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A BRIEF REVIEW ON OPTIMUM POWER GENERATION FOR STANDALONE HYBRID RENEWABLE SYSTEMS

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Abstract—With the rapid change in market of non-conventional sources, the importance of integrating one or many various combinations of renewable sources into a hybrid system has gained immense attraction. This combination of hybrid energy systems can get over from the various limitation like system reliability, source flexibility, fuel efficiency and cost effective. Over the decade, the primary concern is the arbitrary performance of solar cell and availability of source of wind. Sometimes wind can't be correlated with the dynamic load and unwanted due to its heavy flow. Solar source is not available during night time. A hybrid renewable energy system is often faced issues related to fluctuations and source availability. The parameters and random variables in a hybrid energy system needs an optimization to get optimum and economical power generation from the system. The study presents a review of optimization algorithms used for battery management system as well as optimum power generation from a suitable hybrid system.
Keywords: optimization algorithms, hybrid system, solar system, wind system, battery charging control.

1. INTRODUCTION

Day by day power consumption is increasing rapidly. This is the main purpose for which we need to use fossil fuel to get optimum power generation. Unfortunately, this is a very known fact that the fossil fuel will run out one day and carbon emissions from this fossil fuel makes the environment polluted. For overcoming this situation in future to generate power as per demand, we need to use renewable energy. But according to many researchers if we use renewable energy in integrated form then only it will be beneficial for us [1][2]. Since RESs are available in abundance without imposing any significant capital cost, its efficacy can be exploited to fulfill energy demands [3]. Surveys [36] reveal that till 2050 RESs would be capable of delivering almost 80% of the residential, commercial and industrial power demands. Being sporadic in nature RESs undergoes exceedingly high dynamism as per regional environmental conditions makes its implementation with micro-grid complicate [37]. Typically, the availability and feasibility of RESs differ as per geographical conditions. For instance, a geographical location with sufficient sun-light presence can be ideal for solar power, while oceanic coastal regions, mountains etc. can be suitable for wind-turbine based power generation [4]. Though, these RESs can be vital to serve energy demands, it may undergo significantly high dynamism due to exceedingly high geographical and weather conditions.

Due to the nonlinear characteristics of load side, the overall energy management system will be hampered in Hybrid Renewable energy systems. As a result, optimum power generation cannot be achieved and overall infrastructure has sunk to ground level. Under these circumstances, we need to incorporate a great controlled system to manage the overall performance of the system.

This paper presents a short review on the metaheuristics optimization techniques used in hybrid non-conventional systems and an overview of commonly used algorithms for getting optimize power generation of hybrid energy systems. This review paper will be organized by Section 2 will discuss on strategies of metaheuristics algorithm. In section 3, hybrid renewable energy systems performing with metaheuristics algorithm will be discussed. In section 4, design model of hybrid renewable systems. In section 5, the merits and demerits of hybrid systems with different metaheuristics algorithm will be discussed.

2. **METAHEURISTIC OPTIMIZATION STRATEGIES**

Undoubtedly, “Meta” use to specify that it higher level algorithm. Metaheuristic methods are using for solving different complex optimization problems. In all metaheuristic algorithms require initial solutions from which candidate solutions are formed. Then each solution is estimated and the algorithm find it’s the best solution. When the algorithm reached to its meeting criterion then only get final result otherwise it will start again to find its best result from beginning. Here between exploration and the exploitation need proper balancing which the basic criteria to investigate the performance of metaheuristic. Researchers are trying to make appropriate balance between these two criteria of any optimization problem. Accurate balancing is required for getting desired value for the fitness function. [7]. Without proper balance any particular Method cannot achieve their goal to optimize any fitness function.

