FOREX Publication
Open Access | Rapid and quality publishing

International Journal of
Electrical and Electronics Research (IJEER)
Research Article | Volume 11, Issue 3 | Pages 781-787 | e-ISSN: 2347-470X

Enhancement of Agriculture Feeder Performance by Optimal Sizing and Placing of Solar PV Tree through AEO-Based Optimization Technique

Kamal Kumar U[1*], Varaprasad Janamala[2]

[1,2]Dept. of Electrical and Electronics Engineering, Faculty of Engineering, Christ (Deemed to be University), Bangalore – 560 074, KA, India, [1]kamal.kumar@res.christuniversity.in, [2]varaprasad.janamala@christuniveristy.in*

***Correspondence:** Kamal Kumar U; kamal.kumar@res.christuniversity.in

ABSTRACT- Electrical demand, which makes up a large share of the overall power market, agriculture at the top of the list of priorities. To provide end users with a dependable and high-quality supply via various feeders and renewable energy sources, distribution generations are now being developed. In recent years, solar PV systems have been used to meet the demands of numerous applications, including boosting the efficiency of distribution networks. This paper presents the system with effective optimization method like Artificial Eco-System based Optimization Technique for identification of the best location to install distribution generation and the optimum size to minimize feeder losses. To meet service expectations, the integration of a solar PV system is swapped out for a solar tree in this suggested work. A 28-bus Indian agriculture feeder is considered for better understanding the proposed algorithm. MATLAB software is used for implementing the proposed optimization technique and CREO-2.0 is used for designing the 3-dimensional solar PV tree.

Keywords: Agriculture Feeder, Renewable Energy, Solar PV System, Artificial Eco-System Algorithm, Solar Tree.

ARTICLE INFORMATION
Author(s): Kamal Kumar U and Varaprasad Janamala;
Received: 03/07/2023; **Accepted**: 25/08/2023; **Published**: 23/09/2023;
e-ISSN: 2347-470X;
Paper Id: IJEER 0407R02;
Citation: 10.37391/IJEER.110322
Webpage-link:
https://ijeer.forexjournal.co.in/archive/volume-11/ijeer-110322.html

crossref member
CROSSREF.ORG THE CITATION LINKING BACKBONE

Publisher's Note: FOREX Publication stays neutral with regard to Jurisdictional claims in Published maps and institutional affiliations.

1. INTRODUCTION

There may be a drop in the growth of the agriculture sector depending on how the load is used for agriculture, and it is necessary to meet the necessary demand. Any area in the world where it is impossible to place a direct measurement device can utilize this method to determine its potential for solar energy. Because it uses sophisticated intelligence patterns to forecast solar radiation, the suggested system is far more precise and accurate than other approaches. Because it computes quickly compared to gradient descent and gradient descent with momentum, the Levenberg-Marquardt algorithm in the Artificial Neural Network (ANN) approach has been employed for training purposes. It is used to estimate solar radiation. The suggested approach uses a complex, hard-to-understand predictive intelligence paradigm. When compared to other techniques, the ANN's training period is lengthy, and its level of fault tolerance is quite low [1]. With differing design estimates of solar Photo Voltaic (PV) used in different applications, [2] discusses the significance of utilizing the renewable energy resource with reduced cost and getting optimal performance. The system's efficiency was improved with the help of a Maximum Power Point Tracker (MPPT). In northern Pakistan, local farmers observed a conceptual framework to comprehend the obstacles to their use of technology. A similar socioeconomic background and educational attainment was used for data collection, disregarding regional variability [3].

The values of using renewable resources are required while considering land use, costs, accuracy, and sustainability of energy with different solar tree designs. The solar tree is a more efficient solar system than a traditional one at capturing sunlight. It has less ability to direct sunlight at various angles. This makes the solar tree suitable for satisfying a wide range of socioeconomic, cultural, and environmental needs. Urbanization and the use of renewable energies for lighting, charging stations, household supply, and industrial supply are important concepts that are illustrated in the design of solar trees. To make the PV tree work better, the focuses were on different optimal MPPT strategies [4].

The challenge is to adopt the solar PV technology into agriculture end is that its size and location of DG. Meanwhile many heuristics methods are defining that the optimal size and location of DGs for RDS but not for agriculture feeders. For improving feeder performance at home and agricultural loads, the ideal DG size and solar PV system installation are chosen.
To avoid the current issue the researchers suggested a linear, heuristic, and meta-heuristic algorithm. Genetic single objective optimization [5] proposes that the sizing and placing of DG to minimize the system issues, Dragonfly algorithm [6] was an innovative approach to find the accurate and finest method of placing and sizing of DG in RDS. The algorithms are worked with single objective function in respective system, now Whale optimization algorithm [7] tuned for multi objective function to

enhance the performance of distribution networks. Extension of multi objective concepts, Genetic-Salp Swarm algorithm [8] came into picture that testing of DG placement in simultaneous location for better accurate resolution. The system performance was verifying in many methods and for justification of the work [9] approaches in the market of power as described. Genetic Algorithm [10] extends the work of multiple placements of DG and CBs for combining operation and its impacts. An artificial ecosystem-based optimization technique is proposed in this paper.

