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Article

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Soft Computing based optimization employed for efficient Renewable Energy resource deployment

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ABSTRACT

The world's crisis of energy is thought to be effectively solved by renewable energy resources (RER) and hybrid powertrains. The way distribution networks are accessed and investigated is changing significantly as a result of RER penetration. This illustration of a future modified power system is altering the environment in which it was previously set up and run. A careful revaluation of design and allocation is required for effective RER planning. Some utilities are being encouraged to modify their business models to be able to compete with the increasing utilization of renewable energy resources by the most recent trends and innovations in renewable energy resources and their combinations. Even though a number of innovations are manageable, they might help RER be successfully deployed in the system. None of these reports described the effective investigation they conducted or the modifications they found to be useful for RER planning and execution. As a result, the purpose of this research is to examine a number of efficient methodologies and processes for RER blending, allocation, and benefit extraction. The new soft computing-based optimization technique will be looked at after a review of all previously published methodologies in order to successfully deploy RER in the grid with aided benefits.

Keywords: Renewable, Energy, Resources, Soft computing, Optimization

INTRODUCTION

The world's increasing rate of energy depletion is one of the main issues of the rapidly evolving industrial era. The development of well-organized and economical modular energy delivery structures is greatly influenced by economic and environmental concerns, especially in industrialised areas.In all of its versions, distributed generation (DG) is likely to grow in recognition as a great alternative to meet the world's energy needs at a time when energy resources are running out. Most DGs depend on renewable energy resources. According to the International Energy Agency (IEA), renewable energy sources include things like solar heat energy, wind speed, geothermal energy, organic biomass energy, energy from falling water, and tidal energy.

Although their ability to adapt varies greatly depending on geographic and climatic conditions as well as the efficiency of technology for extracting renewable energy sources, their widespread availability makes them a more lucrative solution in this scenario of energy scarcity. These tiny technological solutions' modularity can also be seen as a unique definitional context.Small, factory-assembled components make up mini hydro turbines, photovoltaic systems, wind turbines, CI engines, solar thermal systems, fuel cells, and battery storage. One of those modules' most notable features is how quickly they can be installed at the destination location. Manufacturing and assembly are much faster when done locally as opposed to centrally.

Moreover, every modular unit can start working as soon as it is installed on the site, regardless of the condition of the other components. The other modules are unaffected if one module fails.

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The impact of module failures on net available output power is significantly reduced because each module is small in comparison to the unit size of large centrally located power plants.To sum up, these technologies allow for the cascading of modules in the future or the relocation of modules to a different site if necessary[1-3]. The generation of both heat and power (combined heat and power) is a crucial component of enhancing system efficiency.

For the generation of heat and power, the following technologies are suitable: combined cycle gas turbines, ignition engines and turbines, gasification of biomass, geothermal energy, sterling engines and fuel cells. When heat is used locally, the production of local heat and power is very efficient. Because heat generation uses the losses from power production, heat output and power output almost always correlate positively. Unless a backup system for producing heat is present, the operation process is typically determined by the demand for heat. The combined heat and power generation technology is currently in use all over the world[4],thanks to IC engines, combustion turbines, combined cycle gas turbines, and biomass gasification.

While the use of Renewable Energy Resources (RER) is changing the way distribution networks are used and investigated in significant ways. Despite the controversy surrounding RER installation and operation in distribution networks, Distribution Network Operators (DNOs) have limited control over RER design and allocation. RER placement is decided by their owners and stockholders based on site and fuel convenience. The incredible rate at which petroleum products are decomposing has brought the world to a critical point from which it is quickly approaching the peak of fuel usage, particularly for oil & gas. This phase has started to speed up researchers' efforts to look into substitutes for the limited conventional energy resources. The world's energy crises may be effectively addressed by using hybrid combinations and renewable energy resources (RER). The environment in which it was previously structured is changing as a result of this new modified power system paradigm. A careful revaluation of design and allocation is required for effective RER planning. Previously ignored by states and power system administrators due to limited energy extraction schemes and techniques, such renewable energy insertions and pertinent advancements in grid supporting structures are now receiving considerable attention. The ratio of population growth to the accessibility of traditional energy sources that are compatible for survival is inverse.

This unfavourable situation offers a way to assess the strength and capabilities of current energy sources and look into new ones. The best option for achieving this opposite proportion is a renewable energy source.[3] Governments are creating more favourable conditions for achieving environmental goals while enhancing global energy security. In order to improve output through an improved voltage profile, system steadiness, loadability enhancement, and lower voltage variation, DNOs are actively working to increase the network supportive benefits of such a mixing of energy sources with already existing structures. Execution, establishment, and unrestricted quality of RER addition in already existing systems are the main challenges. To capitalise on all of RER's potential advantages, researchers are working hard to create better, more affordable methods.[4,5] Some utilities are being encouraged to change their business models in order to compete with the rising use of renewable energy resources by the most recent trends and innovations in renewable energy resources and their combinations. None of the reports have introduced and presented their effective investigation, changes discovered effective in RER planning and establishment, despite the fact that various innovations are manageable and may enable successful RER deployment in the system. Therefore, the aim of this work is to investigate and derive potential benefits from a set of efficient methodologies and procedures for RER allocation. A new soft computing-based optimisation technique will be looked into after a review of all published methodologies in order to successfully deploy RER in the grid with aided benefits.