3**. RES SYSTEMS: WITH METAHEURISTICS ALGORITHM**

In [8] authors developed PV/WT based HRES model where Adaptive Neuro Fuzzy inference scheme (ANFIS) was used to perform EMS control and panel voltage estimation. Different micro grid parameters were used in [28] to design EMS control model for HRES power system. Authors focused on addressing non-linearity in power generation. A similar micro-grid parameters-based EMS control model was developed in [29] [30]. In [31] a meta-model architecture was developed for HRES EMS function. To perform cost-optimization, authors applied time-varying quadratic pricing of the energy (per equipment). Their model was primarily depending on a dispersed optimization scheme which was primarily developed by means of a two-level iterative mechanism, Gauss-Seidel decomposition with competitive game-theoretic mechanism. Authors in [32] developed a novel multi-objective EMS control model for grid-connected HRES. They derived a Time-of-use Demand Side Management program that eventually assisted EMS control by considering industrial load demand as decision variable. Authors in [33] focused on developing an electrical Energy Storage System (ESS) for hybrid energy battery-super capacitor storage system (HESS). Authors [7] developed an EMS control design using Model Predictive Controller (MPC) to be used for PV/WT RES system. To augment performance, authors applied two-phased optimization scheme; rolling optimization; and feedback intra-sample correction, where the first phase functions for scheduling power transmission based on forecasted pattern. It is then followed by rolling dispatch scheduling adjustment on the basis of an intra-sample feedback correction scheme that compensates the prediction error in the forecasted data. In [8] authors developed a dynamic power management scheme (PMS) for PV RES system with a proton exchange membrane fuel cell (FC) as the secondary power source. As battery they applied super-capacitor HESS. In their model, the proposed PMS unit generates current references for dc converter current controllers of the FC, the battery, and the super-capacitor. In their model, the mean and fluctuating power components were distinguished by means of a moving average filter and thus the dc-link voltage regulation was done under dynamic load and generation changes. In [9] authors developed a joint control scheme for photovoltaic-based dc grid system where SC was used as energy storage. Tahani et al. describe about the PV/wind/battery system optimization by using Flower Pollination Algorithm (FPA) and Simulated Annealing (SA) algorithm. this works is done on Effect of PV panel tilt angle. [38] Authors in this paper introduced Genetic algorithm for getting an optimum hybrid solar–wind system with battery banks. Here optimum sizing methods was developed for calculating system configuration with minimum cost. [10]. The authors have experimentally proven about the charging stability of batteries by applying a new hybrid algorithm genetic algorithm (GA)-based proportional integral (PI) controller with adaptive neuro-fuzzy inference system (ANFIS) on PV/Wind/Battery system. Here SOC is maintained satisfactorily [11]. The authors establish the truth that using PSO algorithm battery can give better dynamic performance. It's possible only for the faster convergence speed and accuracy of the optimization process [12].

4. DESIGN MODEL OF HYBRID RENEWABLE SYSTEMS:

Here, a block diagram of the hybrid system is shown in fig 1 on which all the optimization techniques applied. In fig 1 components of hybrid systems are solar cell, wind generator, battery, dc -dc converter and dc bus.

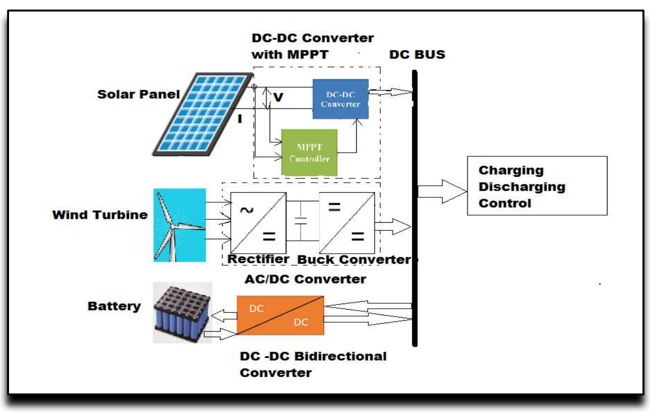
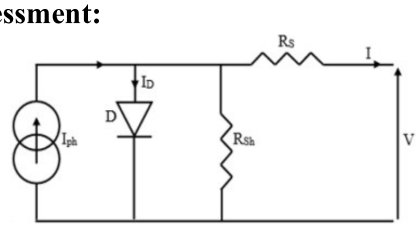


