Enhance performance of grid connected PV-Wind battery energy system with PSO based MPPT approach

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ABSTRACT: This study introduces a novel approach for the integration of hybrid PV and wind energy systems. The proposed method offers a robust solution to the HRESs against to their intermittency. Through MATLAB simulation and performance analysis, the proposed work demonstrates that a PSO-based MPPT approach effectively manages the non-linear characteristics of PV arrays. PSO MPPT method rapidly converges to the optimal operating point during dynamic irradiance changes and minimizes steady-state power ripples compared to other traditional MPPT methods. PSO algorithm maximizes the PV output power and achieves global optimization quickly. A pitch angle control scheme and a DC-DC converter are utilized to stabilize the wind energy output at a constant level. By regulating the VSC, the system delivers a harmonic-free, balanced three-phase AC voltage of 20kV to the grid. The proposed algorithm effectively mitigating voltage transients and distortions caused by non-linear loads and enhance the power quality of the HRESs. The proposed hybrid system maintains a consistent DC bus-bar voltage and a stable.

KEYWORDS; PSO, MPPT, HRESS, PV, WIND.

I.INTRODUCTION: Energy is largely to blame for the most recent development of restraint. There should be no interruptions to horticulture, instruction, medical services, open missions, or the necessary energy. Without viable energy utilization, a country can't prosper. The economy is accepted to be the essential piece of a nation [1]. Environmentally friendly power sources that can be used in RESs incorporate biomass, biogas, geothermal, little hydro, photovoltaic (PV), sun oriented warm, wind, and sun based warm [2]. To find elective wellsprings of energy, it is basic to use supportable power (RE) [3] now to diminish the environmental impact of oil subordinates. Photovoltaic (PV) cells are one choice. However, one of its drawbacks is the business PV module (PVM)'s unfortunate transformation rate of close to 18% [4, 5]. A PV structure is a device that can change over light as harmless to the ecosystem power into DC voltage [6]. One famous RES is wind power [7].

Wind energy presents enormous useful issues because of its erratic nature and eccentricism, especially for delicate or isolated transmission associations. Wind power plants must meet specific requirements in order to comply with the grid code's requirement for the supply of additional ancillary services and a controlled power output. Booking becomes more difficult and the cost of maintaining the framework rises as a result of the breeze's erratic behavior, necessitating a decrease in recurrence [8, 9]. For the purpose of resolving these issues, wind turbines (WTs) can be combined with manufacturing to create half-breed power plants (HPPs). Utilizing a mix of customary and RESs [10], wind daylight based creamer structures (WSHS), wind hydro cross variety systems (WHHS), and twist warm combination systems (WTHS) [11] to manage energy and lessen the breeze created power inconsistency, the HPPs can cut down their energy costs and the normal impact of their undertakings [12]. Due to their intermittent nature RESs can't function as a free power age system. The blend of something like two RES is thus a normal answer for this issue.

The HRES is the blend of different harmless to the ecosystem power age sources. Most of the time, they are used to build an independent power generation system that makes the RES work better. Accordingly, HRES frameworks are broadly used to produce great power and have detonated in prevalence. The HRES are a more practical alternative to conventional energy sources because they enable the dependable utilization of all resources. As shown by the available resources, much survey has been done to present an arrangement of HRES decisions. Academics have examined various HRES groups in order to meet the demand for power in a variety of regions across the globe. The creator gave each of the fundamental boundaries for building and working the half and half energy framework (HES), including control framework, determination models, estimating, energy the board, and arrangements. Wind-based HRES can progressively uphold the utility matrix because of their snapshot of latency, and the accessibility of various energy sources builds the power supply's dependability. To change low over totally to high voltage for more conspicuous maltreatment of RESs, effective DC converters are required. The converter ought to be sensible, lightweight, have low voltage trading pressure (LVST), and have a strong thickness (HPD). The AC-DC/DCDC transformation has recently been the focus of research to further improve power change effectiveness. Figure 1 shows how different power electronic converters (PECs) are utilized in RES applications.

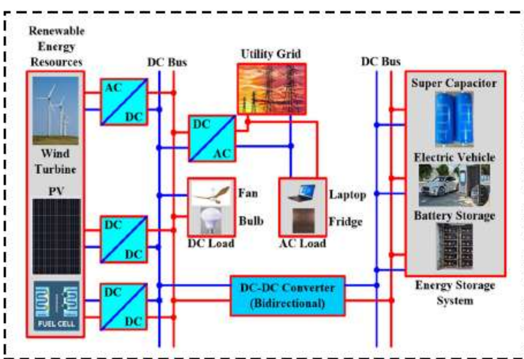


FIGURE 1. Power electronic converter is used in a renewable energy system.