DNOs must pay close attention to RER placement and sizing in order to maximise the benefits of RER installations. What size is appropriate? and where is the best location for RER installation are the two main subproblems that are related to this goal. There is a tonne of excellent literature available to explain this topic. This study offers a comprehensive analysis of RER distribution systems and its influence on ongoing research projects in this area. Through the provision of noteworthy details of research work conducted in the RER designing and installation procedures, an elfin effort has been made through this work to lessen the difficulties associated with obtaining appropriate guidance for future researchers. Thus The main objectives of this research are to maximise the use of solar panels, minimise pollutant emissions, and reduce the cost of energy production by optimising the size of hybrid RER system components.

The rapid growth of renewable energy and its effectiveness would lead to economic growth and significant energy security. It would reduce global warming and reduce environmental pollution that may result from burning fossil fuels.[6] It would also help to restore environmental fitness. In comparison to systems using a single energy source, the production of energy in hybrid systems is more reliable and cost-effective.[7] For integrating different renewable energy sources, there are generally three types of configurations that are feasible: hybrid-grid configuration, hybrid-off-grid configuration, and individual supply from the grid configuration.[8-10] The most significant data regarding energy generation is provided by HRES reliability studies. According to a literature review, the majority of researchers focus primarily on factors like EENS, EIR, LPSP, as well as LA, among others.[11]

Review of Literature

Incorporating RER into the system is a challenging combinatorial problem in and of itself, but the effective and efficient implementation of RER inclusion in system planning calls for effective algorithms and theories. Numerous researchers have put in a lot of effort and investigated rigorous theories and algorithms using a variety of optimisation techniques and combinations of them, yielding a positive and significant contribution to the field. The tree of different optimisation techniques and their subclasses is shown in Figure 1.

Experts studied their effects in order to use or combine (hybridise) a number of already-in-use streamlining techniques to improve the power system and help it speed up the rate of unprotected RER permeation[4,5, 12-15]. The activities of researchers in the field are divided into four main groups in this collection, Search methods include:

- Traditional,
- heuristic/ artificial intelligence (AI),
- Hybrid Systems, and
- Alternate Methods

These tactics reveal a strong interest in RER implementation and planning. The strategies and pertinent significant reports illustrating the various components of the RER arrangement are examined in detail in the sections that follow.

The overall expense of the hybrid system has been further separated into different price constraints, such as NPC, ACS, LCE, PBP, and IRR, which must be assessed as taken into account by each of the authors[16]. NPC stands for the total cost, including income and expenses, of a hybrid system over the course of its life[17]. system. The variety of wind turbines, solar PV cell slope angle, PV module slope angle, batteries, controllers, inverters, cables, and other accessories are all taken into account when determining the best size[18]. The models of HOMER's energy components include solar photovoltaic, wind, hydro, batteries, diesel, as well as additional fuel generators[19,20]. HOGA, TRANSYS, HYBRID2, ORIENTE, RET Screen, GAMS, LINDO, Opt Quest. DIRECT, WDILOG2, SimPhoSys, GSPEIS, DOIRES, and GRHYSO are additional software tools that can be used to optimise HRES[21–23].

Several studies have focused on optimizing hybrid renewable energy systems (HRES) using various optimization techniques and criteria. Awan24 optimized HRES for the minimum NPC (Net Present Cost), while Ndukwe et al.[25] used simulations on HOMER software to determine the best HRES size and cost.[1–26]

Other studies have used different optimization methods such as linear programming (Bhandari et al.[26]), HOMER tool (Aziz et al.[27]), artificial neural networks (ANN) and genetic algorithms (GA) (Rezvani et al.[29]), MLI Control for Renewable Energy Smart Grid Applications (Kumar et al.[30]), and particle swarm optimization (PSO) (Paliwal et al.[35], Hakimi et al.[37], Askarzadeh et al.[38]). These optimization techniques have been applied to various hybrid systems, including solar and wind energy systems (Mekontso et al.[28]), wind and hydrogen systems (Jiang et al.[31]), TIC for intergrated system (Gupta et al.[32]), standalone PV systems (Hontoria et al.[33]), PV-Wind-Diesel-Battery systems (Lujano-Rojas et al.[34]), hybrid systems with fuel cells (Kaviani et al.[36]), and hybrid systems with wind turbines (Merei et al.[40]).

I. TRADITIONAL

Traditional Methods, which employ customary principles for planning conventional methodologies for RER deployment, include techniques like Optimal Power Flow (OPF), Logical Analytical Methods, and the 2/3 rule. Achieving the best solution and advantageous outcomes, such as loss minimization, cost reduction, correction of the voltage profile, improved load capability, etc., may be hampered by procedures showing their track.

II. HEURISTICS /ARTIFICIAL INTELLIGENCE (AI)

The Heuristic or Artificial Intelligence (AI) Filtering method is covered in great detail in this category of optimisation techniques. A method known as heuristic or AI exploration uses heuristics to guide its decisions. Because they store the entire path data, including the moderate nodes that were under investigation, its detection calculations

