Performance investigation for analysis of energy management in renewable energy by using particle swarm optimization

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ABSTRACT – This paper study of renewable energy sources in electrical output by the appearance of numerous and diverse issues and concerns. Finding smart technologies and algorithms capable of producing efficient solutions is one of the most critical issues. This paper also discusses how the algorithm improved to deal with difficulties linked to renewable energies to obtain the required results. The PSO algorithm was handle numerous issues in non-conventional power source, like optimum solar power, hybrid power, size, and total prices, etc. when the PSO method demonstrated its resolving issues versatility and several scholars continued to explore and refine the PSO algorithm. The proposed method efficiency and correctness are confirmed by develop model, its performance by developed model, its performance investigate the result by using MATLAB/Simulink. Overall, investigations and studies have demonstrated that the technique of PSO algorithm is one of the best renewable energy systems. This is because the technique is simple, efficient, and effective when compared with other optimization techniques and methods.

Keywords–Wind Energy, Energy Storage System, PV, PSO, Utility System.

1. INTRODUCTION

Now a day renewable energy increase day by day because they are sustainable, clean, and present in plentiful environment. And its rapidly depleting nonrenewable energy sources are the greatest replacement of renewable energy [1]. In all over the world renewable energy played important role. Some examples renewable energy source is sun, wind, ocean, biomass, and tidal etc. solar power is more power in comparison to other renewable energy because it is most reliable, less maintenance, noiseless and less cost, environment friendly and also reducing fossil fuels dependency more than one third [2-3]. The investments in renewable energy have reaching record- high annual investments exceeding USD 0.5billion in 2021, investment in off-grid renewable solution falls chart of USD 23billion needed annually in off grid solar products alone (mini grids not including between 2021 & 2030 [4].Today, urban areas are home to more than half of the world's population. 75% of the global energy resources are used in metropolitan areas because of their high population concentrations. Expectedly densely populated places. Since urban areas consume between 60 and 80 percent of the globe’s energy, they are responsible for 75 percent of carbon dioxide emissions Due to the rapidly rising density of people in urban areas, it is anticipated that 70% of the global population would live there by the year 2050. This will result in an 80% rise in consumption of energy [5-6].

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Therefore, it is crucial to encourage the use of small wind-solar systems in urban areas. The fundamental problem with low power wind and solar systems is shorter amortization periods. Assuming this is done, urban areas may see an increase in the use of solar and wind power systems. Due to rising worldwide energy consumption, growing concern over global warming and the "green world" idea the use of fossil fuels running out, and the need for energy independence, research on renewable non-conventional energy has grown tremendously over the past two decades [7-8]. The efficiency of the production of renewable energy is influenced by the natural environment meteorological indicators, such as wind speed, the sun temperature effect, and the solar irradiation effect. These elements, such as reversed power flow, voltage variations, and fluctuations, may cause issues in a power network. Therefore, it is crucial to employ a hybrid grid strategy that combines RE with the safer and more effective micro grid (MG) method [9-10]. They continuously supply electricity to loads, micro-grids are created as hybrid resources with wind turbine, photovoltaic (PV) systems, fuel cell, and energy banks systems. An MPPT technique is created to improve the system's efficiency. Different types of MPPT controllers are utilized in hybrid systems to track or extract the maximum power [11]. Techniques used for MPPT control include constant voltage, the short circuit pulse, open voltage, P&O, ABC (artificial bee colony), genetic algorithm, temperature gradient algorithms, PSO, artificial neural network (ANN), Genetic algorithm (GA), fuzzy logic control, etc. The solar and wind system, fundamental topology utilized various forms of MPPT techniques. The PSO algorithm was used to solve a variety of problems in renewable energy systems, including optimum hybrid power systems, size, and net cost, among others. As a result, many researchers continued to study and improve the PSO algorithm. The effectiveness and correctness of the suggested approach are demonstrated through model development, performance analysis using MATLAB/ Simulink, and model performance. Overall, studies and research have revealed that one of the finest algorithms for renewable energy systems is the PSO algorithm. This is due to the technique's advantages over other algorithms and optimization methods in terms of simplicity, efficiency, and effectiveness.

