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A Novel Method for Solar Energy Harvesting Based On Optimization with Fuzzy Logic

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Abstract: *In the recent years, an impressive reduction is being seen in renewable energy a technology that costs as a result of R&D and accelerated deployment. Yet policy-makers are often not aware of the latest cost data. Portability improvement of technological devices has not been followed by energy accessibility of its batteries. Taking into account the low power consumption parameter of a variety of portable devices, the concept of energy harvesting from environmental sources and the human body has gained a new significance. In the search of methods and materials that go with this need, are the energy generated from the piezoelectricity, thermoelectricity, and electromagnetism, among others. This research gives the ways and future trend of energy harvesting methods, as well as its mechanisms in portable medical devices with low power consumption. In this research, we will focus on energy harvesting. Total illumination is calculated against the total time of harvesting. The experiment has been carried out in an environment which contains some consuming units with a total number of rooms. The width and height of the room are considered to be identical i.e. 100×100 having harvesting time of 10 hr. There are three environments in which experiment has been done such as sunny, cloudy and dark. Total illumination is calculated with and without optimization. ABC (Artificial Bee colony) algorithm is used for the optimization and the results obtained are compared with the without optimization results. Fuzzy logic is applied to calculate irradiation.*

Keywords*- ABC (Artificial bee colony) Energy harvesting, Illumination,Irradiance, Solar energy.*

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I. INTRODUCTION

Energy harvesting captures and converts a small amount of readily available energy in the environment into usable electrical energy [1]. Electrical energy is conditioned for direct use or accumulation and storage for later use. This provides an alternative power source for applications without grid power, and inefficient installation of wind turbines or solar panels. In addition to outdoor solar energy, there is no small energy source that provides a lot of energy [2]. However, the captured energy is sufficient for most wireless applications, remote sensing, body implants, RFID, and other applications in the lower portion of the power spectrum. Even if the collected energy is low and the device cannot be powered, it can still be used to extend the life of the battery. Energy harvesting is also termed as energy Scavenging or micro-energy harvesting [3].

1.1 Energy Harvesting System Building Blocks

The process of energy harvesting takes varied forms depending on the source, amount and type of energy source converted into electricity [4]. The simplest form is that the energy harvesting system needs energy such as heat, light or vibration, and the following three key components [5].

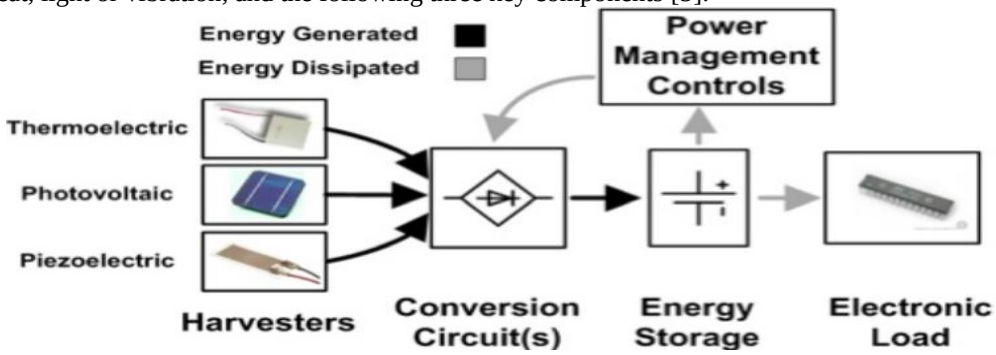

Fig. 1. Energy harvesting basic components

- Transducer/harvester: It collects the energy and transforms it from source to electricity. General transducers have photo-electricity for light, magnetic inductance, thermo-electricity for heat RF for radio frequency, and piezoelectricity for vibration/kinetic energy.
- Energy storage: Like battery or super capacitor.
- Power management: This regulates the electrical energy in an appropriate form for the application. Distinctive regulators such as regulators and complex control circuits that control the power supply based on power requirements and available power.