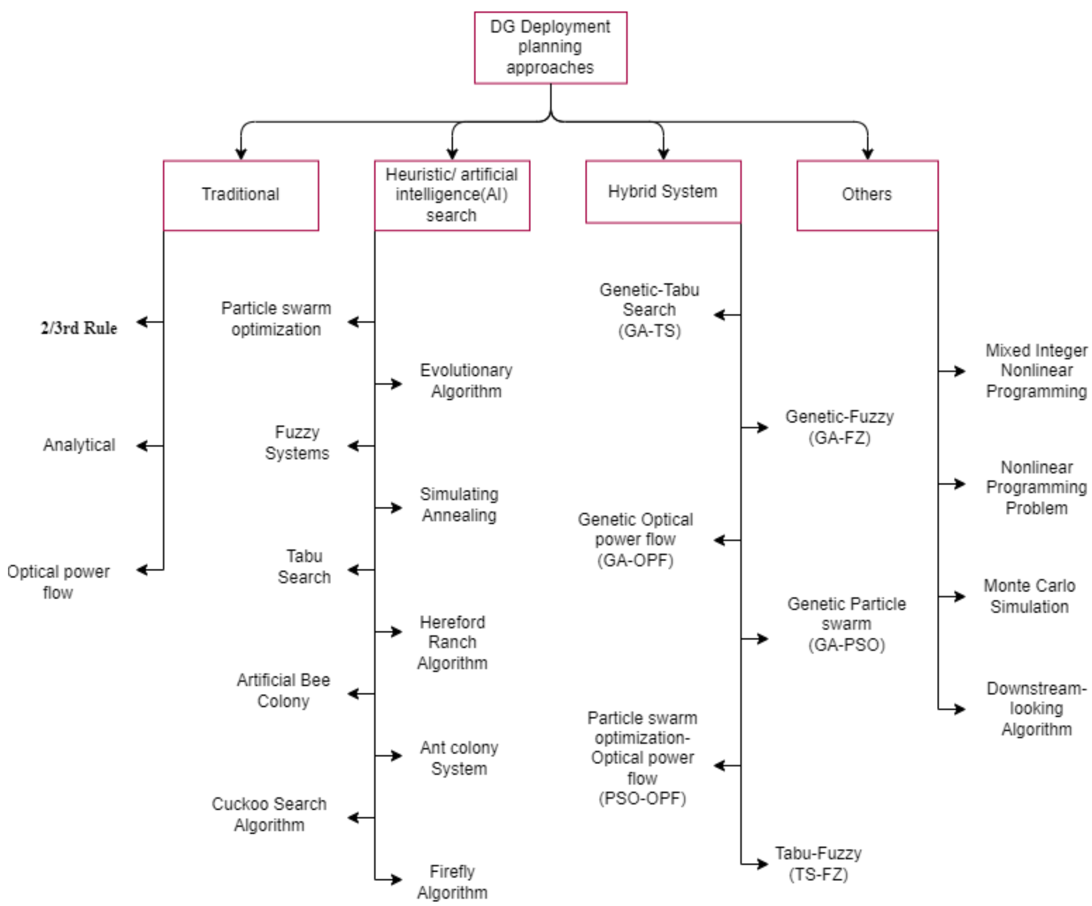

Figure 1. Different optimization techniques Tree

Table 1: Comparative Analysis of Optimization Techniques

Methodology	Advantages	Drawbacks	Based on Assumptions	Economic	Iterations
Traditional	Obtain Global solution, based on realistic equations and expressions, simple strategies	Complex, Limited Scope, fails to cope up the high dimension problems, Time consuming	Sometimes	Yes	Depends on equation and required coordinates
Heuristic/ artificial intelligence (AI),	Simplicity, obtain near optimum solution, Less time consuming, Easily solves the high dimension problems, less time taking	Complex in programming,	Yes	No	less
Hybrid Systems	Advanced techniques, obtain optimum solution, Easily solves the high dimension problems, less time taking	Complex in programming	Yes	No	Even more less
Alternate Methods	Simplicity, uniqueness	Less literature is available	Yes	Depends on the selected tool	Depends on the selected tool

have extraordinarily high reality complexities. As a result, many applications to get the best results are more expensive, like heuristic search strategies. Despite this, the analysts have put a lot of effort into coming up with the best solutions in the least amount of time.The science and methods of intelligent machine planning are frequently used to define AI. Additionally, known as intelligent PC programmes. Particle Swarm Optimisation, Evolutionary Algorithm, Fuzzy System, Ant Colony System, Cuckoo Search Algorithm, Simulated Annealing Hereford Ranch and Tabu Search, Firefly Algorithm, and Artificial Bee Colony are just a few examples of the diverse range of AI exploration projects that fall under this category.

III. Hybrid Systems [1,3]

Each technique has been found to have both benefits and drawbacks. Different strategies might guarantee the best outcome, but they lack adaptability when faced with real-world situations. Arealistic solution may have been created by some, but it required extensive calculations.

While some methods require less work, they have lower accuracy and solution generation reliability. As a result, researchers are constantly looking for ways to combine effective methods inorder to produce successful results. This is done in an effort to achieve advanced levels of accuracy and efficacy. The drive to find the perfect blend frequently leads to better or more complicatedsolutions. The shortcomings of individual approaches are overcome by these hybridised technologies. The terms "genetic-optimal power flow" (GA-OPF), "genetic-fuzzy" (GA-FZ),"particle swarm optimization-optimal power flow" (PSO-OPF), "tabu-fuzzy" (TS-FZ), "genetic-tabu" (GA-TS), and "genetic particle swarm optimisation" (GA-PSO) refer to a number ofoperational hybrid systems.

IV. Alternative Methods [3]

All of the remaining approaches that might not have been able to fit into the first three due to mismatched criteria are included in this group. methods like mixed integer nonlinear programming, Monte Carlo simulation, downstream-looking algorithm, and others. Despite not being a part of the aforementioned major groups, all of these techniques have been proven to be successful and yield noteworthy outcomes. Due to some of these peculiar traits, they have also attracted lot of attention of researchers in this field. It is crucial to divide them into distinct groups in order to evaluate their influence on RER planning strategies. Comparative analysis of all these four methods has been presented in Table 1.