Despite DC change, network blend of appropriated energy resources similarly requires DC-AC change to serve AC loads. The most perused up power converter techniques for private and business applications are amazed inverters (MIs). MIs stand out enough to be noticed in applications including medium voltage and high power ranges because of their various benefits. Diverged from customary two-level inverters, staggered inverters partake in a couple of advantages like lower EMI, less consonant mutilation (HD), and semiconductor parts under less voltage stress. DC converters based blend and development of HRES are shown in Figure 2. In addition, Figure 2 portrays the strategy of data power age that is sent on RESs like PV, WT, and energy part advancement. The as of late referred to energy age sources (EGS) are reliant upon persistent limitations, which achieves their wrecked outcome direct being obliged in stage two. The power improvement stage grows the data power made using RES, which is generally speaking low appeared differently in relation to stack demands (LD).

The store is coupled at the last stage, which contains direct DC load, AC weight, and DC microgrids. Power quality and reasonability under load assortments depend upon the DC converter's ideal show writers cautiously depict how the corresponding thought of wind energy (WE) and PV sources ensures a high likelihood of consistent power supply, meaning that throughout the span of the day, wind turbine power age (WTPG) is low and PV yield is high. Thusly, PV yield is immaterial while evening WT power rises. Oil based commodities make the greatest degree of energy age to satisfy the rising need, according to makers who discussed India. Coal-terminated nuclear energy stations generate 54% of all power, while renewable energy sources like wind, hydro, solar, and so on only deliver 36.8%. The makers of take a gander at the issue of a combination power system's shortfall of solidarity using BSS structures, diesel generators, and PV with the ideal outcome of power cuts and reducing brownouts in the Pakistani district of Azad Jammu Kashmir.

The three expected powers were the battery reference power, the grid reference power, and the load power, and it was fundamental to deal with the power stream between the combination systems (HS). To make a HEBS with persistent transport voltage, the creators recommended utilizing a buck help converter in a framework associated in equal. In light of the qualities of the PV module, two sun powered chargers were associated in a series to create variable voltages of 0 to 30 V. An Air conditioner/DC converter is utilized to change over the DC voltage from the WTG AC voltage. Dependent upon the breeze speed, this DC voltage goes from 0 to 30 V. The buck assist converter with canning is used to change over moving data voltage into steady state voltage yield. Their proposed course of action handles wind energy's intermittent nature by logically changing business sector interest power.

There are distinct benefits to each of these approaches. However, switching between multiple energy suppliers increases system implementation costs and complexity due to the numerous power conversion stages and intricate structural design and control. To address these concerns, this investigation targets directing the sporadic thought of RESs. However, the conventional sources of power are insufficient and have numerous ecological issues. RESs for electricity have received a lot of attention as a result.

Various natural advantages build to RESs. It does, nevertheless, share a similar drawback, specifically irregularity. Exactly when the structure is related with a tremendous utility grid, energy intermittent most likely won't be a critical issue. Little microgrids and segregated structures, in any case, will experience this issue. Hybrid energy systems, which combine two or more RESs, are one strategy for dealing with the intermittent issue. The breeze/PV microgrid is a representation of this kind of microgrid.

Something like two power age procedures are incorporated into HRES. By fittingly utilizing the open standard resources, such HRES diminishes the intermittent thought of individual RESs, dealing with overall utilitarian efficiency (OOE) and updating capital endeavors (OCI).

II.PROPOSED SYSTEM: Fig.1 presents the model of the proposed HRES, which integrates multiple energy sources and storage units to deliver quality power to the grid and various loads. This configuration is specifically designed to mitigate the intermittency and uncertainty inherent in individual renewable resources. PV output, highly dependent on irradiance and temperature. A DC-DC converter, managed by an MPPT algorithm, stabilizes it to ensure consistent DC bus voltage.

The Wind Energy Conversion System (WECS) connects in parallel with the PV system to meet total power demand, significantly enhancing supply reliability. A Battery storage system is incorporated to ensure continuous supply to the network. VSCs serve AC loads and synchronize the system with the utility grid. These VSCs regulate voltage transients and maintain power quality, especially under non-linear loads that introduce harmonics. The controllers mitigate these disturbances, ensuring harmonic-free, balanced three-phase voltages.