In these days the biomass energy is in the news - but what are the most common problems associated with this type of energy? Potentially, this is a great source of renewable energy that is as close to a zero carbon footprint as possible. Biomass encompasses many different types of fuel [6]. It can be a plant such as corn or switch grass, the methane produced in a landfill or the garbage discarded by households every day. The potential for use of biomass energy is tremendous but the reality is our technology has not caught up to the potential. Some of the common ways biomass energy is used and has been used for generations produce a high level of carbon dioxide. This occurs when wood is burned [7]. It becomes more of the a problem when the wood is cut for the purpose of burning as we create more carbon dioxide while removing a living plant that helps control carbon by its very existence. Biomass energy is a subject of hot debate in industrial and scientific communities. Common problems of energy harvesting are cost, transportation, seasonal restrictions and the efficiency (or lack of efficiency) of the fuels produced. Biomass is considered as a useful resource of energy. Energy wastage is one of the very serious issues in the modern world. In day to day life, people often forget to switch off lights and fans even air conditioners. Few steps have been taken in this direction like automated refrigerators which can adjust the temperature of the appliances as per the content kept [8].

This leads to huge amount of energy wastage. In the existing work, storage of energy, time to maintenance of time is considered as a major issue in energy harvesting techniques. Therefore, a system is required that can maintain the harvesting technique itself using optimization. Previously, the small amount of energy was not stored; therefore, by using the optimization technique, the energy can be the store [9]. There is several ways for the generation of automated system for energy harvesting, but the selection of the optimization techniques is a major task in the automated system for energy harvesting system. ABC (Artificial Bee Colony) Algorithm is one of the popular algorithms of using the intelligence of swarm bees. The ABC algorithm mimics foraging and dance behaviours of real bee colonies. It has high performance and success for numerical optimization problems [10]. Although, the exploration of solution of ABC algorithm is good, exploitation to found food sources is very bad. In ABC algorithm, the colony of artificial bees mainly contains three groups of bees like: employed bees, onlooker bees, and scout bees searching for optimal solution in the energy harvesting system. Both onlookers and scouts are also called unemployed bees and are used for searching of best data. The nature of ABC algorithm in energy harvesting system is ABC algorithm which is inspired by the foraging behaviour of honeybees and is used in the energy harvesting system and ABC algorithm is a global optimization algorithm for energy harvesting purpose [11]

In this work, the analysis of the ABC algorithm is described for the energy harvesting system with fuzzy logic concept has been proposed. In the proposed work, ABC algorithm is applied on the basis of fuzzy logic rule sets and the fuzzy logic has worked as a controller in energy harvesting system [12]. Fuzzy logic starts with and builds on a set of user-supplied human language rules in the energy harvesting system. The fuzzy systems convert these rules to their mathematical equivalents. This simplifies the objective function of the system and results in much more accurate representations of the way systems behave in the real world. The additional benefits of fuzzy logic include its simplicity and its flexibility. Fuzzy logic can handle problems with imprecise and incomplete data, and it can model nonlinear functions of arbitrary complexity. A Fuzzy Rule Set is any set that allows its members to have different grades of membership function in the interval [0, 1]. Control of the energy harvesting system for large computing systems is often a great challenge.

II. RELATED WORK

J. M. Belman-Flores et al has proposed a hybrid system for the present and growing global interest in energy resources search for energy resources for decreasing fossil fuels usage for generation of power. The systems are coupled to conventional as well as non-conventional sources. A survey of hybridization of energy systems for photovoltaic solar energy is presented. It has been observed that the varied incentives, policies, and conditions are established by the Mexican government for the energy sector and renewable sources are projected for the constructive outlook for hybrid system implementation. Peter D. Lund et al has reviewed varied approaches, strategies, and technologies for managing the large-scale schemes of different renewable electricity like wind and solar power. Demand and supply sides are considered as the measures. The importance of renewable electricity is discussed with the addition of presenting the energy system flexibility measure that ranges from traditional ones like grid extension and pumped hydro storage for more advanced strategies like demand side linked and management approaches. More of the energy system flexibility could be handled by