Utilizing renewable energy resources is crucial when considering land, money, accuracy, and sustainability of energy sources, as well as other solar tree design factors.

2. PROBLEM IDENTIFICATION AND MODELING OF PV SYSTEM

It is necessary to understand the basic design and functioning requirements of a solar PV system to run it effectively.

The following objectives are taken into consideration while placing DGs to better understand how well a distributed feeder performs in the aspects of minimization of power losses and voltage profile.

2.1. Objective Function

2.1.1. Minimization of Power Losses

The RDN performs differently depending on the kind of load due to variations in X/R ratio at load ends. The faults are impacted by load reconfiguration, and the solution is to reduce system losses as described in *equation (1)* below.

$$minf(P_L) = \sum_{\substack{i=1 \\ j=2}}^{n} I_{ij}^2 * Z_{ij} \tag{1}$$

2.1.2. Minimization of Voltage Profile

The voltage at each bus varies in accordance with the load variations, and the lowest voltage can be calculated by *equation (2)*.

$$minf(V_i) = \sum_{i=1} I_i * Z \tag{2}$$

For validation, the active and reactive power restrictions are as shown in *equations (3) and (4)* below.

$$P_{dg}(T) \leq P_{load}(T) \tag{3}$$

$$Q_{dg}(T) \leq Q_{load}(T) \tag{4}$$

The voltage and current restrictions considered for validation are listed in *equations (5) and (6)* below.

$$|V_i|_{min} \leq |V_i| \leq |V_i|_{\max} \ ,i = 1,2, \dots \dots nb \tag{5}$$

$$|I_i| \leq |I_i|_{\max} \ ,i = 1,2, \dots \dots nl \tag{6}$$

2.2. Sizing of PV system

The size of a PV array calculation is typically rather complicated when the devices are connected and being used. But the tools utilised, like inverters, batteries, and voltage controls, analyse the size of a distribution network. [11]

2.3. Mathematical Modeling of PV Module

PV modules are constructed from an arrangement of PV cells. PV arrays are created by connecting these modules in a parallel-series arrangement [12].

The PV module photo current is given as below.

$$I_{ph} = [I_{SCr} + K_i(T - 298)] * \lambda/100 \tag{7}$$

Module reverse saturation current is given below.

$$I_{rs} = \frac{I_{SCr}}{\left[\exp\left(q * \frac{V_{OC}}{N_S} * k * A * T\right) - 1\right]} \tag{8}$$

Below equation is showing how the module saturation current fluctuates with PV cell temperature.

$$I_0 = I_{rs}\left[\frac{T}{T_r}\right]^3 exp\left[\frac{q * E_{go}}{Bk}\left\{\frac{1}{T_r} - \frac{1}{T}\right\}\right] \tag{9}$$

The output current of the PV module is given in below.

$$I_{PV} = N_P I_{Ph} - N_P I_0 \left[exp\left\{\frac{q(V_{PV} + I_{PV}R)}{N_S AkT}\right\} - 1\right] \tag{10}$$

2.4.Solar Tree Models

Need of Solar Tree instead of Traditional Solar PV System: Solar trees allow the placement of multiple layers of solar panels in locations with limited space, maximizing the productivity of the available space. The solar tree design is beautiful as well as practical. Solar trees are much more aesthetically pleasing than conventional solar PV system because of the way they are arranged. A solar array shaped like a tree might be visually appealing. There are various solar tree designs that are thought to produce much more electric power when compared to typical solar PV system covering the same surface area [13-22].

F.Hyder[13] describes the new design of solar tree to sustain the renewable sector for tiny applications. S.A. Swastik [14], shown that importance of solar tree concepts in power market, and other beneficiaries. Varaprasad Janamala [15] installed a shaded free design of solar tree for the basketball court and analyzed the cost by compared with traditional solar PV system. V. Avdic [16] at Sarajevo location proposed and installed the solar trees for many small applications to fulfill the requirements of energy sources, and S.MadhuPriya [17] proposed a new artistic design for the industrial applications. V. Avdic, S. Zecevic [18] different latest designs for urban applications only, and S.N. Maity [19] proposes new innovative approach of solar tree for urban resources and compared with the conventional SPV system.

