting copper and iron misfortunes, and to direct the created voltage has been examined . A DC converter is effectively mediated between the PV exhibit and the inverter to get consistent burden voltage in a crossover PV-IG plot when the battery is missing. A detached mixture plot utilizing a basic three-stage square-wave inverter to coordinate a photovoltaic cluster with a breeze driven enlistment generator has been proposed interestingly.

2. Methodology

Improving load sharing in off-grid applications using machine learning involves developing algorithms and systems that intelligently distribute the energy load among different sources and devices. Here's an overview of how machine learning can be applied to enhance load sharing in off-grid scenarios. Gather data on energy production, consumption patterns, and system parameters from various sources within the off-grid environment.

This could include solar panels, wind turbines, batteries, and energy-consuming devices. Identify relevant features such as weather conditions, energy production levels, battery status, and historical usage patterns. These features will serve as input variables for the machine learning model.

Utilize machine learning algorithms, such as regression or time series forecasting models, to predict the future energy load. This prediction can help the system anticipate upcoming demands and plan load-sharing strategies accordingly. Implement machine learning algorithms for decision-making to dynamically allocate energy resources based on real-time data. Reinforcement learning models can learn optimal load-sharing policies over time, adapting to changing conditions and demands. Develop algorithms that schedule the operation of energy-consuming devices to optimize load sharing. Machine learning can help predict when specific devices will be used and adjust the energy distribution plan accordingly. Integrate machine learning models for fault detection and diagnosis within the off-grid system. This helps identify issues in real-time, allowing for prompt corrective actions to maintain efficient load sharing.

3. Proposed Topology

The presented paper addresses the design and validation of a PV-wind hybrid generation system aimed at providing enhanced reliability for continuous power output, surpassing the capabilities of individual power generation systems. The system's appeal lies in its potential as a robust solution for remote applications where utility grid connectivity is either impractical or economically unviable.

Specifically focusing on hybrid wind-solar configurations, the utilization of Permanent Magnet Synchronous Generators (PMSG) for wind-driven generators is highlighted, particularly in standalone applications. In these hybrid setups combining PV and wind power through PMSG, the challenge arises from managing the varying amplitude and frequency of the stator voltage in the PMSG and the fluctuating DC voltage from the PV array. Achieving the necessary conditioning of these diverse outputs typically involves complex power-electronic interfaces.

However, the paper introduces an innovative approach by proposing the use of self-excited induction generators with capacitors. This alternative is particularly advantageous for off-grid systems, as it offers the potential for components and their associated controls to be not only economically viable but also maintenance-free. By exploring this avenue, the paper contributes to the development of more reliable, cost-effective, and easily maintainable hybrid power generation systems, thereby addressing the unique challenges of remote applications where conventional utility grid solutions may not be practical or feasible.