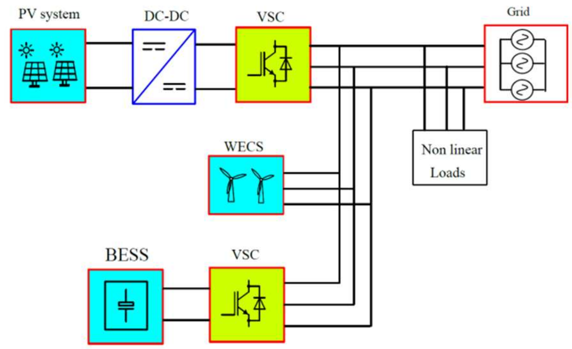


Fig.1 Block diagram of HRES model.

A. Solar-PV system**:**

A solar-PV system is designed to convert solar energy directly into DC electrical energy. These systems typically consist of multiple solar cells configured in series or parallel to form modules that meet specific power demands. A standard PV cell is mathematically modeled using the single-diode relationship. The operational performance of a PV module is highly sensitive to environmental variables, specifically solar radiation and ambient temperature. Due to fluctuations in solar intensity and dynamic atmospheric conditions, PV systems often exhibit intermittent and discontinuous output. To mitigate this, the PV module is interfaced with a DC-DC power converter. By precisely modulating the converter's duty cycle, a consistent and stable DC bus-bar voltage is attained.

The current-voltage (I-V) and power-voltage (P-V) characteristics (illustrated in Fig. 2) demonstrate that each curve possesses a single peak where the module produces its maximum power. To eliminate these fluctuations and maintain a stable output, advanced MPPT algorithms, such as PSO, are essential. The PSO algorithm ensures the system consistently tracks the GMPP, maximizing overall conversion efficiency even under partial shading and rapid irradiance shifts.

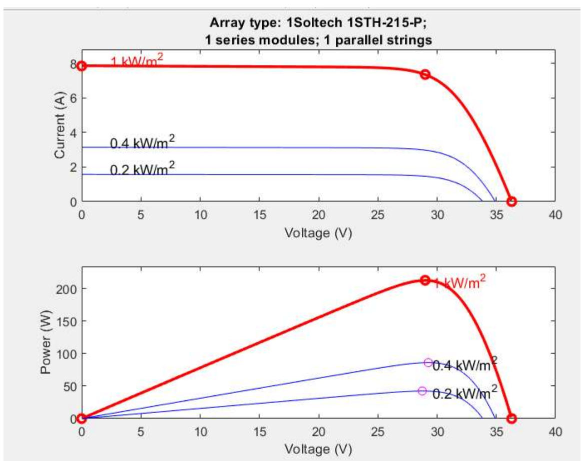


Fig.2 VI and PV characteristics of PV module.

B. WECS System:

A WECS transforms the kinetic energy of wind into mechanical torque through the turbine blades. Subsequently, an electrical generator is utilized to convert this mechanical energy into electrical power. The efficiency and operational stability of a WECS are critical when integrated into HRES alongside solar PV to mitigate the inherent intermittency of these resources. Wind energy is characterized by non-linear nature, which can lead to frequency fluctuations, voltage transients, and power quality degradation within transmission networks. In this work, a pitch angle control mechanism and a DC-DC converter are utilized to regulate the power output and maintain a consistent DC bus-bar voltage during varying wind speeds.

III PSO MPPT approach:

Fig. 3 depicts the model of the PSO algorithm for solar PV systems. PSO is a stochastic evolutionary method for MPPT that optimizes the duty cycle D of a DC-DC converter to maximize power extraction from the PV array. Unlike conventional techniques like P& O, INC, PSO algorithm handle the nonlinear P-V curves, particularly under partial shading with multiple local maxima.

The PSO algorithm models candidate duty cycles as "particles" in a search space ($0 < D < 1$). It initializes particles at values such as 0.2, 0.3, 0.6, and 0.9, each representing an initial estimate for the optimal operating point. Particles iteratively update their positions to maximize power $P = V \cdot I$.

Key parameters include:

- P_{best}: The best (peak-power) duty cycle found by an individual particle.

- G_{best}: The global best duty cycle across the entire swarm.
- Acceleration coefficients c_1 and c_2: These balance attraction toward a particle's own P_{best} (c_1) and the swarm's G_{best} (c_2).