power system and energy system. Wai Shin Ho et al has focused on the technique for efficient electricity usage for determining the most favorable power generation capacity, energy storage power with capacity, load profiles and discharging/charging of ES. The proposed technique is an extension of ESCA (Electric system cascade analysis). A heuristic approach for performing LS analysis on a renewable stand alone system of DEG is proposed. The research has concluded that direct LS incorporation with ES, the ES capacity, and power generators can be reduced. Reduction of 3.1% for solar PC installation areas with 3.9 % of biomass power generator is recorded. J.server,provides an introduction to the production of electricity from conventional concentrating solar power (CSP) and biomass power plants that help in evaluating the technical and economic benefits related to hybrid CSP-biomass energy system. A different configuration of 10 MWe hybrids CSP – biomass combustion power plant is analyzed. Solar Advisor model is used to govern the rate of the influence of solar field using quasi-steady generation conditions. Biomass and gas boiler contribution are also estimated. Economic assessment of the power plant is calculated through hybrid technology, biomass combustion etc. This paper gives an initial technical and economic analysis of hybrid CSP-biomass combustion plants which are a substitute to conventional CSP and biomass technology. The results have shown the investment cost of hybrid CSP as higher than conventional CSP.Haslenda Hashim et al has discussed an IBS model and explanation for self-sufficienteco-village electricity with plus without load shifting (LS). Energy storage (ES) is included for reducing the demand for electricity during exact periods and smooth variations into a generation of power by solar power variable generation. LS is utilized for increasing the demand when the high supply period and load intervals shifting for low demands takes place. Reduction of ES size is recorded with high competitive electricity prices. The work has also shown the competitive high prices of electricity with the economic growth and environmental protection by improvement of energy efficiency and low-carbon technologies deployment.

III. PROPOSED ARCHITECTURE

This research has proposed an automated harvesting system for the solar/biomass energy using fuzzy set. For the optimization of the proposed energy harvesting system, ABC (Artificial Bee Colony) algorithm has been executed. For the evaluation of the performance, parameters, namely, Illumination and irradiance are considered.

Following are the steps that have been carried out for the proposed work:

Design the proposed work in the Matlab using the following process:

Display the message “WELCOME TO ENERGY HARVESTING SYSTEM”

Display the message “SELECT THE TYPE OF WEATHER YOU WANT TO KEEP”

Select the weather using:

wt=input('PRESS 1 FOR SUNNY WEATHER \nPRESS 2 FOR CLOUD WEATHER \nPRESS 3 FOR DARK OR OTHER TYPE OF WEATHER')

Where wt is the selected choice

Display the message “FLUX IS BY DEFAULT 130000 FOR SUNNY WEATHER”

Create the rm as a global variable

Define the number of room

Set the range of flux as fs=13000 to 130000

Start idol time record

The flux for sunny weather and it has been set for 30 % of the original flux

$$fc = (fs * 30)/100 \quad (1)$$

$$fo = (fs * 10)/100 \quad (2)$$

Equation 2 is for other type of weather

Enter time of harvesting in hours for the simulation

Enter total number of energy consuming elements in one room

Enter total number of rooms getting used at the current time

Enter the length of room

Length would be identical for each and every room

Enter the width of room

Width would be identical for each and every room

Press 1 for selecting total number of on consuming elements per room

Creation of an environment which contains some consuming units with a total number of rooms.

$$\text{Area of room} = \text{length} * \text{width}$$

$$\text{Total area} = \text{area of room} * \text{no of room}$$

The width and height of the room have been assumed to be identical.

There are three types of the environment which have been assumed to be present.

i) Sunny

ii) Cloudy

iii) Other types
Initial flux being generated and is taken to be 13000.
Flux distribution is completed on the type of whether being chosen

Select the status of the elements using the Fuzzy Rule Sets, so that we can develop a rule set.Fuzzy logic is a method used to compute degree of truth rather than true or false. It uses Boolean logic like 0 or 1 on which all modern computers are based. Fuzzy logic is a complex mathematical toolthat allows solving difficult simulated problems with many inputs and output variables. Fuzzy logic is able to give results in the form of recommendation for a specific interval of output state, so it is essential that this mathematical method is strictly distinguished from the more familiar logics, such as Boolean algebra. This paper contains a basic overview of the principles of fuzzy logic.

To optimize the energy, ABC (Artificial Bee Colony) algorithm is used and the fitness function of the optimization algorithm is being set. The artificial bee colony algorithm is a recent swarm metaheuristic technique based on the intelligent foraging behaviour of honey bees. It is used to solve the nonunicost set covering problem.