Trade-offs between the cost of energy and other factors

The trade-offs between the cost of energy and other factors, such as reliability, sustainability, and environmental impact, are crucial considerations when evaluating renewable energy sources. Table 2 presents the entire summery of such trade-offs,

The technological advancements, economies of scale, supportive policies, and market dynamics can influence these trade-offs over time. Continuous innovation and improvement in renewable energy technologies can help mitigate these trade-offs and make renewable energy more competitive with conventional sources while simultaneously addressing sustainability and environmental concerns.

Prominent contribution in the proposed field of study

While many researchers have advocated and employed iterative or graphical techniques with the intention of optimising hybrid system apparatuses, very few researchers have utilised novel algorithms. Innovative methodologies start by creating a design space of likely answers for the ideal component dimensions. Then, using a searching method, the best optimal conformation that fulfils the specified objective jobs is selected. These methods are praised once the multi-objective function must be satisfied and/or when various parameters (variables) building the decision vector must be optimised. When the operating strategy for the hybrid system needs to be optimised, they are also recommended. It is challenging to solve these optimisation problems in practise using linear programming or iterative methods. The genetic algorithm, particle swarm optimisation, and simulated annealing approach are a few of these cutting-edge search methods. In the reviewed literature, it is possible to find additional, uncommon approaches. Although each of these strategies has distinctive qualities of its own, the literature review reveals that the genetic algorithm has superior qualities that make it popular for solving optimisation problems, especially in hybrid systems. It is perfect for optimisation problems with a lot of optimised parameters because of how effectively it finds the global optimum. It is more difficult to code than other algorithms, and solving optimisation problems requires more time when multiplied.

components were optimised using the genetic algorithm. The types (brand names) of these components were selected from a variety of assigned brands, and the goal utility was to reduce the COE. Among the optimised parameters are the surface azimuth angles and the tilt angle of the photovoltaic panel. Additionally, it is possible to optimise the type of each component.In this instance, the structure for erecting PV panels is also optimised. The results of this hybrid system are also contrasted with those of a hybrid system that substitutes a CI generator for a micro turbine as a backup power source. It has also been investigated how the load's effect on the COE will change if the load is concealed with 100% trustworthiness and if a specific value for the Loss of Load Probability (LLP) is specified.

3] To reduce electricity costs, cut carbon emissions, and enhance

Table 2: Trade-offs between the cost of energy and other factors

Trade-offs between Cost Vs	Causes	Results in
Reliability	• RESs like solar and wind are highly dependent on weather conditions. • For reliable and steady energy supply it requires surplus investments in storage or backup systems.	Increase the overall cost of energy generation
Sustainability	• RES are more sustainable than fossil fuels, there can be trade-offs in terms of their environmental effects. For example, few renewable types like hydropower (large-scale), biomass etc., may have atmospheric issues related to habitat disturbance, water or land need and respective alteration if any	Balancing the cost of energy with long-term environmental sustainability requires careful consideration and mitigation strategies
Environmental Impact	• RES have lower greenhouse gas emissions compared to other traditional sources. • Though, there can be trade-offs in terms of the ecological control allied with their complete life cycle. Like, the development and discarding of few RES technologies, like solar, wind turbine may generate waste materials having many environmental consequences.	Evaluating the cost of energy must study the complete life cycle situation and diminish possible negative ecological effects.
Grid Integration	• Incorporating RES in the power grids can stance technical and economic problems. • Variable generation from RES demands grid upgrades and the up gradation to smart grid systems expecting more effective and competent operation.	The cost of grid incorporation, including transmission, distribution and set-up can be counted beside the renewable energy generation cost.
Energy Access	• The price of installing RES in remote or deprived locations is always high as compared to traditional plants. • The installation costs, infrastructure designing and equipment obtaining prone obstacles in gaining universal energy goals.	Matching the energy prices with the goal of seeking affordable and reasonable energy entrance is significant.

Numerous significant advancements have been made in the area of optimisation methods for RER planning and control.

1] A thorough literature on the best scheduling of DG systems in distribution systems has been provided by Rajkumar Viral and D.K. Khatod[3].Effectively presented is detailed information on distributed generation, the definition of RER, its effects on the power system, and various planning methods for optimisation.

2] Genetic algorithm-based optimisation on hybrid renewable energy system modelling and design was presented by M.S. Ismail et al.[5]. In this paper, the scopes of the various hybrid system

UC in relation to thermal, visual, air quality, and time delay, G. Hafeez et al.[1]proposed an efficient load forecast and energy managing controller for the construction of smart homes. In this piece, a smart building using renewable energy, a battery storage system, and grid power is imagined. The large HVAC load is planned with additional flexible and intelligent applications to reduce load. Every appliance in the smart home is scheduled using the Hybrid-GA, Particle Swarm Optimisation, and WDO optimisation techniques that have been suggested. The suggested method assists in selecting the best optimal schedule while accounting for system constraints for each home appliance.