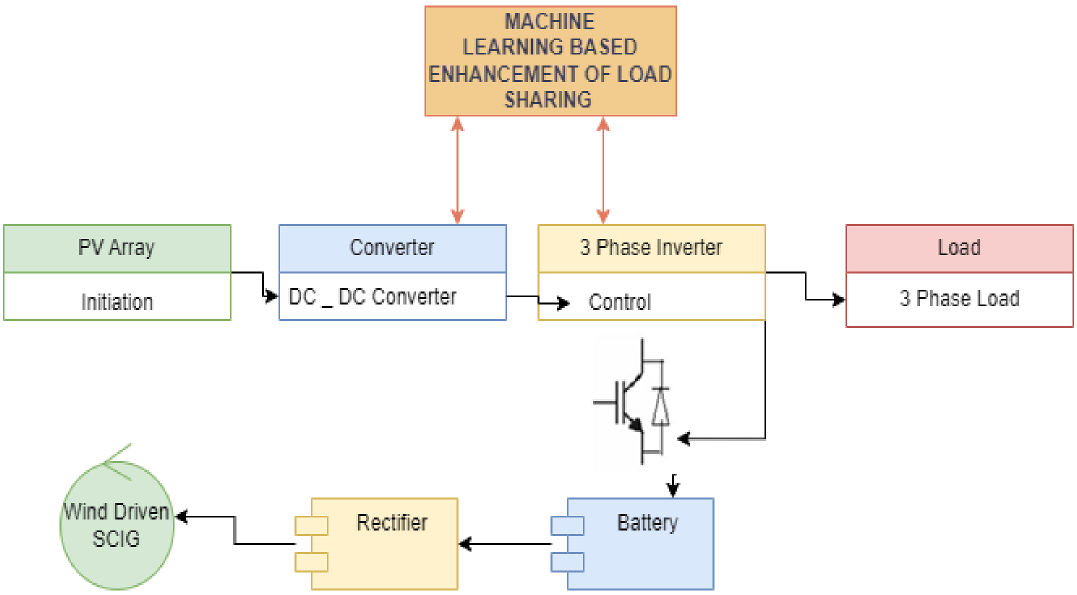

Fig.1 Block Diagram of Power Circuit for PVEWIG System

The PVEWIG framework comprises of PV exhibit, dc converter, battery, 3 leg inverter, wind driven three stage squirrel confine enlistment generator and a non-straight burden. The PV cluster takes care of a dc help converter. The voltage across dc help converter is associated with battery which is upset by a three stage inverter and is given to the heap. The IG would require responsive power which it would ordinarily draw from utility framework in matrix associated conspire. In the current plan responsive power expect by enlistment machine is provided by pv cluster took care of inverter. The result of inverter goes about as a virtual lattice giving a steady voltage and recurrence. The three-stage load is associated with inverter yield and is provided by PV-IG and battery (or) PV-IG, the heap sharing being relied upon wind speed and light. The PV result and wind yield frames the reason behind normal coupling (PCC). The block chart of PVEWIG plot is displayed in the fig.1.The genuine, responsive and clear power disseminations accepting the misfortunes in the inverter and dc converter are immaterial, are given as

4. Simulation of PVEWIG System and Results

A controller built into the inverter itself can also be used to adjust the output voltage. The more effective way to achieve a strong output is to use the internal pulse width modulation control of an inverter. This technique disposes of a steady dc input voltage into the inverter. Additionally, an unflappable AC output voltage can be achieved by controlling the inverter units' on and off times. Pulses with a fixed amplitude are used to depict PWM approaches. The best way to regulate the output voltage is with this technique. The name Pulse-Width Modulation (PWM) refers to this technique. PWM inverters are excellent choices for industrial use. Following the modulation to reduce the harmonics present and to accomplish the inverter's output voltage control