The velocity update follows:

$$v_{new} = w \cdot v_{old} + c_1 \cdot r_1 \cdot (P_{best} - D_{old}) + c_2 \cdot r_2 \cdot (G_{best} - D_{old})$$

followed by the position (duty cycle) update:

$$D_{new} = D_{old} + v_{new}$$

where w is the inertia weight, and r_1, r_2 are random values.

PSO quickly adapts to variations in irradiance by monitoring PV power and current. A significant environmental change triggers a reset signal. Upon receiving the reset (Rest = 1), the algorithm reinitializes particles for a new GMPP search. The optimized D is then used to generate PWM pulses for the buck-boost converter, regulating output voltage for grid integration and loads.

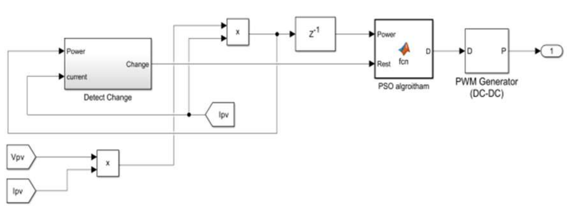


Fig.3 MATLAB layout of PSO MPPT approach.

III.SIMULATION RESULTS:

Fig. 4 presents the MATLAB/Simulink model of the proposed PV-wind battery hybrid energy system. To evaluate the control scheme's effectiveness, the system was tested under intermittent environmental conditions, such as the variation in solar insolation, temperature and limited availability of wind energy.

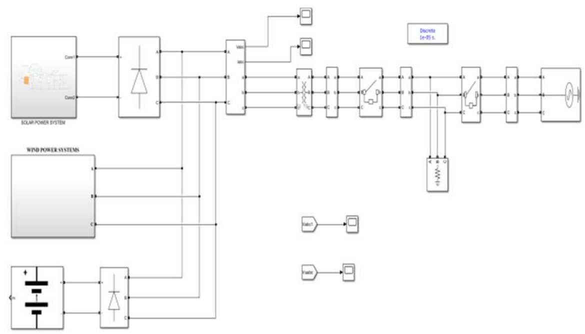
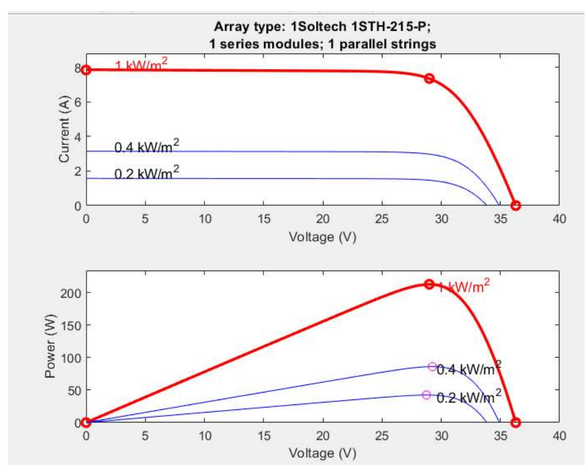
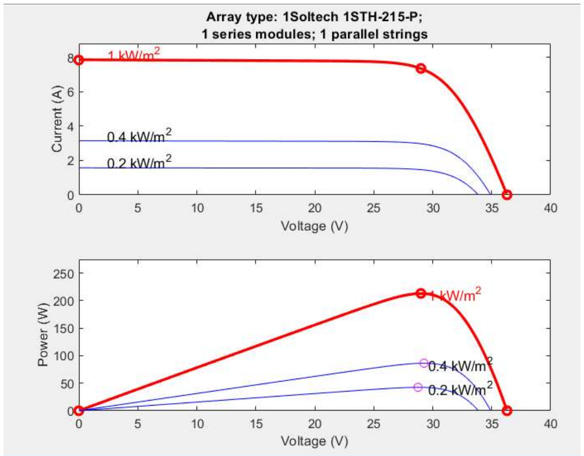


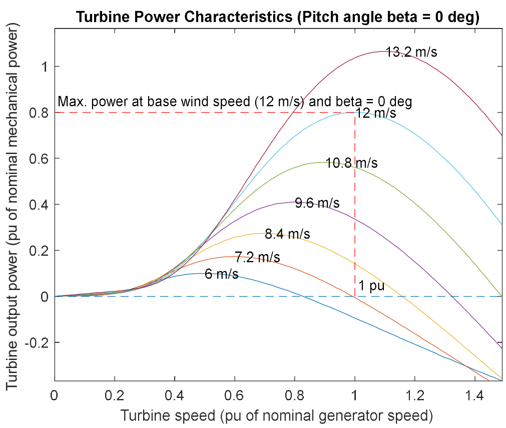
Fig.4 MATLAB layout of HESS model.