4] In an almost zero energy building, E. Tsioumas et al.[2] offered a better method for sizing renewable energy sources and battery storage systems. In order to successfully convert a conventional residential building into a nearly zero-energy building, a novel methodology for determining the right size of renewable energy sources and battery storage systems must be presented. The methodology uses energy sources like solar, wind, and thermal power to swing load to peak hours and achieve the goals. This is achieved by taking into account the building's location's long-term weather history, the energy consumption of the appliances, and the implementation of the energy management system (EMS). The initial investment devaluation, the self-consumption rate, the feed-in rate, the simultaneity in generating and consuming power, and the effects of the depth-of-discharge and discharge power on the BSS's state-of-health are all embedded in a budget function that stabilises the impact factors that significantly affect the extent and have a notable effect on the trustworthiness and lifecycle of the RES and BSS. As a result, by considering both the efficiency and the commercial aspects, the appropriate sizing of RES and BSS is provided. By using genetic algorithm techniques to minimise the aforementioned budget function, the best solution is discovered.

Research Objectives and Work Plan

In this work, the extents of the various hybrid system components (Solar cells, Wind Turbines, and ultracapacitorare optimised using the genetic algorithm. The types (brand names) of these components have been carefully selected from a variety of allocated types. If further this system is used it can also attain the goal to reduce the Cost of Energy (COE). The outcomes of this hybrid system will be contrasted with those of another hybrid system that substitutes a diesel generator for a battery as a backup source. The impact on the COE can also be examined, taking into account both the case where the load is completely enclosed and the case where a specific amount of LLP is quantified.

The work schedule is listed below;

1. An analysis of the research on the design and planning of renewable energy sources and their combinations, as well as the various optimisation techniques applied to improve the efficacy of such planning procedures.
2. After reviewing the available literature, the most pertinent methodologies that are relevant to the chosen problem will be listed out, and the problem will be formulated in accordance with these stages:
   - studying the pertinent literature,
   - looking into and analysing current research,
   - examining the gap in the work,
   - figuring out what likely work can be done, and
   - looking into methodology and implementation in soft computing technologies.
3. Problem investigation: After problem formulation, the methodology under investigation will be examined and analysed.
4. Looking into a fresh set of equations to account for RER deployment characteristics and evaluating the results on power system performance.
5. Comparing the investigated method to previously described techniques and determining any gaps.
6. Solution estimation and results validation through comparison with other accepted techniques.
7. 7. The execution of the final RER deployment strategy that has been evaluated.

Proposed methodology for the duration of the research work

Nowadays, many people use hybrid energy systems that depend on renewable energy sources, especially solar photovoltaic (PV). They have proven to be effective when used to supply power to several locations, especially small isolated loads. Their use can assist in meeting the Kyoto Protocol's requirements for mitigating the effects of greenhouse gases because they primarily reduce CO_2, NO, NO_2, and SO_2 emissions. Low maintenance costs and lower pollution emissions are their main benefits[3,5]. This study suggests using genetic algorithms to plan a hybrid system that can includes an ultra-capacitor, a wind turbine or fuel cell as a backup source, and a solar PV system as a renewable source.

A block diagram of the anticipated hybrid energy system is shown in Figure 2. The bi-directional inverter connects the AC and DC buses, with the AC bus combining the output of the wind turbine and load and the DC bus combining the DC output of PV panels via the solar charger converter and the ultra-capacitor bank. Hybrid systems, also known as systems with multiple supply sources, can increase the reliability and energy security of systems with a single energy source when supplying power to a particular application[5]. An important step that should be taken either before or during the optimisation process is balancing energy for every hour of the year. Every energy source's output should be planned for this use in advance.This calls for the mathematical modelling of each system component, which calls for the availability of climate data, which calls for the analysis of data.

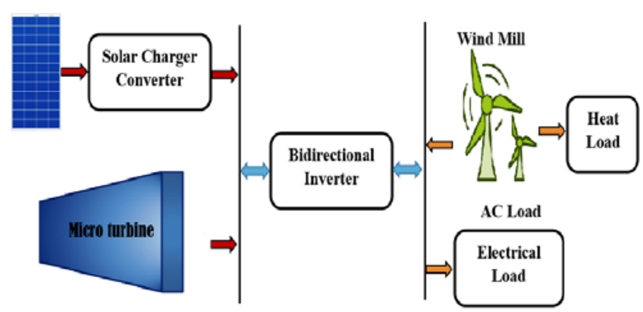

Figure.2 Block diagram for proposed system

Prior to performing the sizing optimisation of the hybrid system modules, which will be elaborated at the conclusion of this study, the solar radiation exploration and the development of a mathematical model of the hybrid system modules are necessary steps. The renewable energy source and how simple it is to use determine the different hybrid system types. In the MATLAB environment, the system shown in Figure 2 has been simulated, and the following studies are carried out on it:

1. Sizing a hybrid system that includes photovoltaic (PV) panels, a backup source (a wind turbine), and microturbineas back up,