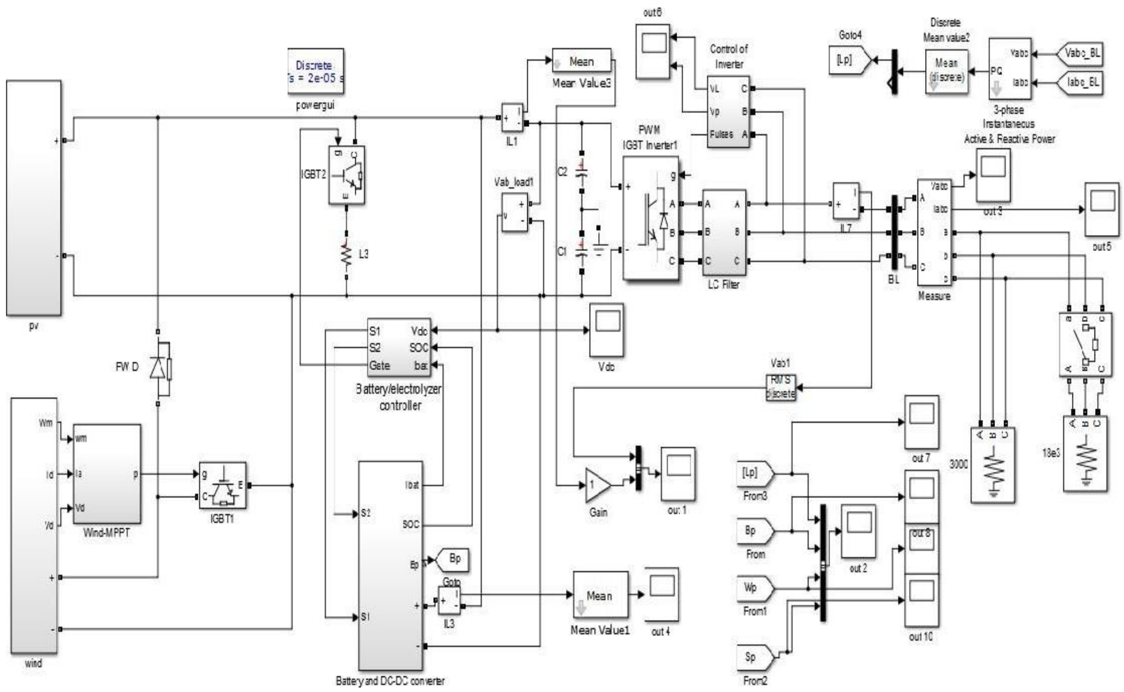

Fig.2 Simulation of PVEWIG System

The project described involves the integration of two distinct power sources, photovoltaic (PV) and wind, to meet the load demand and ensure system reliability. The incorporation of a battery is implemented to enhance system stability, particularly at the point of common coupling (PCC), where maintaining a fixed voltage is crucial. This setup effectively utilizes the synergy of renewable energy sources and energy storage to optimize overall system performance.

To address potential ripples in the DC link, filter capacitors are strategically placed in front of the 3-phase inverter. These capacitors act as a filtering mechanism to smooth out variations in the DC link, contributing to a more stable and consistent power supply. The DC link serves as the input to the 3-phase inverter, consolidating DC power from various sources.

.Table 1 Specifications of PVEWIG System

S.No.	Parameter	Value
1	Total load Power	10KW
2	Rated PV Power	9.6KW DC
3	No. of PV module in series	20
4	No. of PV strings in parallel	2
5	Wind output power	4KW AC
6	Battery rating	300V,20Ah
7	Nominal Dc link Voltage	430V

The 3-phase inverter plays a key role in the system by converting the DC power to AC, and its output is fed back to the inverter controller. The controller, in turn, regulates both the phase and magnitude of the AC output, generating gate pulses based on the load requirements. This closed-loop control system ensures that the power supplied to the load aligns with the specified criteria, maintaining the desired stability and reliability.

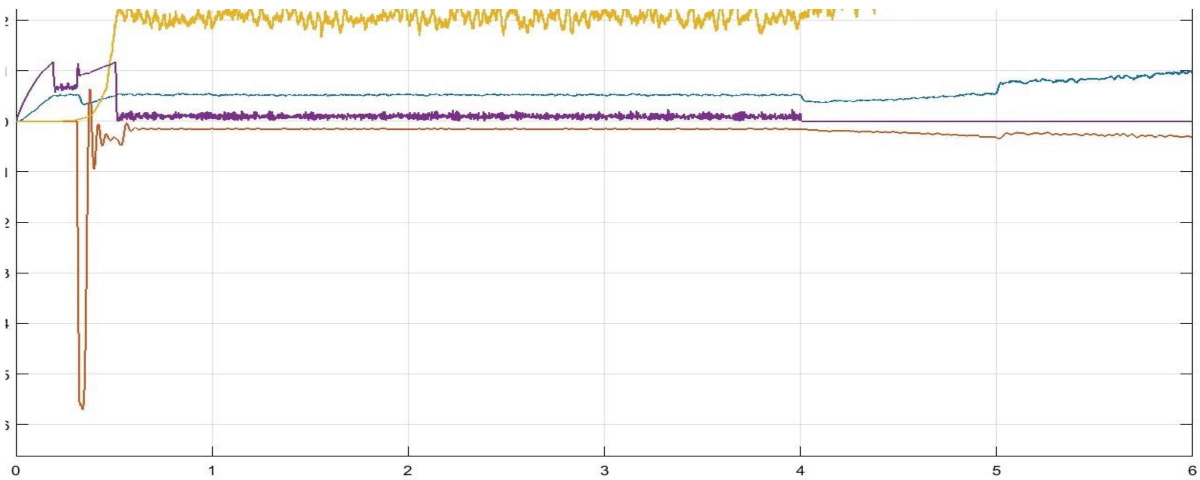

Fig.3. Integrated Output Powers of PVEWIG

In summary, the integration of PV and wind sources, coupled with a battery and effective filtering mechanisms, demonstrates a comprehensive approach to reliable and stable power generation. The efficiency of ML algorithms in predicting load sharing efficiency is shown in table 2. The simulation parameters provided in Table 1 likely detail specific aspects of the project, such as component specifications, control settings, or environmental conditions, offering a more detailed insight into the system's characteristics and behavior.

