Performance Evaluation of Solar Renewable Energy System by Genetic Algorithm

Mr. Jitendra Kumar Sharma, Mr. Vikas Khare

A*bstract* — **In a hybrid renewable energy power generation system, optimization and control is a challenging task because the behaviors of the system are becoming unpredictable and more complex. After the system is built, optimization and control of its operation is important for utilizing the renewable energy efficiently and economically. The objective of this paper is twofold: first we analyze performance parameter of SOLAR renewable energy system such as temperature and solar radiation of solar system, by process of regression analysis. second genetic algorithm is applied on final equation of regression analysis and solar system performance represented by graph individually.**

Index terms: Solar energy, Genetic algorithm

I.INTRODUCTION

Providing reliable, environmentally friendly, and affordable energy has been a goal for many countries throughout the world. The rising consumption of energy and falling accessibility of natural resources are increasing the cost of electricity. In addition, as the industry develops, greenhouse gases are becoming a threat to the natural ecosystem. Therefore, renewable energy has received more attention recently **[1]**. Hybrid Renewable Energy Sources (HRESs) is defined as a combination of one or more resources of renewable energy. It represents one of the promising options for the considerable energy needs of desalination processes especially in remote and arid regions, where the use of conventional energy (fossil fuels, electricity) is costly or not available. Solar radiation and wind are considered the most preferred renewable energy sources for their availability and inexhaustibility. However, due to the sporadic characteristics of natural resources, it has been a challenge to generate a highly reliable power with photovoltaic (PV) modules and/ or wind turbines. To overcome this limitation, previous studies were conducted using a hydro energy system as another energy source and simulated results showed that a PV/wind/hydro hybrid power system may be a feasible solution for different applications. Since a multi-source hybrid power system increases energy availability significantly, it becomes advantageous for practical applications that need highly reliable power regardless of location. The mathematical design problem (sizing and control of the hybrid system) involves a significant number of variables. That is why classic optimization techniques are not able to obtain good results, and necessitate the application of other techniques that allow for obtaining satisfactory results. Evolutionary algorithms present the advantage of having low computational requirements **[2, 3]**.

Regarding the energy management of the hybrid renewable energy generation system, Distributed Artificial Intelligence (DAI) is envisaged in the paper for managing and optimizing the system performance by making use of its basic properties, such as heterogeneity, self-adaptive, distribution, autonomous, openness and dynamism[4,5]. There are different types of problems to be resolved, including communication among devices, distributed control algorithms, and multi-objectives on the optimization process, and in this paper the focus is on the optimization process of

the system. Since John Holland introduced the use of the Genetic Algorithm in 1975 as functional optimizers, it has been widely researched and applied in different fields **[6]**. Being regarded as a family of computational tools, an improved genetic algorithm is developed for optimizing the hybrid RE system as a global system process. It requires optimization of the stand-alone hybrid renewable energy power generation system. The rest of the paper is organized as: in section II we represent formulation of independent energy system by regression analysis. Genetic algorithm discuss in section III. Section IV represents simulated result by genetic algorithm. Paper is summarized in section V and last section represents references which is helpful in this paper.

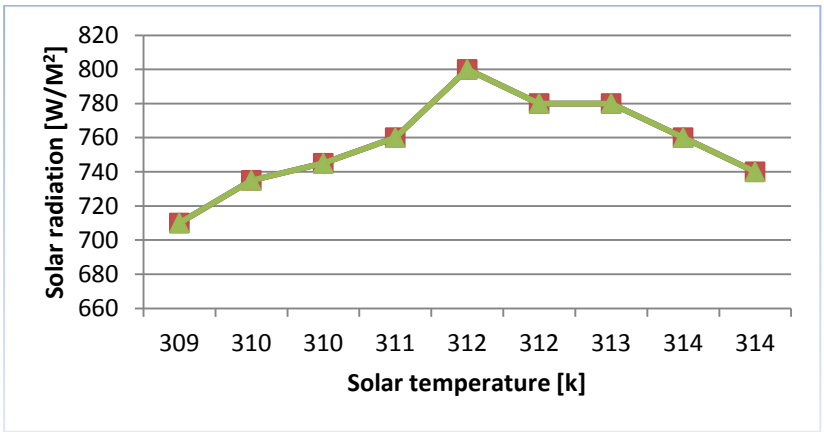
II.FORMULATION

(1) Development of correlation between instant solar radiation and instant temperatures