which could lead to an affordable solution and a thorough design of this optimised system supplying power to rural areas.
2. A scenario using a single PV and a different scenario using a backup source has been examined.
3. To optimise the procedure, used a genetic algorithm. With a known value for the probability of load loss (LLP), the investigated objective function will meet the load mandate while minimising the cost of energy generation.
4. A simulation programme was created to achieve energy balance for every hour of the year. This program's objective is to simulate the operation of a hybrid system using multiple energy sources in accordance with the recommended strategy for controlling power flow through this hybrid system. The power flow between the various sources in the hybrid system is described in this strategy, along with the urgencies that control it. As part of this strategy, the energy generated by the PV panels and stored in the ultracapacitor takes precedence in supplying the load because it maximises the use of the PV system. The micro turbine can also be used as a backup source if this energy is insufficient to meet the load requirement.
5. When the energy generated by the PV panels exceeds the load requirement and the batteries are fully charged, a dump load is used to consume extra energy. As previously mentioned, when the battery bank has been squared to the maximum permitted depth of discharge and there is not enough energy produced by the PV system to quantity the load, the decision to run the micro turbine is made. The bi-directional inverter functions as a rectifier and permits the battery to be charged up until the point at which the battery is fully charged.
6. The genetic algorithm is one of the cutting-edge algorithms that has been used to fix optimisation issues.The population's singular solutions are randomly selected at each stage. To create the next generation from the current population, the genetic algorithm uses three main rules: selection rules, crossover rules, and mutation rules.
7. As was already mentioned, the purpose of optimisation is to select the proportions of the hybrid system's components in order to mollify the various predetermined objective functions. This optimisation problem was solved using a genetic algorithm, and it is simulated in MATLAB environment. The simulated system generate population members (possible solutions) at random to create the initial population. Each potential outcome is represented by a decision vector code that considers the upper and lower constraints.The flowchart that the genetic algorithm uses to optimise the process is shown in Figure 3.
8. After applying the GA in accordance with the flowchart in Figure 3, ancillary system parameters like reliability and compatibility in challenging circumstances like voltage surges will be tested to find the best possible outcome.

HYBRID POWER SYSTEM MODELLING AND SIMULATION

The hybrid power system integrates the two renewable energy sources—a PV array via a DC/AC inversion and an array of wind turbines connected to a generator—to deliver a single phase AC load.

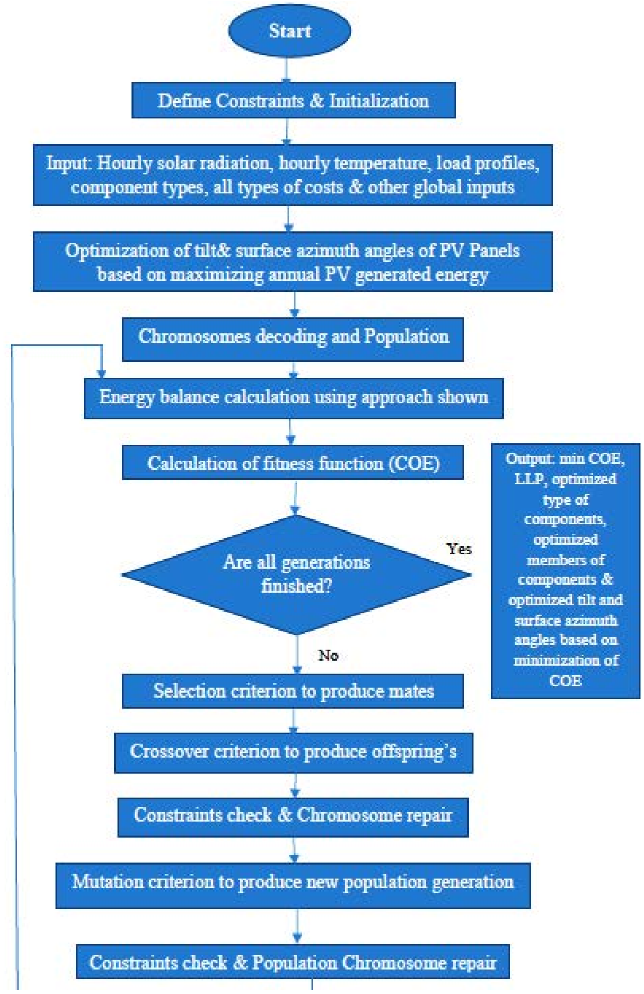

Figure.3. Flowchart of the proposed methodology in GA

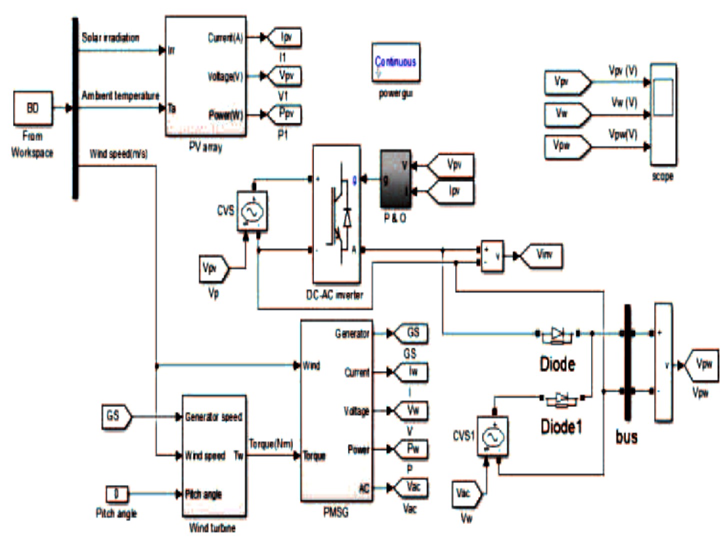

Figure 4: Hybrid power system Simulink model

A. THE HYBRID POWER SYSTEM'S MODELLING

Both power supplies have wiring attached to a single phase AC load and function in parallel. Figure 4 shows the hybrid power system Simulink model, which was created in the Matlab/Simulink setting.

B. Results of simulation

The simulation was run for nearly 11 hours, from 07:00 to 17:50, on a sunny spring day.