S. Gupta [20] proposes the stem less solar tree with existing of natural trees and their benefits accordingly, G. Pavan, [21] a real time Fibonacci Sequence-Based Solar Tree for urban application and analyzed its performance with different phyllotaxy pattern based solar tree and M.D.Patil [22] designed the solar tree for domestic applications and their effects.

International Journal of Electrical and Electronics Research (IJEER)
Research Article | Volume 11, Issue 3 | Pages 781-787 | e-ISSN: 2347-470X

In the above literature most of the applications are treated to urban regions. In this paper the new innovative solar tree suggests for the rural applications specifically for Agriculture sector as mentioned below.

2.4.1. Objectives of solar Tree

a. To conserve land resources.
b. To improve the efficiency by strategically placing panels.
c. To raise public knowledge about the benefits of solar energy.

2.4.2. Advantages of solar Trees over Conventional PV system

a. The solar PV panels get an extra hour of sunlight every day and produce 10 to 15% more electricity than an earlier setup on land.
b. Farming difficulties can be addressed while solar energy can be employed on land with the potential to produce. Both rural and urban areas have been shown to be viable for the concept.
c. Solar Tree can create energy from the wind by shaking itself and has flexible stems that can rotate in any direction.

For instance, if a solar PV system produces 2MW of electricity, the space required is 10 to 12 acres of land to accommodate the panels. Through solar tree, the same amount of energy can be produced by 0.10–0.12 acres of land.

Due to their amazing ability to produce energy while consuming the least amount of possible land, solar trees are currently in use and are anticipated to do so in the long run. Based on the literature, all the resources of solar tree are preferred and applicable to urban applications like mobile charging, low power utilities etc. In this paper, the proposed solar tree is designed for rural applications like water pumping, soil moisture and humidity measurement etc.

3. ARTIFICIAL ECO-SYSTEM BASED OPTIMIZATION TECHNIQUE

The Artificial Eco-System-Based Optimization Technique (AEO) is a population-based optimizer method which uses three distinctive behaviors of extant organisms. This is driven by the movement of energy throughout an earthly ecosystem and encompasses the processes of creation, consumption, and breakdown. The primary operator seeks to enhance the balance between exploration and exploitation. The second operator keeps track of how the algorithm's exploration is progressing. The third operator is suggested to encourage the use of the algorithm [23–25].

A. Eid [23] an enhanced AEO method proposes for optimization of location and sizing of multiple DGs for enhancing the performance of distribution networks, M. Ćalasan [24] presented the workflow of the ecosystem for other environments like PID controllers etc., and W.Zhao [25] described the nature inspired ecosystem for the power system applications and their impacts of implementing. In this work the AEO method is chosen for optimal sizing and placement of solar tree to enhance the performance of agriculture feeder as suggested.

3.1. Production Operators

All members in the ecosystem are arranged in descending order of fitness value, and flow of energy is to be analyzed. Based on the energy level, the worst person is a producer, and the best person is a decomposer. The worst person has the highest fitness value, and the best person has the lowest fitness value. In this arrangement, the producer consumes the decomposer's nutrition while also using sunlight to manufacture food energy. It should be highlighted that in AEO, the decomposer must be modified through the best person, the producer, and the worst person. The updated person can then tell the rest of the population where to look for herbivores and omnivores, among other things. The manufacturing operator uses AEO to arbitrarily construct a new individual to replace the old one in the search space, choosing between the best individual (xn) and a randomly generated individual (xrand). *Equation (11)* shows how to figure out the production operator, and he or she may suggest heavily exploiting the area nearby.

$$x_1(t+1) = (1-a)x_n(t) + a x_{rand}(t) \tag{11}$$

Where, $a = \left(1 - \frac{t}{T}\right) r_1$; $x_{rand} = r(U-L) + L$

3.2. Consumption

The consumption factor, a stage with the Levy flight function, is suggested to reduce complexity and the tuning of numerous parameters, and it is stated as follows:

$$C = \frac{1}{2}\frac{v_1}{|v_2|},; \quad v_1 \approx N(0,1), v_2 \approx N(0,1) \tag{12}$$

Where, $N(0,1)$ → Normal distribution with the mean = 0 & Standard deviation = 1

By examining the consumption factor, random walks frequently become congested at a single spot and occasionally move far from the original location to hop.

This enables AEO to explore the search room and reduce extremes, and it also helps every client find food since different customer kinds, such as herbivores, omnivores, and carnivores, have distinct eating habits.