2. Energy management system of hybrid renewable energy

The energy management system is used multiple sources to manage the power that is photovoltaic (PV), Fuel cell (FC), Battery bank and wind turbine (WT) etc. The hybrid renewable energy system could be an economical improve solution and produce the clean energy to match with time varying and efficiency [12]. The schematic diagram of photovoltaic grid-connected is shown in below Fig-1.

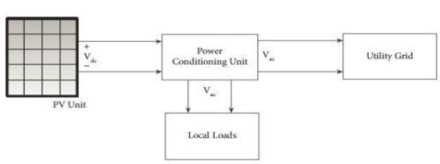

Fig-1 PV grid-connected block.

3. THE HYBRID SYSTEM INCLUDES

3.1 PHOTOVOLTAIC SYSTEM (PV)

An array of photovoltaic (PV) cells, a converter converts the DC-DC, DC-AC and a load make up a PV system. The most efficient PV system component may be a solar cell. The PV array is built with numerous PV cell that connected to parallel and series for producing the necessary power, voltage, and current [13]. The PV System are available in various range of size, including building-integrated systems and rooftop-mounted, as well as standalone and grid-connected system, with capacities ranging from a few kilowatts to many tens of kilowatts. When the Maximum Power Point Tracking (MPPT) power control technique is applied, solar module operation is more productive. When the Maximum Power Point Tracking (MPPT) power control technique is applied, solar module operation is more productive. Maximum power point is essentially a matching of operating points between a power converter and a photovoltaic panel. Tracking the maximum power point is a difficult process because of the I-V characteristics of PV array and non-linear P-V and the irradiance and humidity, as well as the results of altering climate condition [14]. The PV cell electrical circuit diagram shown in fig 2.

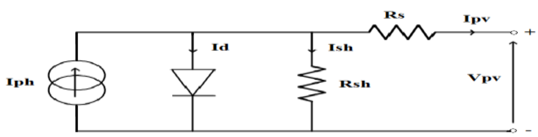

Fig-2 PV cell electrical circuit diagram.

Photovoltaic cell mathematical equation is evaluated as [6].

$$\mathbf{I_{pv} = N_{ph}I_{pv}} - \frac{(V+R_sI)}{R_{sh}} \text{ - } \mathbf{N_pI_O}[\mathbf{exp}\left(\frac{q(V+R_sI)}{N_sAKT}\right) - \mathbf{1}]$$

Where, $\mathbf{I_{ph}}$ = PV cell terminal current (Amp), $\mathbf{I_{pv}}$= Solar irradiation current (Amp), $\mathbf{I_d}$ = Diode current (Amp), **q** = charge of an electron (C), $\mathbf{R_{se}}$= Series resistance of PV cell (ohm), $\mathbf{N_s}$= No. of solar cells connected in series, $\mathbf{N_{sh}}$= No. of solar cells connected in shunt, **k** = Boltzmann's constant, **d** = factor of diode, T= Temperature of the surrounding, $\mathbf{R_S}$= Shunt resistance of PV cell (ohm)

3.2 WIND ENERGY SYSTEM (WES)

The terms of renewable energy sources (RES), the wind energy is lead thanks to benefits including year-round availability, affordable prices, and flexibility [15]. The one of the most promising non-conventional sources, wind's capacity has grown greatly in recent years and now makes up a sizeable portion of the world's electrical energy supply as shown in fig 3.

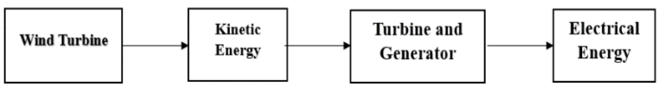

Fig-3 Wind energy System.

3.2.1 Modeling of wind power

The power production from wind turbines is calculated using the following formula [16].

