Evolutionary Algorithms based AGA and BPSO Computing for Hybrid Renewable Energy System

Sampath Kumar V. Patil, S. B. Shivakumar

Abstract: ***Solar and wind Renewable system have more advantages compared to Conventional energy sources and it is environment friendly and also from economic point of view...For overcoming the problems of Conventional Energy sources, this paper proposed an hybrid renewable energy system using Different evolutionary algorithm approaches. This proposed method hybrids the three systems namely, solar PV, wind and Fuel Cell which have the biggest potential to provide power. The battery and loads are also integrated with this hybrid system. Then, the charging and discharging of this system is controlled by an Optimized PID controller for balancing the generated power and load power. Here, the PID controller works based on the rules to provide an efficient system. Also, the tuning parameters of the PID controller are enhanced by Adaptive Genetic Algorithm and Particle Swarm Optimization. Finally, the performance of the Combined Solar and wind system is tunedwith the Evolutionary algorithm based PID controller and is compared with the existing hybrid renewable systems based on Generated Power, Load side Power, Speed Controller and Torque.***

Keywords: ***Hybrid Renewable Energy system, Solar, Wind, Fuel Cell, Adaptive Genetic Algorithm, Particle Swam Optimization, PID Controller***

I. INTRODUCTION

Now, energy is a vital issue [1].From the last few dacades the world energy scenario has been rapidly changing and renewable energy is taking an leading role. Efficiency and energy saving leading an role [2]. Today, no one can imagine life without energy such as electricity [3]. So, more power generation is needed.In rural parts Renewable energy is the only leading option ,due to current energy scenario [4]. However, for residential load purposes also renewable energy leading an key role due to its more advantages [5]. Irrespective of seasons Combination of renewable energy sources leading an role [6]. For a present scenario Hybrid system is one of the best system compared to conventional energy sources [6]. Due to some disadvantages of Renewable energy resources like solar cant be used all 12 monhs in a year or wind.So In order to overcome the Disadvantages of solar alone or wind alone,here combination of solar and wind is used which is called as Hybrid system.so here solar and wind combination is used in order to overcome the Disadvantages of seasonal renewable energy system..

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II. PROPOSED METHODOLOGY FOR HRES

After finding the combination of solar and wind using the Evolutionary algorithm approach Energy Management is achieved..Finally the best algorithm conclusion is drawn out of four algorithms. Here the combination of Solar and wind is used.The Hybrid solar and wind commination role is verified using the Homer energy software and using the Data of around 600 to 1200 families in Hosapete..Using the Homer energy software the Best Hybrid software is determined through Cost analysis,Payback period Analysis… The combination of Solar,wind and Energy Management used is showm in Figure 1,

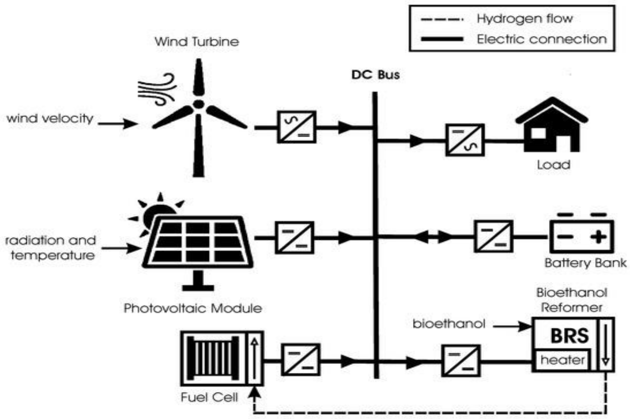

Fig 1: Block diagram for the proposed Methodology

A. Hybrid Renewable Energy System (HRES)

The proposed system hybrids solar, wind and Fuel Cell. The proposed system contains solar, wind, Fuel Cell, convertor, and battery bank with Load which provides much efficiency compared to other systems.Due to load variation effect,Batteries are used The hybridization is mathematically expressed as follows,

$$S_{pv} + W_d + B_{ms} + B_y + P_{load} = 0 \qquad (1)$$

Where S_{pv}, W_d, B_{ms}, B_y and P_{load} represent the PV result, the wind turbine result, fuel cell result, Battery result , and the load power, respectively.