Fig.1 Block representation of hybrid systems

4.1. Solar Panel Power Assessment:



$$I=N_P[\, I_{ph} - I_{rs}[\exp\left(\frac{q(V+IR_S)}{AKTN_S}\right)-1] \quad \ldots\ldots\ldots\ldots\ldots(1)$$

Where,

I_{rs}=$I_{rr}\left(\frac{T}{T_r}\right)^3 \exp\left[\frac{E_G}{AK}\left(\frac{1}{T_R}-\frac{1}{T}\right)\right]$ …………..(2)

In equation 1, q is the electron charge (1.6×10^{-9} C), K is Boltzmann's constant, A is the diode ideality factor, T is the cell temperature (K). I_{rs} is the cell reverse saturation current at T, T_r is the cell referred temperature, I_{rr} is the reverse saturation current at T_r, E_G is the band gap energy of the semiconductor used in the cell.

Objective function:

$$F(V,I) = I - I_{ph} - I_0\, exp\left(\frac{q(V+IR_S)}{AKTN_S}\right) - 1 + \frac{(V+IR_S)}{R_{sh}}$$

……………….(3)

4.2. Wind Potential Assessment:

The fundamental equation governing the mechanical power of the wind turbine is given by

$P_{wind} = \frac{1}{2} KC_p \rho As^3$ ………………………..(4)

where ρ is air density (kg/m^3), Cp is power coefficient, A is intercepting area of the rotor blades (m^2), s is average wind speed (m/s). The theoretical maximum value of the power coefficient Cp is 0.593, also known as Betz's coefficient.

The Tip Speed Ratio (TSR) for wind turbine is defined as the ratio of rotational speed of the tip of a blade to the wind velocity. Mathematically,

$\lambda = \frac{rw_{tw}}{s}$ ………………………… (5)

where r is radius of turbine (m), w_{tw} is angular speed (rad/s), s is average wind speed (m/s).

The energy generated by wind can be obtained by

E_{wind}=P_{wind}* time in kWh……….(6)

The objective of the optimization need to be defined for an optimization problem. Main key factors for finding the optimum size of components of hybrid systems are reducing cost with dependable and eco-friendly power supply. Mainly focused point for designing optimal systems are based on dependability, cost-effective, and eco-friendly [36].

5. MERITS AND DEMERITS OF USING DIFFERENT OPTIMIZATION ALGORITHMS IN HYBRID

OPTIMISATION TECHNIQUE	MERIT	DEMERITS	REFERENCE
PSO	Objective function is less dependent of the set of initial points. Convergence speed is fast	Requires large computational time	[22]
SA	Can use for non-linear models of finding an optimal solution easily	Initial assumption affects the final solution and also a no of constraints are needed.	[24]

GA	Can resolves problems with numerous solutions	Need sufficient initial population otherwise face difficulty to locate local minima	[14]
BPSO	Efficiently reduced the objective function iteratively to get optimum solution easily and it can be used in discrete domain	No of generation applied was fixed	[15]
FPA	Overall system outcome is that the order fulfillment cycle time is less	Choose proper parameters otherwise make problem to system sustainability	[17]
PSO-BPSO	Get best option for sizing of system	Components of the model selected directly from the manufacturer and pre sizing algorithm is required .	[18]
FPA-SA	increase the global search and check the algorithm to be confined in local optimum solutions.	a no of objective functions needed	[38]

Table:1

By using any above optimization techniques, it is possible to get maximize output power from the given hybrid systems. But for getting best result we have to consider proper algorithm and comparative study is also needed.

6. CONCLUSION

HRESs have been acknowledged as the greatest reasonable solution for the upcoming energy scenario. In this current scenario main aim of us to get maximum energy from these hybrid sources. This paper has reviewed various algorithms which are used for optimum output of the system. The literature review shows the different aspects of hybrid system under battery management system or sizing optimization. Here also showing the comparison between the different algorithms used for optimization process with their merits and demerits. In future, there is a lot of scope to work on the hybrid systems for further improvement in efficiency to assists reliable and quality power supply.

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CONFLICTS OF INTEREST:

The authors declare no conflict of interest.

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