The radiation of the sun reaching the earth surface has different values during the day. This fluctuation results from the earth's spin about its axis. There are a number of factors affecting the total solar radiation. For example these factors may be – wind velocity, cloud-cover, humidity, etc. Aim of the studies made here is to find out variation of instant solar radiation with temperature only. So, the dependence of instant solar radiation on different factors except instant temperature is neglected. To develop relation of instant solar radiation with instant temperature, data for instant solar radiation and instant temperature are needed **[8]**.

Table 1: instant solar radiation and solar temperature

TIME	Temperature(T=x) [K]	Solar radiation(R=y) $[W/M^2]$	Y = $log10y$	x^2	Yx
10 A.M	309	710	2.851258	95481	881.03877
10:30 A.M.	310	735	2.866287	96100	888.549
11 A.M.	310	745	2.872156	96100	890.3683
11:30 A.M.	311	760	2.880813	96721	895.9328
12 Noon	312	800	2.903089	97344	905.763
12:30 P.M.	312	780	2.892094	97344	902.3333
1 P.M.	313	780	2.892094	97969	905.2254
1:30 P.M.	314	760	2.880813	98596	904.5752
2 P.M.	314	740	2.869231	98596	900.9385
	$\sum x = 2805$	$\sum y = 6810$	$\sum Y =$ 25.907835	$\sum x^2$ $= 874251$	$\sum Yx$ $= 8074.7249$



Graph 1, instant solar radiation and solar temperature data

For manual calculation of the relation, we have used the process of regression analysis as it is given by the exponential relation of the type.

$$\boldsymbol{y = AB^x} \quad (1)$$

Where A and B are the constant.
Taking log on both sides of equation (1), we get

$$logy = logA + xlogB \quad (2)$$

Putting $logy = Y$, $logA = a$, $logB = b$ in equation (2), we get

$$Y = a + xb \quad (3)$$

From equation (3) we get

$$\sum Y = \sum a + \sum bx \quad (4)$$

$$\sum xY = \sum ax + \sum bx^2 \quad (5)$$

From the table we put the value in equation (4) and (5)

$$25.907835 = 9a + 2805b \quad (6)$$
$$8074.7249 = 2805a + 874251b \quad (7)$$

From equation (6) and (7) we get

a = 1.4842
b = .004474

$$Y = 1.4842 + .004474x \quad (8)$$

We know that logA= a and logB = b so that

A = 30.49
B= 1.010355

Put the value of A and B in equation (1)

$$\mathbf{y = 30.49*(1.010355)^x} \quad (9)$$
$$\mathbf{y = 30.49*e^{0.010301754x}} \quad (10)$$

$$\mathbf{R = 30.49*e^{.010301754T}} \quad (11)$$

III.OPTIMIZATION WITH GENETIC ALGORITHM

Genetic algorithm is an optimization method inspired by Darwin's reproduction and survival of the fittest individual .This algorithm looks for the fittest individual from a set of candidate solutions called population. The population is exposed to crossover, mutation and selection operators to find the fittest individual. The fitness function assesses the quality of each individual in evaluation process. The selection operator ensures the fittest individuals for the next generation. The crossover and mutation operators are used for variety of populations **[6, 7]**. The steps of genetic algorithm are depicted as follows:

1. **[Start]** Generate random population of *n* chromosomes (suitable solutions for the problem)
2. **[Fitness]** Evaluate the fitness *f(x)* of each chromosome *x* in the population
3. **[New population]** Create a new population by repeating following steps until the new population is complete