Here, using the Evolutionary algorithm approach the charging and Discharges of battery is controlled

B. Solar PV system

The Solar cell is combined using parallel or series combination to provide the desired output. It IS essentially that converts solar energy directly into electricity. Output is calculated as below

$$S_{pv} = \delta_{pg} \ R_{pg} \ D_t \qquad (2)$$

Where, δ_{pg} is PV generation compotent R_{pg} is area of power generation (m^2), and D_t is Radiation of solar panel (W/m^2). The δ_{pg} is further explained as follows,

$$\delta_{pg} = \delta_r \delta_{pc} \left[1 - \alpha\left(\chi_c - \chi_c(ref)\right)\right] \qquad (3)$$

Where, δ_{pc} is efficiency of power conditionaing and α is Temparature coefficient.

C. Wind turbine

Wind Turbine produces the max output power at desired wing location.But choosing the best place is one the most best creteria for producing the max wind turbine output with high high efficiency.

$$W_d = \frac{1}{2} \times \rho_a \times S_a \times P_c \times \upsilon^3 \qquad (4)$$

Where, ρ_a denotes the air density, P_c indicates the power coefficient, S_a signifies the swept area and υ express the wind velocity.

D. Fuel Cell

Here the fuel cell converts chemical process to electric process through oxidizing agent often oxygen is used,through a redox reactions.

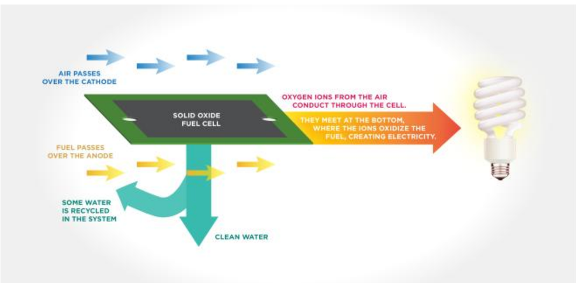

Fig 2: Diagram for power generated from the Fuel cell

Here negative ions travels from cathode to anode instead of anode to cathode as like other fuel cels.Oxygen is supplied through cathode where it captures electrons to create oxygen ions..Oxygen then react with Hydrogen gas at the anode.where the reaction produces the electricity and water as by product..CO2 may be also depending on the guel but carbon emmisions are less compared to other fossil fuel plant…

Anode Reaction:

$2H2 + 2O2- \rightarrow 2H2O + 4e-$ (6)

Cathode Reaction: $O2 + 4e- \rightarrow 2O2-$

Overall Cell Reaction: $2H2 + O2 \rightarrow 2H2O$

E. Battery bank

Batteries are used to comsume the energy during the excessive period and will be utlizied whenever load power is lesser depending on charging and discharging cycle and current may be positive or negative. The state of charge is expressed as

$$S_{charge}(t+1) = S_{charge}(t) + \left(1 - \frac{\lambda \times \Delta t}{24}\right) + \frac{Z_{battery}(t) \times \Delta t \times \omega_{battery}}{I_{battery}} \qquad (7)$$

Where, δ represents the discharge position, $Z_{battery}(t)$ is the present rate of battery at time t. $I_{battery}$ is the current position of battery current and $\omega_{battery}$ is the efficiency of the battery. The output power is described as,

$$B_y = S_{pv} + W_d + B_{ms} - \frac{P_{ac\ load}}{\tau_{inv}} - P_{dc\ load} \qquad (8)$$

Where, τ_{inv} is the efficiency of battery. $P_{ac\ load}$ indicates the power output of ac load and $P_{dc\ load}$ denotes the power output of dc load. The point at which the state does not exceed battery bank are expressed as,

$$\left(S_{charge}\right)_{\min} \le S_{charge}(t) \le \left(S_{charge}\right)_{\max} \qquad (9)$$