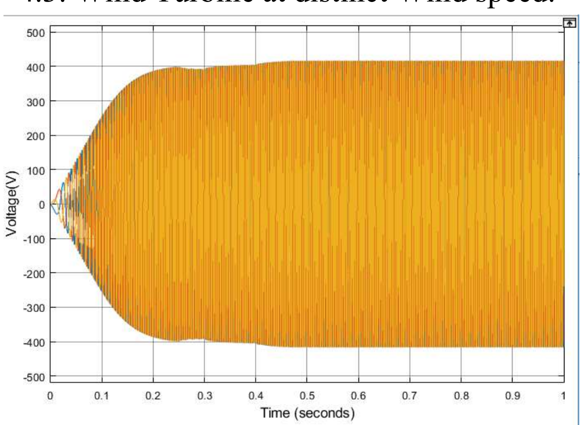
4.1 current, voltage and power characteristics of PV.



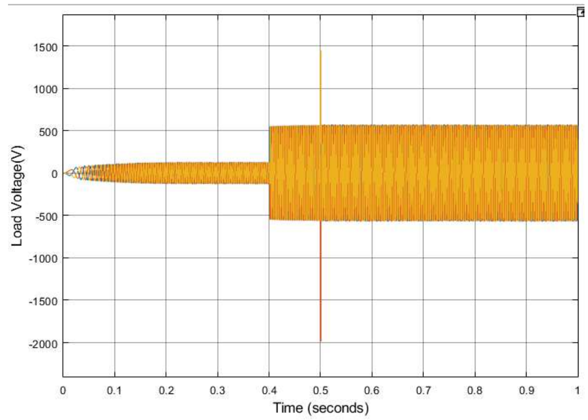
4.2.I-V and P-V characteristics of PV at different Temperature.



4.3. Wind Turbine at distinct Wind speed.



Inverter Voltage



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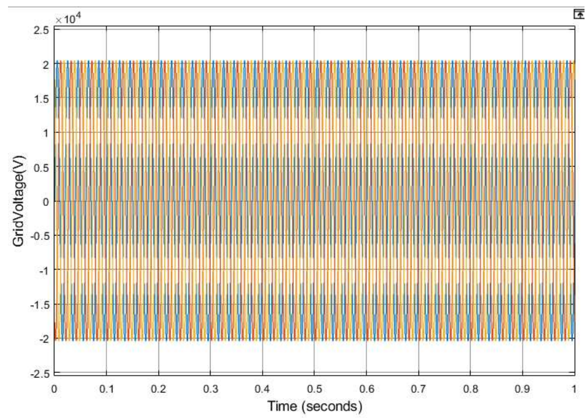

Grid Voltage

IV.CONCLUSION: This study familiarizes a unique technique with planning creamer based photovoltaic (PV) and wind energy structures, offering a promising solution for Pakistan's energy challenges. Through cautious reenactment and assessment, the strong show of the proposed combination energy structure has been totally examined, showing its ability to really handle harmless to the ecosystem power sources and convey stable voltage yield. Also, the revelations feature the sincere prerequisite for Pakistan to change towards non-petrol subsidiary wellsprings of energy, given the regular and financial disadvantages related with traditional energy age methods. Pakistan is able to lessen its reliance on a finite supply of petroleum products while also preparing for an energy future that is easier to maintain and more technologically advanced by investing in eco-friendly power infrastructures of a variety of breeds. The survey's ideas loosen up past the space of the academic world, offering significant pieces of information for the sun fueled business region and the greater neighborhood. The best angles and orientations for solar systems in various solar energy zones may lead to standardized procedures and lower installation costs. Moreover, the survey includes the possible roundabout benefits for society through informal regulations supporting harmless to the ecosystem power sources, particularly daylight based energy, empowering a conductive environment for useful energy improvement in Pakistan. Looking forward, the blend of various upgrade techniques for ideal preparation of harmless to the ecosystem power sources presents a shocking street for future investigation and execution, promising further movements in the field of practical power development. Generally speaking, this study makes a critical commitment to the conversation of feasible energy arrangements in Pakistan by featuring the significant job that half and half sustainable power frameworks play in forming Pakistan's future as one that is cleaner, greener, and more prosperous.

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