According second Newton' Law of motion, F = ma (1)

$$E = mas \qquad (2)$$

$$E = \frac{1}{2}mv^2 \qquad (3)$$

$$P = \frac{dE}{dt} = \frac{1}{2}\frac{dm}{dt}v_w^2 \qquad (4)$$

$$P = \frac{1}{2}\rho A v_\omega^3 \qquad (5)$$

$$P_{\omega} = \frac{1}{2}\rho A v_{\omega}^{2}(v_u^2 - v_d^2) \qquad (6)$$

$$\rho A v_{\omega} = \frac{\rho A(v_u + v_d)}{2} \qquad (7)$$

$$P_{\omega} = \frac{1}{2}\left[\rho A\left\{\frac{V_u}{2}(v_u^2 - v_d^2) + \frac{V_d}{2}(v_u^2 - v_d^2)\right\}\right]$$

$$= \frac{1}{2}\left[\rho A\left\{\frac{v_u}{2}(v_u^2 - v_d^2) + \frac{v_d}{2}(v_u^2 - v_d^2)\right\}\right] = \frac{1}{2}\left[\rho A v_{\omega}^{3}\left\{\frac{1-\left(\frac{V_d}{V_u}\right)^2 + \left(\frac{V_d}{V_u}\right) - \left(\frac{V_d}{V_u}\right)^3}{2}\right\}\right]$$

$$P_{\omega} = \frac{1}{2}\rho A v_{\omega}^{3} C_p \qquad (8)$$

$$\text{Where } C_p = \frac{1-\left(\frac{V_d}{V_u}\right)^2 + \left(\frac{V_d}{V_u}\right) - \left(\frac{V_d}{V_u}\right)^3}{2} \text{ or } C_p = \frac{\left(1+\frac{V_d}{V_u}^2\right)\left(1-\left(\frac{V_d}{V_u}\right)^2\right)}{\frac{1}{2}} \qquad (9)$$

$$\lambda = \frac{v_d}{v_u} \qquad (10)$$

$$\lambda = \frac{\text{blade tip speed}}{\text{wind speed}} \qquad (11)$$

$$\text{blade tip speed} = \frac{\text{angular speed of turbine}(\omega) * R}{\text{wind speed}} \qquad (12)$$

$$C_p = \frac{(1+\lambda)(1-\lambda^2)}{2} \qquad (13)$$

$$P = \rho RT \qquad (14)$$

$$P = \rho_0 e^{-\frac{.297}{3048}H_m} \qquad (15)$$

$$C_p(\lambda, \theta) = C_1(C_2 - C_3 - C_4 - C_5)e^{-C_6}\frac{1}{\beta} \qquad (16)$$

$$\frac{1}{\beta} = \frac{1}{\lambda + .08\theta} - \frac{.035}{1+\theta^3} \qquad (17)$$

$$C_p = \frac{1}{2}(\lambda - 0.022\theta^2 - 5.6)e^{-0.17\lambda} \qquad (18)$$

Where, λ is turbine's tip speed ratio as described by and θ is the blade's pitch angle in degrees, $\lambda = \frac{v\omega_{(mph)}}{\omega_b(rads^{-1})}$. ω_b is the turbine angular speed.

4 SOLAR -WIND ENERGY SYSTEM

A PV array and a wind power conversion system powered by an induction generator are both part of the hybrid energy system. The PV system is composed of PV arrays and related DC-AC inverter modules. The maximum power point tracking control mode is used for PV systems, which tries to maximize solar power use, depending on the lighting conditions [17]. Pitch angle controller, wind turbine model, mass drive system, and PMSG make up the wind generation system (permanent magnet synchronous generator). To control the performance and power characteristics of this hybrid system, we have connected a P V- wind hybrid system together with a PSO controller as shown in fig 4.

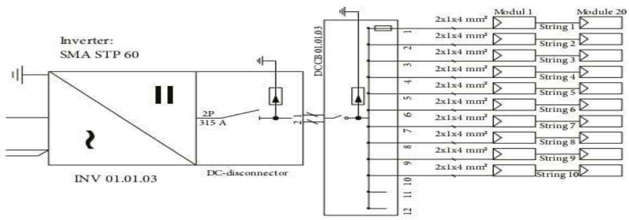

Fig-4 Multi string topology arrays coupled to one inverter.