F. Adaptive Genetic Algorithm

In GA, a population of strings, also called chromosomes encodes an individual solution to optimize the result, evolves toward a better solution. Here, the solutions are presented in binary form (i.e., the string of 0 or 1). In GA the generation starts where the single population sector generates anonymously and generation continues till stopping criteria. In all iteration the fitness value of each population is measured based on which the higher strengths are selected to provide solution and are accommodated for next generation. Further, the selected populations are altered by performing reproduction and mutation that yields a new generation having better fitness and proximity to the optimal . To achieve better solution than the previous once and this process continues till the stopping criterion is met. Process continuous till the ITAE error becomes minimal by maintaining generation and load demands equal. As depicted in Fig. 12, in our proposed model, difference between a RES generated voltage and the load voltage is fed as input to the EMS model that tries to maintain optimal generated power by regulating RSC parameters. Meanwhile, EC assisted PID control performs charging-discharging control to meet load side demands, where it considers generation power as well for better EMS control. In AGA-PID control, AGA intends to optimize PID gain parameters to make swift charging and discharging control. In our simulation MATLAB 2015a optimization toolbox has been applied where only two parameters (P and I) are given as optimization variable, while the total number of population is 200.

The simulation is performed for 100 generations that eventually gives optimal/sub-optimal values of P and I. P and I gain parameters of the PID are taken as population which are represented in the binary string (0's or 1's), which are then processed for crossover and mutation to yield optimal gain parameters $(K_p \text{ and } K_i)$. In addition to the defined stopping criteria, AGA applies additional stopping criteria that estimate the total number of populations having similar fitness value and accordingly assigns probability of crossover and probability for the next generation.

It avoids the key issues of local minima and convergence. In our model, once 95% of the populations are having the same fitness value, optimization program terminates and the obtained gain parameters are assigned to the PID controller to perform control decision

G. Particle Swarm Optimization

Typically, BPSO approach that performs removal of the features from the correlation investigation. In our model, BPSO applies swarm intelligence technique to identify optimum PID gain parameters by obtaining global minima. In this algorithm, the particles inform the inner velocity in PSO and unlike GA, BPSO avoid iterative crossover and mutation that significantly reduces computational overheads and time. Additionally, in GA chromosome spreads information to the others, which is avoided in BPSO that performs information swap through best region. Classical EC algorithms function in continuous domain, while BPSO can be applied in both continuous as well as discrete domain. The overall functional schematic of BPSO is given in Fig. 11. As depicted in Fig. 11, BPSO contains four parameters; initialization, initial population and velocity, particle own best position .

In Particle Swarm Optimization PID parameter tuning, P and I gain parameters are taken as initial population which are initialized randomly and sprinkled in the search space. The parameter $x_i = x_1 + x_2 +, \ldots, + x_I$ and $V_i = V_1 + V_2 +, \ldots, + V_I$ refer the initial positions and velocities of the particles, respectively

III. RESULT AND DISCUSSION

In this section, the performance of the proposed Solar,wind and Fuel cell hybrid system is analysed. The proposed work is executed on the platform of MATLAB. The proposed system considers the battery, solar PV, wind, Fuel Cell and loads.. The performance is analyzed based on the hybrid power generation, load power, speed control and Torque. The performance of the proposed AGA,BPSO based PID tuned Controller for Hybrid Renewable energy system..

A. Performance Analysis

Here load deviation and charging,discharging control paramtent is considered.. Here PID Controller is tuned using Adaptive Genertic algorithm and Particle Swarm Optimization techniqye.Primiraly here we used Wind Turbine of 3 KW,50Hz Supply and PV Cell of 1KW is used for Maximum power point tracking facility. With the above here used Bidirectional convertor ,Nickel Cadmium battery storage ,Circuit breakers and Evlutioanry algorithms to control charging and Discharging.. Model is developed using MATLA 2015a/Simulink tool... Here Bidirectional convertors are used to convert pv cell ourput to desired dc output . Here we propsed three simple steps:First is to Examine using PID Controll with Predefined gains and Second using Adaptive Genetic Algorithm and third is using Binary Particle Swarm Optimization with population size of 50 and Iterations of around 100..

B. Classical PID Based EMS Control

Here the proposed model uses generation side as well as load side…It may non linear generation patern on wind side of turvine... As stated Wind turbine input is appr 3 Kw and output got is aroud 2700 W . 14. Here, the continuous 440 Volt power is generated (Fig. 15). Similarly PV Cell Ouput is around 680 W for around 1KW.. The comparison of the generated current and voltage can be found in Fig. 18.