The procedure of ABC algorithm is given below:

```
For all data
    totalbee = number of irrediances
    employedbee = totalbee
    onlookerbee = mean(totalbee);
    fitestbee = fitestbee(employedbee, onlookerbee)
    inputmethod = readfis('sunitafis.fis')
    inputmethod.input(1,1).range = [min(employedbee), max(employedbee)]
    writefis(inputmethod, 'sunitaupdated.fis')
    kfs = readfis('sunitaupdated.fis')
   optimizedoutput = kfs.output.mf(1,1).params
   optimizedoutput = abs(optimizedoutput)
  opt = sum(optimizedoutput)
  irrenabc = irren + abs(opt)
  powerabc = power + abs(opt)
end
```

Where the fitesbee is the objective function of the proposed work

```
fitestbee is the function of (empbee, onlookerbee)
f = zeros(1, numel(empbee))
for i = 1: numel(empbee)
  currentbee = empbee(i)
  if currentbee < onlookerbee
     f(i) = True
   end
end
```

To check the performance of the proposed work, the parameters of energy harvesting model are calculated.

II. RESULT AND ANALYSIS

The results obtained after the simulation of the proposed work are defined below:

Table 1. Result Simulations

Time of harvesting	10 Hr
Area of room	100×100
Simulation Tool	MATLAB
Authentication Parameter	Energy Consumption
Evaluation Parameter	Illumination in flux and Irradiant

Above table is showing the time for harvesting as 10 hours, the area of the room is 100*100, the authentication parameter is energy consumption. Illumination flux and Irradiant are taken as the parameters for evaluating the simulation work.

3.1 Results of Sunny Weather

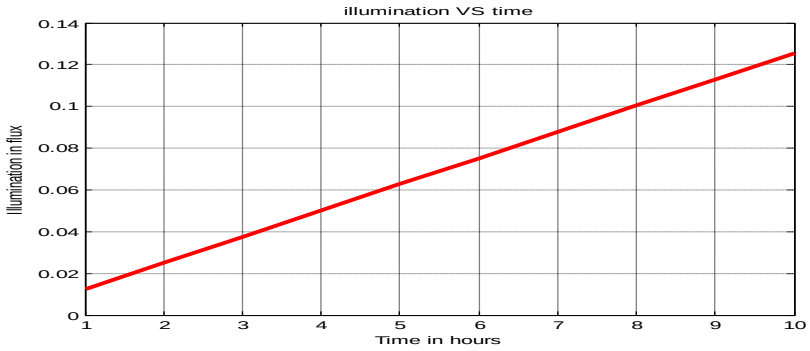

Fig.2. Illumination vs time graph for sunny weather

The above figure depicts that with the increase of time, illumination is also increasing for sunny weather. The graph obtained for the same is linear. The average value obtained for illumination is .07 flux.

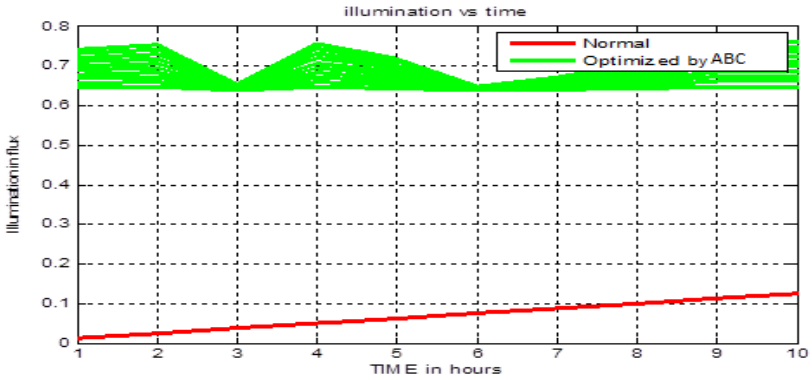

Fig.3. Comparison graph for sunny weather

The above graph represents the comparison between illumination in flux and time in hours. In the above Fig., the red line indicates the illumination obtained without optimization whereas, the green part of the graph is obtained when optimization of the proposed work is executed by using ABC algorithm. It is clear from the graph that for sunny weather value of illumination is more than without optimization.