In order to support the group's simplest position and best value, the equations (4) and (5) are continually updated to reflect the velocity of the particles, speed of the particles, and therefore the current position [18]. The equal inverter circuit diagram with the ideal regulator shown in Fig. As previously mentioned, the optimum control strategy will increase the force dividing steadiness between inverters in a microgrid, which is one of the main goals of this investigation. As a result, particle swarm improvement PSO is a clever regulatory system for real self-turning to shape more productive in power sharing burden to reduce recurrence and voltage deviation, determine the ideal value of the coefficient power control that affects the consistent quality. PID controllers are used to improve the framework reaction. Probably the most method utilized in tuning calculations [19].

$$Vi^{K+1} = \omega^K V_i^K + C_1 r_1[X_{pbest,\,i} - X_i^{K+1}] + C_2 r_2[X_{pbest,\,i} - X_i^{K+1}] \quad (19) \quad (X_i^{K+1} = X_i^K + V_i^{K+1})$$

The recurrence and voltage conditions of equal inverters in microgrid by utilizing particle swarm optimization.

$$\omega = \omega* - (Kp + Kdp\ d\ dt)\ (P - P*) \quad (20)$$

$$E = E* - (Kq + Kdq\ d\ dt)\ (Q - Q*) \quad (21)$$

In conditions (20) and (21), a decision component that is familiar with PD regulator is added to prevent overshoot drifters by using PSO hang manage to locate the controller for optimal coefficient.

Simulation Results

The simulated structural analysis for the micro gride (MG) is depicted in the picture below and was carried out using MATLAB/Simulink. The MATLAB/Simulink model of the matrix related framework in the VSI stage region is also used and is shown in Fig. 1 since the suggested regulator is re-enacted. M-document generates the PSO calculation in MATLAB, thus the model bounds of the transmitted age unit are reflected as follows. R = 20, Ls = 0.05 mH, f = 50Hz, and channel capacitance C = 550F. A single DG with a capacity of 50kW is used. The PV cluster limits are defined as the number of equal strings = 10, shunt opposition (Rsh) =77.64, and series resistance (Rse) = 0.25. The hydrogen power module's boundaries are as follows: number of cells = 65, operating temperature = 65 C. The ostensible mechanical yield power =2000W, base force of electrical generator =2000/0.9VA, most extreme force at base breeze speed =0.8pu, base breeze speed =12m/s are the limitations for wind energy framework. During the programme, all outcomes for each DG unit are displayed, and the associated destinations are studied. To put the suggested regulator to the test, the Simulink model starts with framework related mode and then switches to independent mode. The output of a Simulink model of a microgrid with a suitable age using PSO computation is shown below. Fig.5,6,7,8,9,10 shows the various results.

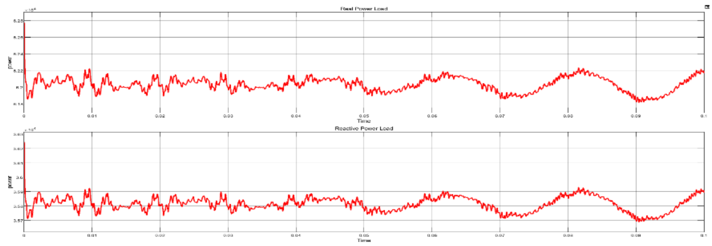

Fig-5 Real power load and reactive power load.

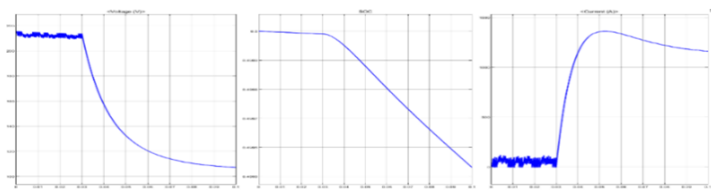

Fig-6 The response of voltage, soc and current of the battery management system.