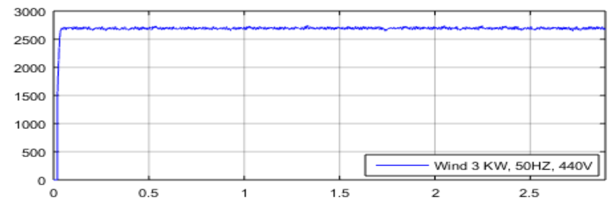

Fig 3. Power Output of Wind with classical PID control

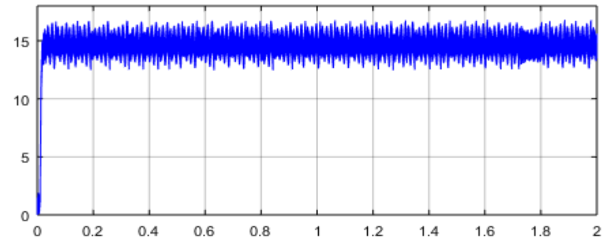

Fig 4. Current Output of wind with classical PID control

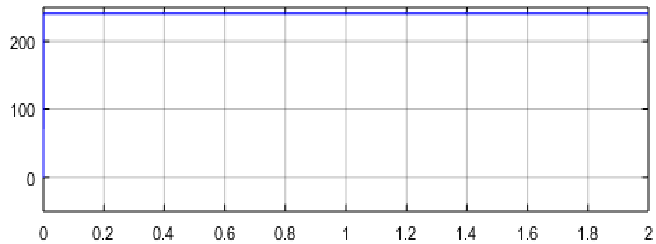

Fig 5.Voltage Output of wind for PID Controller

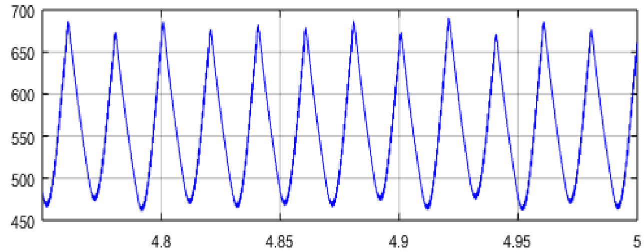

Fig 6. Power generation of PV Cell for PID Controller

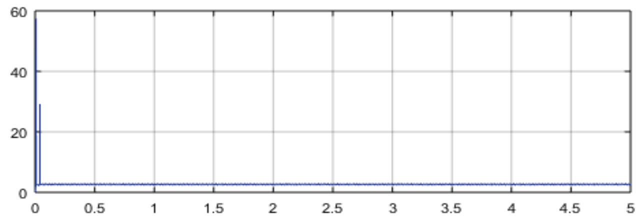

Fig 7. Current generation of PV Cell for PID Controller

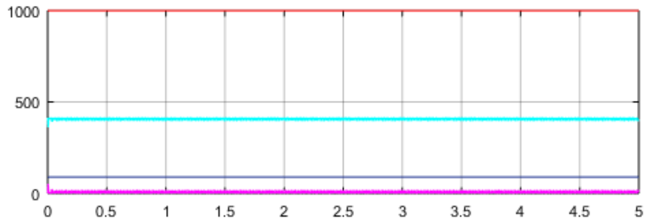

Fig 8. Pv cell generated and Current below

Combination of solar and wind Power output is considered and shown in fig 9. The overall load sensitive power generation by Hybrid PV/WT RES system could be visualized in Fig. 9. Overall it generates A Combined Pattern found to be 3.6 KW of Power.. The efficiency of charging and discharging could be easily visualized through these results. The speed control performance by PID controller can be observed in Fig. 21.

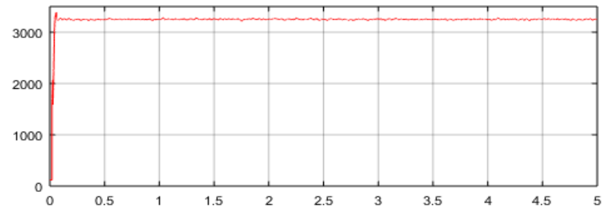

Fig 9. Hybrid-RES generated power (W) with classical PID control

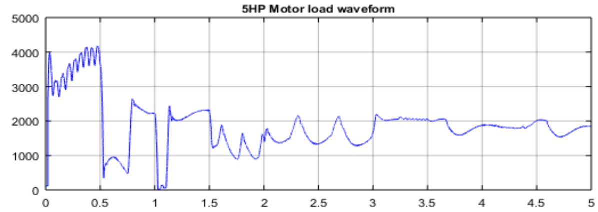

Fig 10. Load side power (W) demand variation

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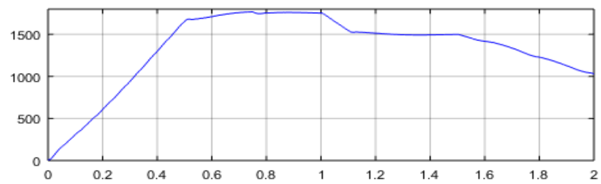