3.2 Results for Cloudy Weather

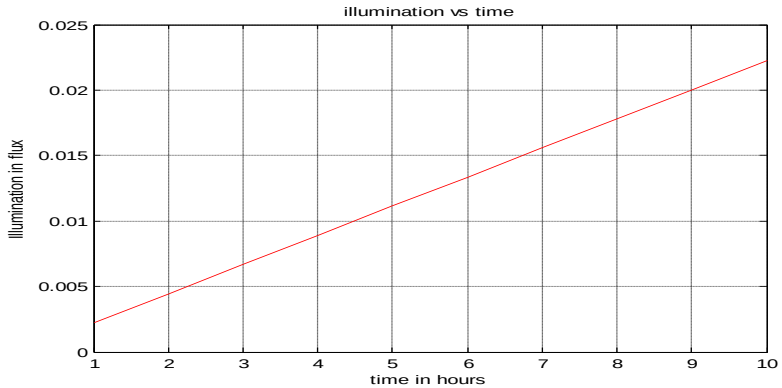

Fig. 4: Illumination vs time graph for cloudy weather

The above graph represents that with the increase of time, the illumination flux is also increasing and the graph obtained for the cloudy day is linear. The average value obtained for illumination is .012 which is less than the value obtained for sunny weather. This is becauseon a sunny day the intensity of light is more than the cloudy days.

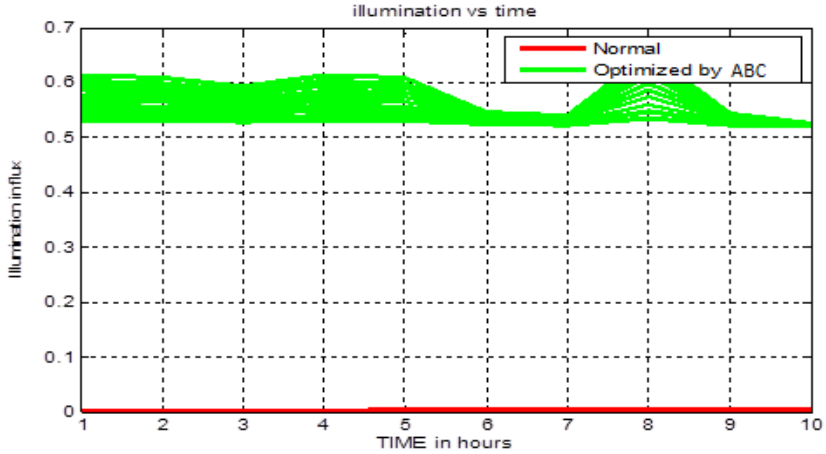

Fig. 5. Comparison graph for cloudy weather

Above Fig. shows that without optimization, poor results has obtained as shown by red line. Whereas, with optimization i.e. when ABC is used, energy harvesting is more which as shown by green lines. The approximate average value obtained from the above graph with and without optimization are .585 flux and .001flux respectively.

3.3 Results For Dark or Other Type of Weather

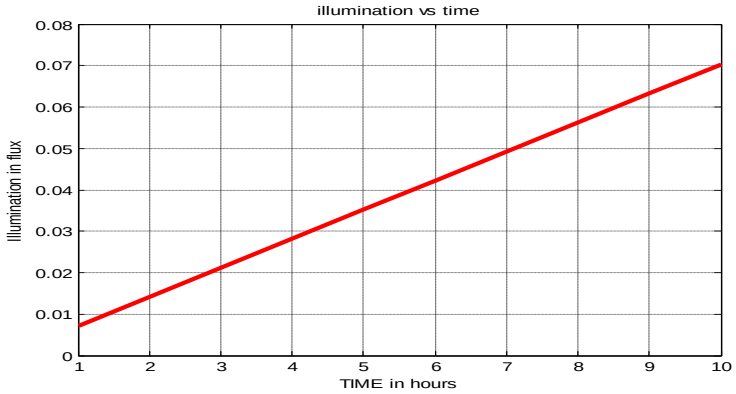

Fig.6. Illumination vs time graph for dark and another type of weather

The graph obtained for the dark and another type of weather is linear having an average value approximately equal to .035 flux. The value obtained for these weathers lies between the value of illumination obtained for sunny and cloudy weather.