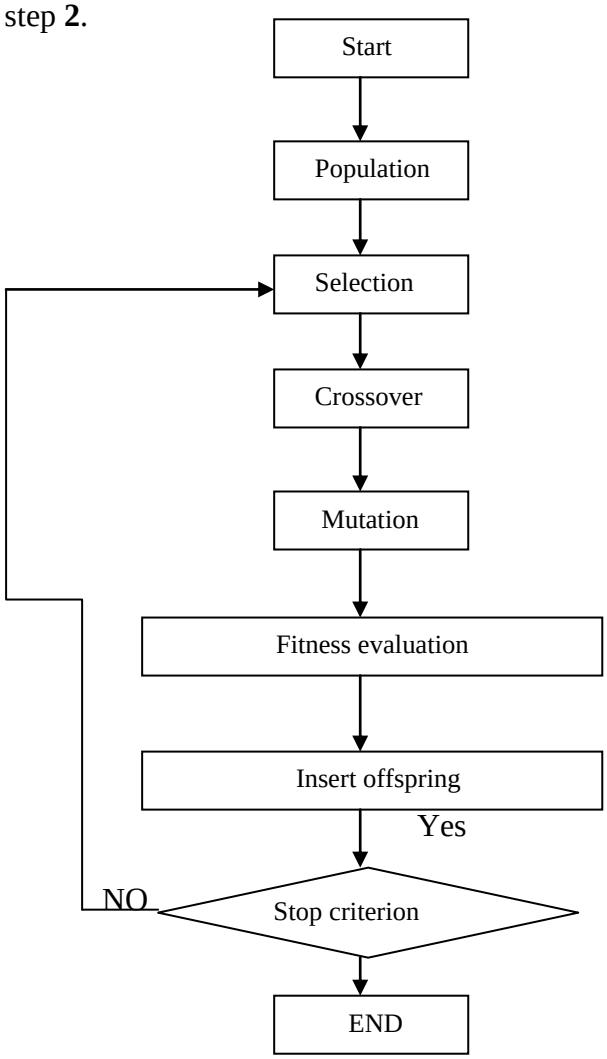
a. **[Selection]** Select two parent chromosomes from a population according to their fitness (the better fitness, the bigger chance to be selected)

b. **[Crossover]** with a crossover probability crossover the parents to form a new offspring (children). If no crossover was performed, offspring is an exact copy of parents.

c. **[Mutation]** with a mutation probability mutates new offspring at each locus (position in chromosome).

d. **[Accepting]** Place new offspring in a new population

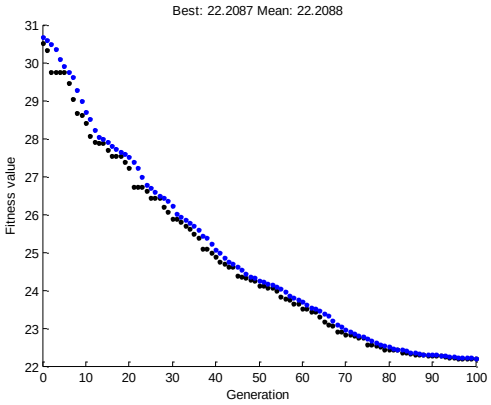
4. **[Replace]** Use new generated population for a further run of Algorithm
5. **[Test]** If the end condition is satisfied, **stop**, and return the Best solution in current population
6. **[Loop]** Go to step **2**.



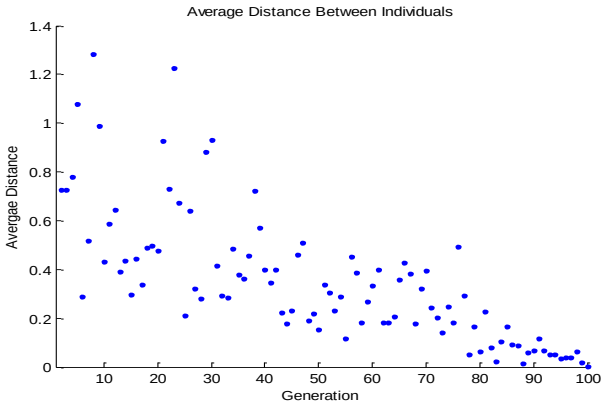
We minimize the function separately which is correlation between solar radiation and temperature, wind velocity and measured height, and flow rate and size of head in the case of solar, wind and hydro energy system respectively with the help of genetic algorithm. All these parameter which are described by equation **(11), (18),(24),** important aspect of any hybrid energy system. We manage the result by genetic algorithm.