Fig 11. Speed control (r/s) with reference to PID

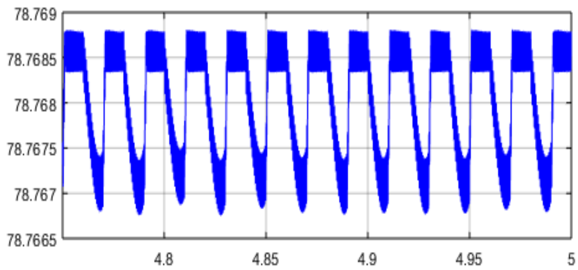

Fig 12. Charging and discharging control with reference to PID based EMS control

C. BPSO-PID based EMS Control

Similar to the classical PID controller and AGA-PID controller for EMS control, we have applied BPSO algorithm for PID gain parameter optimization to perform load sensitive charging and discharging control. In our simulation, the total number of generations applied was fixed for 100, while lower and upper bound for optimization was fixed at 200. Here, BPSO was used to optimize or obtain the optimal/sub-optimal value for the P and I gain parameters of the PID controller. The results obtained for HRES power generation (Fig. 13), respective load variations (Fig. 14), and load sensitive WT speed control (Fig. 15), and battery charging and discharging control (Fig. 16) are presented as follows:

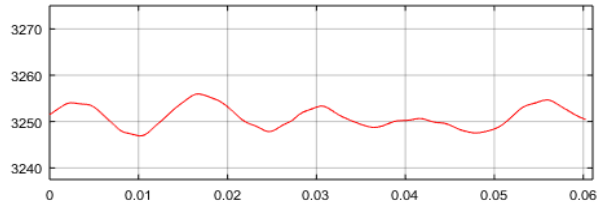

Fig 13. Total power generated from the HRES system

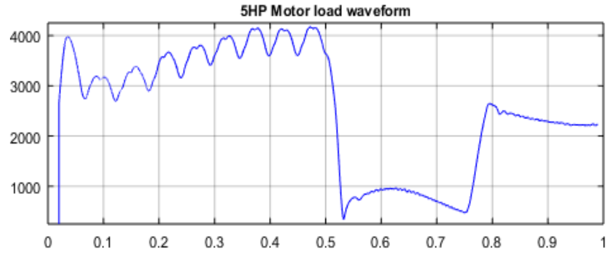

Fig 14. Dynamic load variation in HRES system

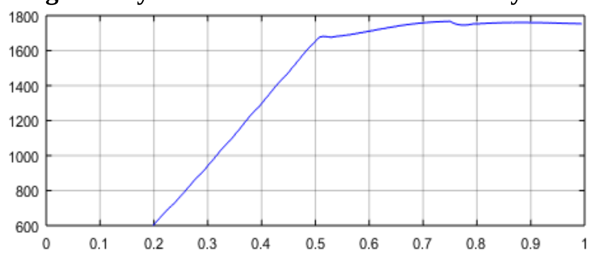

Fig 15. Speed control with BPSO-PID controller

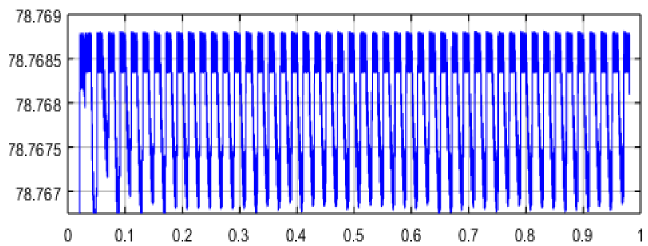

Fig 16. Charging and discharging control using BPSO-PID Controller

The simulation results obtained for AGA-PID based EMS control for Hybrid-RES system are given as follows:

D.AGA- PID Based EMS Control

The overall power generated by HRES model with AGA-PID is given in Fig. 17.