Table 2 Efficiency of ML algorithms in predicting load sharing efficiency

Models	**Accuracy**	**Specificity**	**Sensitivity**
Decision Tree	72	81	81
Regression	85	86	85
Random forest	84	83	82

5. Conclusions:

A dependable and basic plan coordinating breeze driven enlistment generators and PV cluster has been effectively created interestingly to supply a three-stage remote burden with steady recurrence adjusted voltages. The half and half framework is practical and requires a basic connection point for reconciliation, in this manner making it reasonable for off-network applications. Thus the proposed control conspire is fit for giving a managed yield voltage to the heap under a wide range of unsettling influences remembering variety for light, temperature, wind speed. The outcomes further mean that the PVEWIG framework with the proposed control conspire is an appealing answer for secluded off-lattice applications where utility matrix isn't accessible.

References:

[1] B. S. Borowy and Z. M. Salameh (1997, Mar.).Dynamic response of a stand-alone wind energy conversion system with battery energy storage to a wind gust.

[2] R. Leidhold, G. Garcia, and M. I. Valla. (2002, Feb.).Field-oriented controlled induction generator with loss minimization.

[3] N.A Orlando,M. Liserre, R.A.A. Mastromauro.A. (2013,July). "Survey ofY. Xia, K. H. Ahmed, B. W. Williams, "Wind Turbine Power Coefficient Analysis of a New Maximum Power Point Tracking Technique".

[4] H.Shariatpanah, R. Fadaeinedjad, M. Rashidinejad. (2013,Sept.).A New Model for PMSG-Based Wind Turbine Yaw Control.

[5] J. S. Thongam and M. Ouhrouche, "MPPT control methods in wind energy conversion systems."

[6] M. Kuschke and K. Strunz.(2014,Mar.). Energy-Efficient Dynamic DriveControl for Wind Power Conversion with PMSG: Modeling and Application of Transfer Function Analysis.

[7] O. Alizadeh and A. Yazdani, "A strategy for real power control in a direct-drive PMSG-based wind energy conversion system."

[8] C. Grantham, D. Sutanto, and B. Mismail, "Steady-state and transient analysis of self-excited induction generators."

[9] S. Kim, C. Kim, J. Song, G. Yu, and Y. Jung," Load sharing operation of a 14kW photovoltaic/wind hybrid power system".

[10] S. Arul Daniel and N. Ammasai Gounden.(2004,June). A Novel Hybrid Isolated Generating System Based on PV Fed Inverter-Assisted WindDriven Induction Generators.

[11] M. Arutchelvi and S. Arul Daniel(2006, July).Voltage control of autonomous hybrid generation scheme based on PV array and wind driven induction generators.

[12] G.Rupesh,Wandhare,Vivek Agarwal(2015,July). Novel intrgration of a PV-Wind energy system with Enhanced Efficiency.

[13] K. Wang, H. Huang and C. Zang, "Research on Time-Sharing ZIP Load Modeling Based on Linear BP Network," 2013 5th International Conference on Intelligent Human-Machine Systems and Cybernetics, Hangzhou, China, 2013, pp. 37-41, doi: 10.1109/IHMSC.2013.16.

[14] J. J. Nancy, T. Mani S., S. Rohith, S. Saranraj and T. Vigneswaran, "Load Balancing using Load Sharing Technique in Distribution System," 2020 6th International Conference on Advanced Computing and Communication Systems (ICACCS), Coimbatore, India, 2020, pp. 791-794, doi: 10.1109/ICACCS48705.2020.9074304.