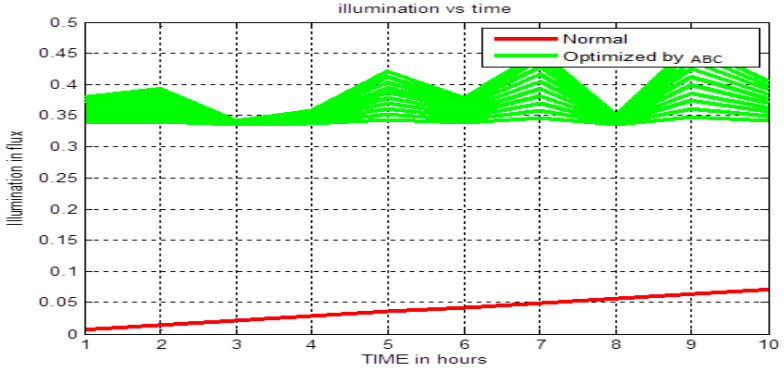

Fig.7. Comparison graph fordark and another type of weather

In the above figure, poor results are obtained when the optimization is not used. Whereas, with optimization i.e. when ABC is used energy harvesting is more which is shown by green lines. The approximate average value obtained from the above graph with and without optimization are .395 flux and .035 flux respectively. When these values are compared with the graph obtained for sunny and cloudy weather, it is

concluded that the value obtained from the above graph lies between the values obtained from these two kinds of weather.

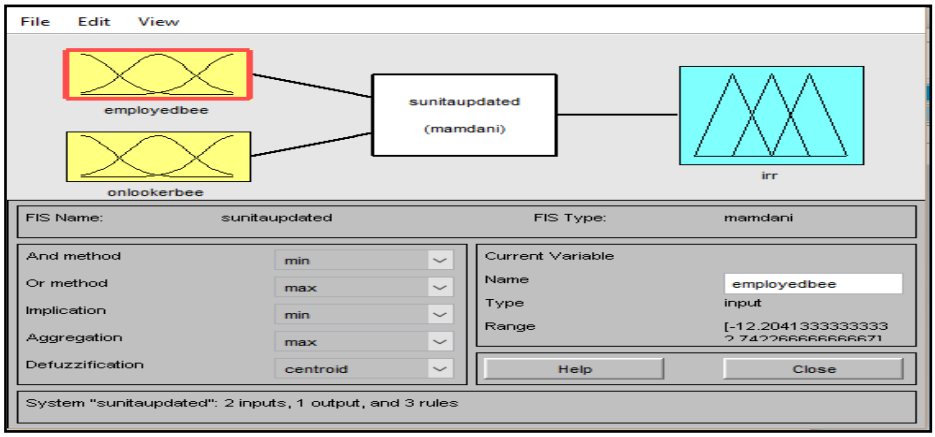

Fig. 8. FIS editor

Above figure is representing the input and output structure of the proposed algorithm. There are two inputs to the system namely employed bee and the onlooker bee and they are associated with a rule set which is defined as the Mamdani rule set.