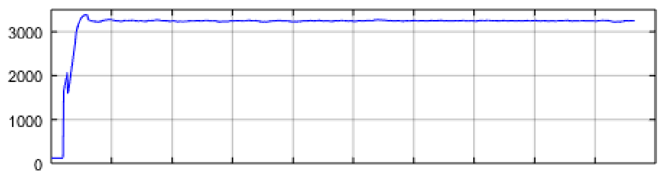

Fig 17. HRES power generation using AGA-PID based EMS

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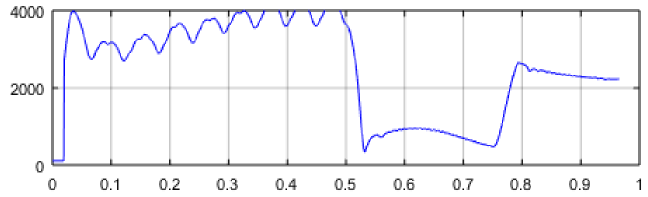

Fig 18. HRES load side power demand's variaiotn using AGA-PID based EMS

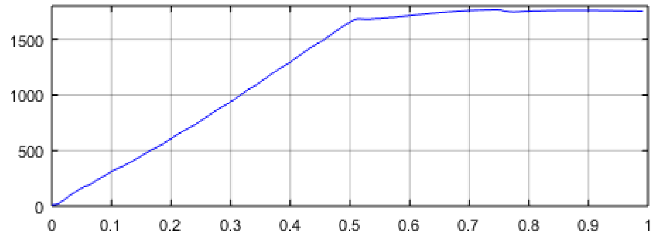

Fig 19. WT speed control with AGA-PID assisted EMS

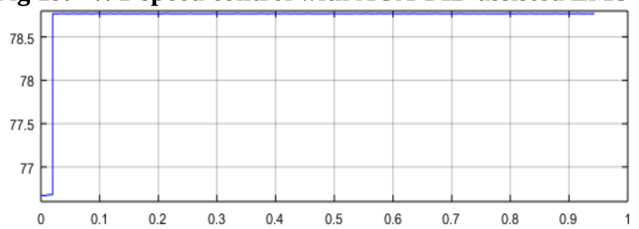

Fig 20. Charging and discharging control with AGA-PID

On the other hand, the outcomes signify that the use of AGA-PID makes power delivery more stable than the generic PID based controller. The augmented power supply signifies the efficacy of the proposed charging and discharging control. It states the efficiency of the proposed AGA-PID controller to achieve efficient energy management.

Table 1.AGA and BPSO Result of Iteration size 100

GA RESULTS	VALUES	PSO RESULTS	VALUES
Kp	3.816	Kp	0
Ki	9.593	Ki	7.5117
Kd	0.588	Kd	0.1967
Population Size	50	Population Size	50
Number of Iterations	100	Number of Iterations	100
Objective Function Value	691.36	Objective Function Value	588.7338
Rise Time	2177.634	Rise Time	2261.378
Settling Time	58994.87	Settling Time	58234.050
Settling Min	455.8427	Settling Min	482.8712
Settling Max	1737.550	Settling Max	1794.856
Overshoot	243.7992	Overshoot	235.2764
Peak	1737.550	Peak	1794.8561
Peak Time	20009.00	Peak Time	19865.00

IV. CONCLUSION

The use of power is rapidly increasing due to the growing nature of the world's population. The generation of power becomes an important issue. The Non converntional energy usage is a big trend to address power generation. To provide a reliable and efficient renewable energy system, this paper proposed an efficient hybrid Solar wind system using a rule-based optimized PID controller. This proposed system hybrids the solar PV, wind, biomass, battery and loads. Then, the generated power, load power, and speed control are balanced by using the ROP controller. Then, the performance of the proposed renewable energy is compared with the existing controllers such as PID, PID controller, GAPID controller, FPAPID controller, HSSPID controller, and PSOPID controller based on the power generation and speed control. From the comparison, the proposed system provides better performance than the existing methods.. The proposed system provides an efficient and reliable hybrid renewable energy system. In the future, the proposed method can be extended by using advanced evolutionary algorithms and also more systems can be hybrid in the hybridization phase.

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