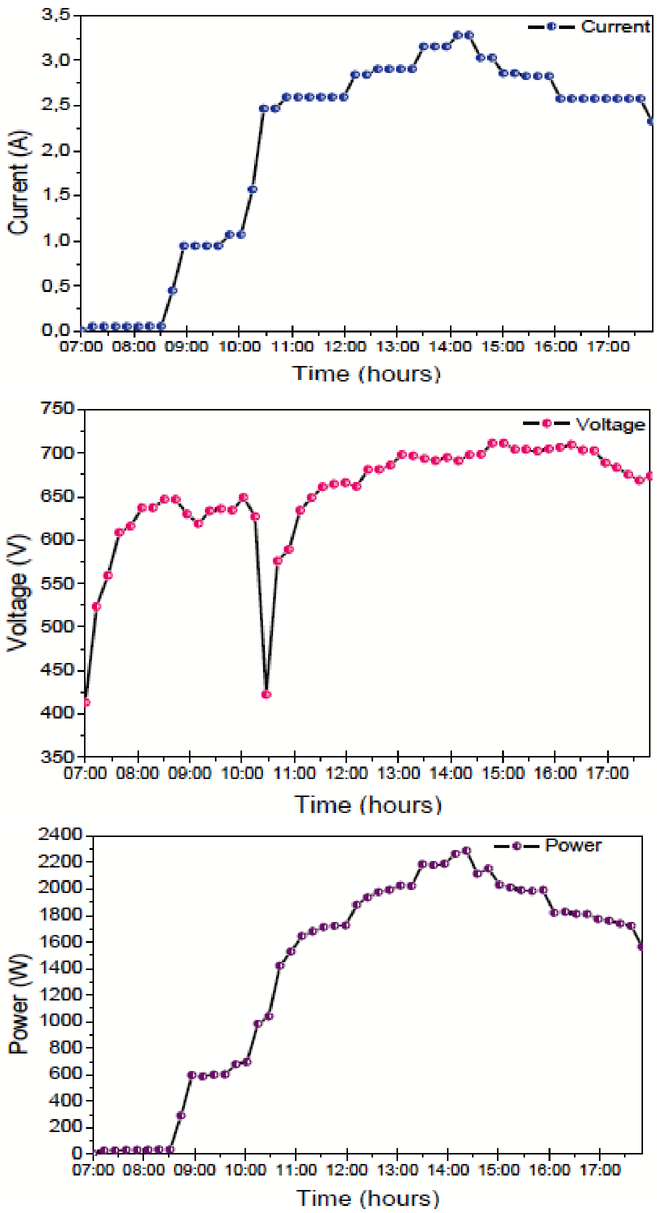

Figure 5: Current, voltage, and power variation of the system

The simulation results from this study are shown as curves in Fig. 5. The first one shows the fluctuation in current, the next one shows the fluctuation in voltage, while the final one shows the power produced by the photovoltaic generator.

Figure 6 shows a plot of the total variation of the AC voltage produced by the hybrid bower system.

The hybrid system's AC voltage is 1500V, with the PV system's voltage varying between the 400V and 700V and the wind turbine system's voltage varying within 200V and 700V.

In besides the total power produced by the hybrid system, Figure 7 also includes two power curves from the PV and wind turbine systems and Figure 7 shows the combined PV-Wind Power.

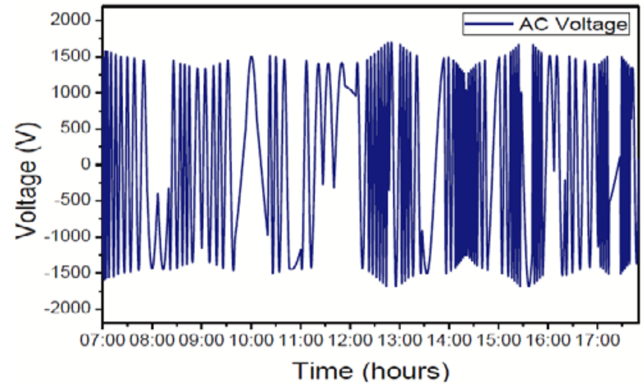

Figure 6: PV-Wind system AC voltage curve

The fuel cell polarization curve for selected voltage corresponded to the current at peakpower is given in figure 8..