IV.SIMULATED RESULT BY GENETIC ALGORITHM IN MATLAB

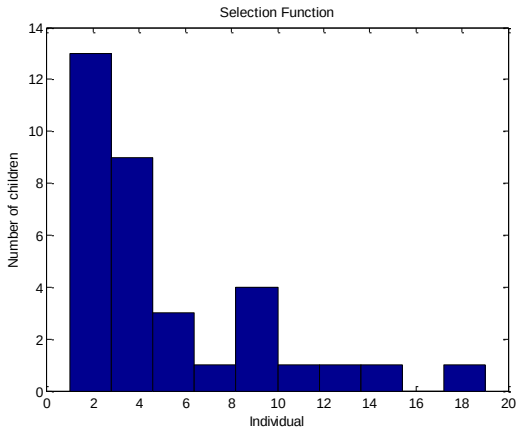
In this paper the calculation was done based on a regression analysis and find the resultant equation [**R = 30.49*$e^{.010301754T}$],** [**V = 5.164*$e^{.011720149H}$**], [H = **37.93*$e^{0.1432012F}$**] for solar system, wind system and hydro system respectively. Results are simulated in genetic algorithm in Mat lab workspace, here we consider population type double vector, selection function stochastic uniform and crossover is 0.8. first we represent simulated result between solar temperature and solar radiation in **Graph [4]** we represent fitness value with respect to 100 number of generation and find best fitness value 20.2087 and mean fitness value is 22.2088.



Graph 2, Fitness value of solar system



Graph 3, Average distance representation of solar system



Graph 4, selection function of solar system

V. CONCLUSION

The usage of solar renewable energy has been increasing over the past of few years to help solve acute problems of energy and environment concern. By the help of above discussion it is concluded performance of any hybrid energy system is largely depend on the own independent system parameter. In above article we used genetic algorithm optimization technique to find performance of different parameter and find best fitness value which is utilized to increase system efficiency and also used for reduced the overall hybrid system cost.

VI. REFERENCES

[1] Deshmukh MK, Deshmukh SS. Modeling of hybrid renewable energy systems. Renewable and Sustainable Energy Reviews 2008;12:235e49.

[2] Hossam-Eldin A, Ismaiel A. An investigation into economic desalination using solar/wind energy system. In: Tenth international water technology conference, IWTC10 2006, Alexandria, Egypt; 2006. p. 733–43.

[3] Voivontas D, Misirlis K, Manoli E, Arampatzis G, Assimacopoulos D. A tool for the design of desalination plants powered by renewable energies. Desalination 2001;133:175–98.

[4] J. Zeng, J. F. Liu, H.W. Ngan, J. Wu, "A multi-agent solution to energymanagement of distributed hybrid renewable energy generated system,"*8th International Conference on Advances in Power System Control, Operation and Management*, 2009

[5] J. Zeng, J. Wu, J. F. Liu and L. M. Gao, An Agent-based Approach to Renewable Energy Management in Eco-building[C] ， *IEEEInternational Conference on Sustainable Energy Technologies*，pp.46-50, 2008

[6] D. Whitlry, "A genetic algorithm tutorial," Statistics and Computing, vol. 4, No. 2, pp.65-85, 1994

[7] L. Davis, "Handbooks of genetic algorithm", New York: Van Nostrand, Reinhold, 1991

[8] G.D. Rai , Non-conventional energy sources "pp 50-51.

[9] G.D. Rai , Non conventional energy sources "pp 245-250.

[10] B.R.Gupta , Generation of electrical engineering pp 132-135.