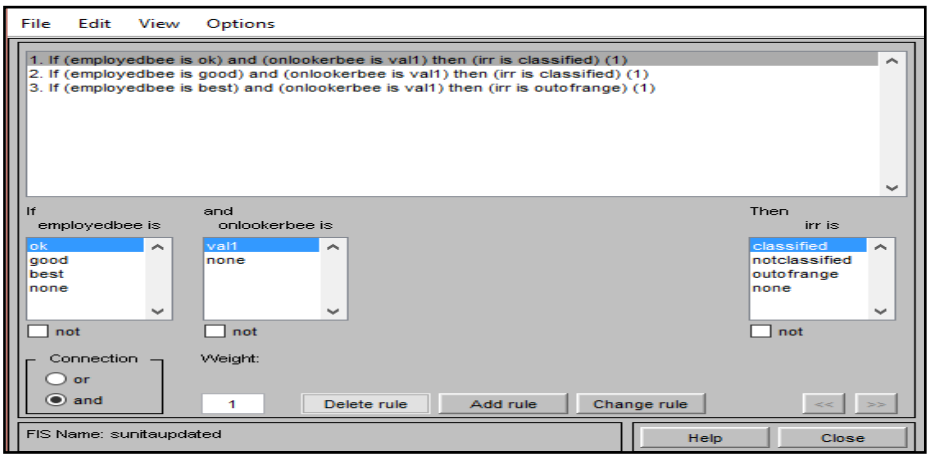

Fig.9. Rule editor

The above figure represents the rule set applied for the selection of the irradiance. If employee bee is satisfactory and onlooker is Val1 then irradiance is classified. If employee bee is better and onlooker is val1 then irradiance is non-classified. If employee bee is best and irradiance is val1 then irradiance is out of range.

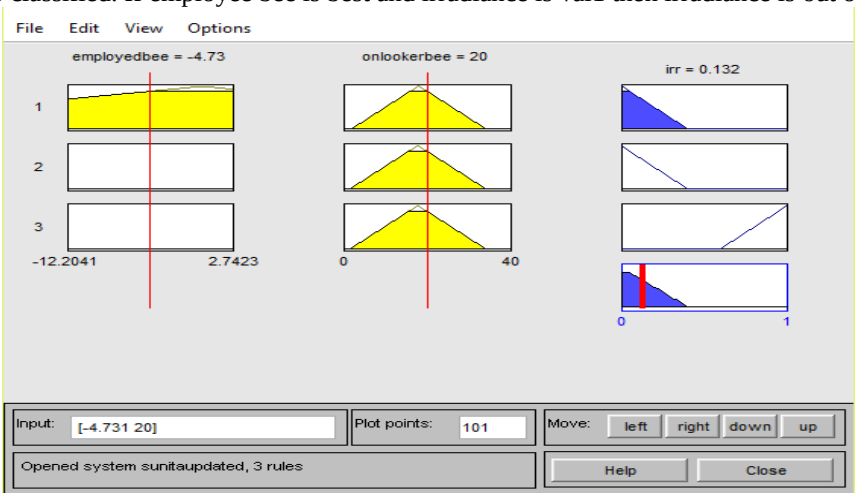

Fig. 10: Rule viewer

In the above figure, there are two inputs, namely, employeebee and onlookerbee. Both are variable inputs having ranges from -12.2041 to 2.7423 for the employebee input and 1-40 for the onlookerbee. When the employbee input is set at -4.73 and onlookerbee is set at 20 then the value of irradiant obtained I 0.132 which is very less.

III. CONCLUSION

This study provides a validation for the need to modify current solar energy performance models to better estimate the influence of snow on solar panels for installation in climates where snowfall is common. As we know that Energy harvesting is the process by which the energy is derived from outside sources like solar power, thermal power, wind power, hydro power etc. and storing these energies for a period of time and process them so that they can be used later. Energy harvesting holds great promise for both low-voltage and low-power applications in large range of portable or mobile markets like medical equipment, consumer devices, transportation, industrial controls, and military. The aim of the research work is to harvest energy. Fuzzy logic along with ABC algorithms is applied as a forecasting model to measure the total illumination against the total time of harvesting. The total time of harvesting taken in the proposed work is 10 hr. whereas the size of the room is 100×100 and the initial flux generated is 13000. The total energy harvesting has been observed for three type of environment namely: Sunny, Cloudy, for the dark and another type of weather. From the experiment, it is concluded that the illumination obtained for sunny weather is higher than the cloudy weather.Whereas the illumination obtained for the dark and other type of weather lies between sunny and cloudy weather, Illumination value obtained for sunny weather, cloudy weather, dark and another type of weathers are .07 flux, .012 flux, and .035 flux respectively. Also, the total energy harvesting obtained for all these three environments has been shown in the form of graph and it is concluded that in sunny weather energy harvesting is higher than the cloudy weather whereas, for dark and another type of weather energy harvesting obtained lies in between these two kinds of weather.72 illumination influx has been harvested for sunny weather. Whereas, for cloudy weather .585 illuminations in flux has been harvested. For the dark and another type of weather .395 illuminations in flux has been harvested. Also, irradiance has been determined during fuzzy logic and the value of irradiance obtained is .132 for the inputs of -4.73 of employbee and 20 of onlooker bee.

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