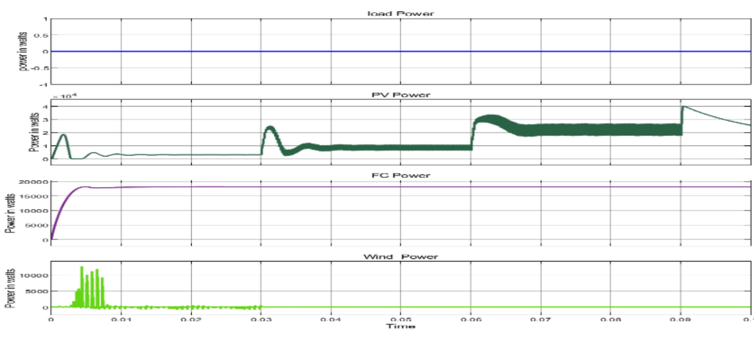

Fig-7 Waveform between power and time (a) load power (b) PV Power (c) FC Power (d) wind power

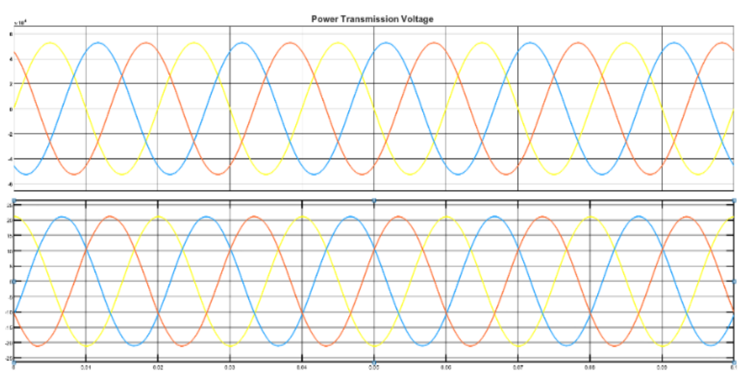

Fig-8 Power transmission voltage.

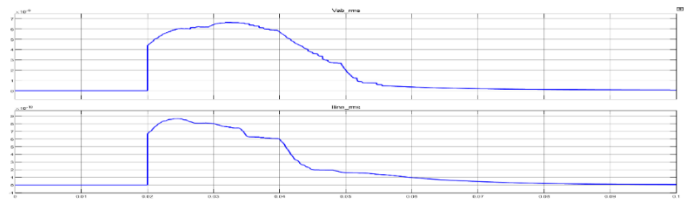

Fig-9 The response of fuel cell output power.

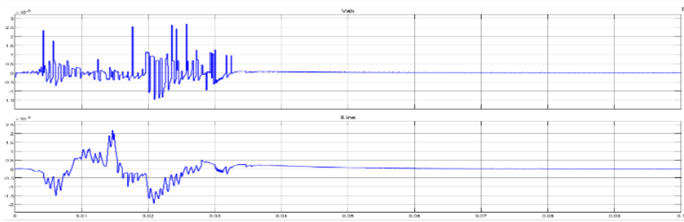

Fig-10 The waveform of voltage of wind energy system.

CONCLUSION

The rapid growth of non-conventional power in general, and non-conventional power system, has resulted in a plethora of complex difficulties that necessitate a smart algorithms application of provide optimal solutions. Multiple smart optimization technologies and algorithms have been developed for tackle challenges associated with non-conventional power systems. The PSO algorithm is one of the most significant of these algorithms. Many scholars and scientists have committed their time to addressing issues with renewable energy systems, particularly those with hybrid energy systems. The PSO applications structured around 3 key axes generating optimal solutions with a high convergence rate, it has demonstrated its greatest capabilities and efficiency across the financial, scientific and managerial domains. Control system was utilized to additionally settle power conveyance during micro grid to decrease in reverse and blackouts and to lessen power portion and current sharing mistake. The DG and PSO calculation are coordinated with the v-f control mode to make a continuous technique for controlling the Micro grid volume and volume, particularly when the Micro grid move is in free mode or during exchanging mode, and the DG is incredibly upgraded by the contrast between the PSO. I need a solid reaction, a steady state reaction, and driving consonant flows with an inverter. Impersonation results show that the proposed regulator gives a great reaction to controlling Micro grid volume force and volume and accomplishes a present moment with an adequate degree of consonant mutilation. This regulator utilizes a solitary DG unit at Micro grid time, considering the force sharing issues.

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