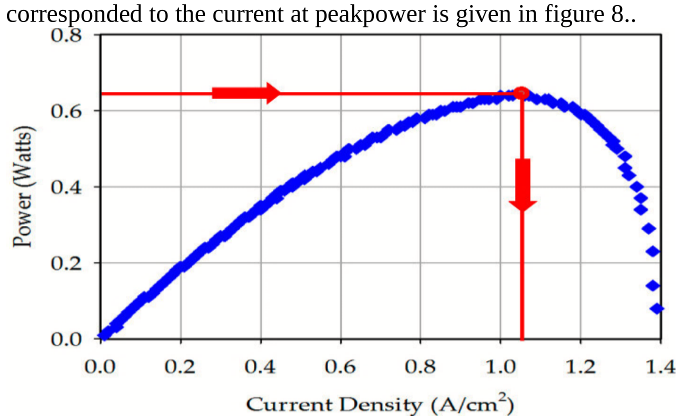

Figure 7: PV-Wind combined power variation curve

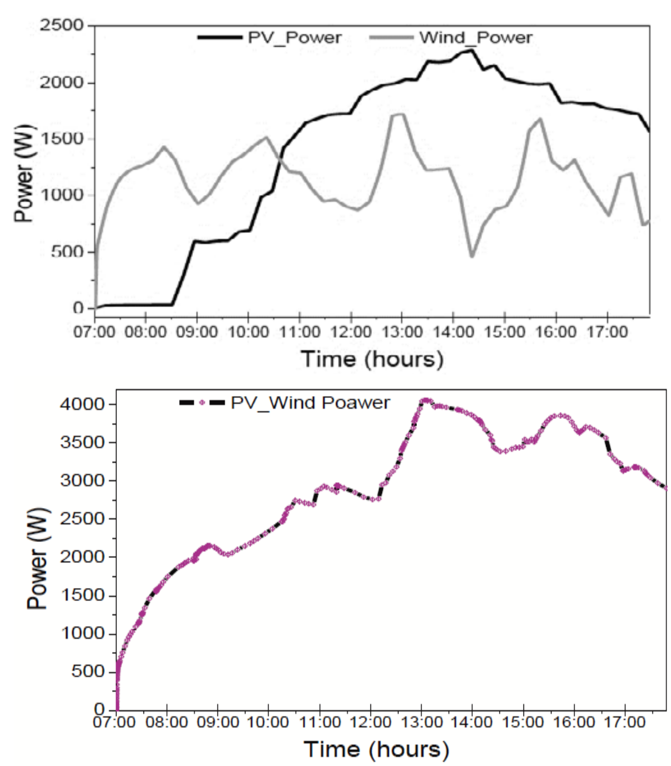

Figure 8: Fuel cell polarization curve

The simulation runs of the power flows between specific components of the under consideration hybrid renewable energy system are shown in Figure 9. The simulation data are present in the simulation. The hybrid system's operation was divided into four distinct states for the reason of the simulation: States 1, 2, 3, and 4. Different assumptions were made for each state regarding the load power usage, extent of solar radiation, along with wind conditions.

The effectiveness of using HRES systems and the superior operational characteristics of its subsystems were confirmed by the simulation tests that were carried out. A viable and trustworthy energy system is provided by the hybrid energy system's overall framework, which consists of a wind/PV/battery energy system. Each of the system's energy sources are capable of supplying power, and any power drops can be made up for with additional energy from other sources. When there is extra energy generated, it can be transferred to the AC grid or stored in a battery.

Even in conditions of low wind speeds or just low sunlight exposure, the proposed renewable hybrid system is capable of maintaining a steady power supply regardless of the load.

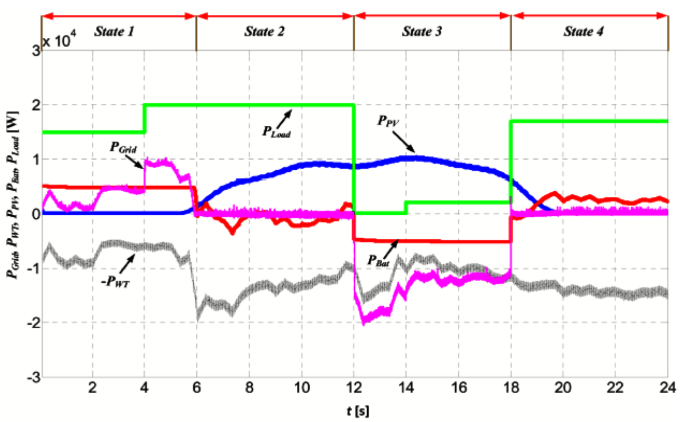

Figure 9: Wind turbine & generator o/p power, PV power , battery power,grid power, and load power

The hybrid system's power output is almost exactly comptible to the combined power of the wind turbine and solar array. As a result, using a hybrid system to generate power when there is a strong wind or light air is effective.

Effect of microturbine power to suppliment the load requirement can also be analysised through the system. The said system can be used effectively to supply the load.

Conclusion

An analysis of the research on the design and planning of renewable energy sources and their combinations, as well as the various optimisation techniques applied to improve the efficiency of such planning procedures has been executed in this paper. To exhibit the efficacy of the explored analysis ot has been implemented on the prototype of the proposed system. The simulated system leads to the following conclusions;

1. The genetic algorithm has been used to abstract the parameters used in the design of the PV panels.
2. Various cases and scenarios have been examined in this work in order to determine the best optimal configuration that will meet the load demand.
3. The creation of a hybrid PV-wind energy system with the best possible design is the aim of this research. According to this work, the hybrid system, which consists of PV panels, wind system and a micro turbine as a backup source, is the most economical choice.
4. The most economical scenario is found to be one in which the micro turbine directly supplies the heat load while operating at its graded power (rather than in track load mode) to supply the electrical portion of the load.
5. This research will provide in-depth analyses of the most appropriate design parameters for the RER that will be installed in the system to fulfil a portion of the grid load.
6. It will incorporate a parameter analysis to verify the suggested approach and make it appropriate for assessing workable solutions.
7. A hybrid PV-wind energy system's best design will also be researched in order to provide power to isolated areas.
8. This will be done by utilising an algorithm for designing the hybrid system in GA, which will lessen the effort required of researchers in the field to find the optimal solution and which will be found to be a useful tool for designing more of these types of hybrid combinations of RER systems based on state and space requirements.
9. The optimisation analysis also takes into account the cost of greenhouse gas emissions, which will make the strategy more economically advantageous.
10. The simulation results show that the proposed hybrid system is more effective at producing the maximum amount of power for a warm spring weather than using merely a single renewable energy source. Additionally, it is efficient to generate power when there is wind or lightness present.
11. The current hybrid system can be upgraded to include a battery in the future to store extra energy and This optimisation analysis can take the costs of global warming emissions into account.

Conflict of Interest

Authors declare no conflict of interest is there for publication of this article

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