3.2.1. Herbivore

If a consumer is chosen at random to be an herbivore, it just eats the producer. Given that both *x2* and *x5* consumers are herbivores who only consume products from the producer, they are illustrated as follows in *equation (13)*:

$$x_1(t+1) = x_i(t) + C\big(x_i(t) - x_1(t)\big) \tag{13}$$

Where $i \varepsilon$ [2,…n]

3.2.2. Carnivore

The consumer with the highest energy level only consumes the food if any of the consumers is chosen as a carnivore. The *x6* consumer is a carnivore, but because the *x2* and *x5* consumers all have higher energy levels than the *x5* consumer, one of them must be chosen at random to eat, as seen in *equations (14)* below.

$$x_1(t+1) = x_i(t) + C(x_i(t) - x_j(t)) \quad (14)$$

Where j = randi([2i-1]); i ε [3,….n]

3.2.3. Omnivore

An omnivore will eat at random, as will a consumer with a greater energy level and a manufacturer. The *x7* consumer is an omnivore, therefore it prefers to consume both the *x1* producer and the randomly chosen *x2* and *x6* consumers due to their greater energy levels and is depicted in *equation (15)* as follows.

$$x_1(t+1) = x_1(t) + C(r_2 x_i(t) - x_1(t) + (1-r_2)(x_i(t) - x_1(t)) \quad (15)$$

Where $j = randi([2i-1])$, $i \in [3,...n]$ and r_2 is random number within the range of [0, 1].

For this consumption operator, AEO changes the location of a search person in relation to either the worst individual or a randomly chosen individual in a population, or occasionally both. This step encourages exploration and enables AEO to go on a global search.

3.3. Decomposition Operator

An important process in the functioning of an ecosystem is the element's decomposition, which offers vital nutrients for the growth of the producer.

The decomposer will decay or chemically breakdown the remains once every member of the community has passed away throughout the decomposition process. The mathematical behaviour of this model is represented by the decomposition factor *D* and the weight coefficients *e* and *h*.

$$x_1(t+1) = x_n(t) + D(ex_n(t) - hx_i(t)) \quad (16)$$

Where, $\mathrm{D} = 3\mathrm{u}, \mathrm{uN}(0,1), ; \mathrm{e} = \mathrm{r}_3 \mathrm{randi}([2\mathrm{i}]) - 1$ &
$\mathrm{h} = 2\mathrm{r}_3 - 1, ; \ \mathrm{j} = \mathrm{randi}([2\mathrm{i} - 1])$

4. RESULTS AND DISCUSSIONS: CASE STUDY

4.1. 28-Bus Indian Agriculture Feeder

The load flow analysis is carried out using the forward sweep and backward sweep algorithms for the 28 bus Indian agricultural feeder are displayed above. Losses are found using that algorithm. *Fig.1* represents the 28 bus Indian agricultural feeder.

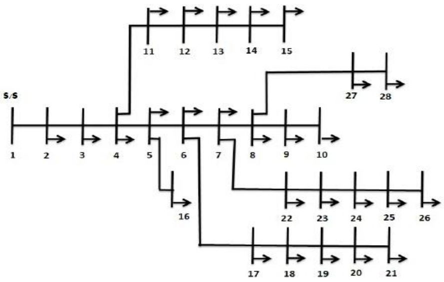

Figure 1: Single line diagram of 28-bus Indian Agriculture Feeder

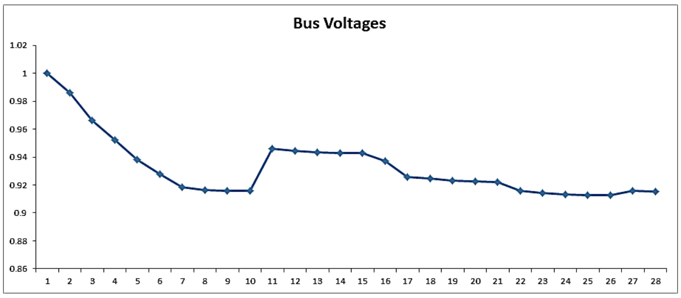

Figure 2: Bus Voltages of IEEE-28 Bus Feeder

Figure.2 represents the bus voltages of the agricultural feeder and *Fig.3* gives the active and reactive power losses in the system. The active power loss is high in the lines 6 and 22 and the values are 15 kW and 14.9 kW respectively. The reactive power loss is high in the lines 6 and 11 and the values are 12 kVAR and 11.8 kVAR.

The proposed Artificial Eco-System based Optimization Technique is applied to the feeder and the performance is given in Table-1 compared with other optimization techniques. The concept of solar tree is developed using the software CREO-2.0. Simple tools like sketch extrude, and other similar ones were used in conjunction. The proposed solar tree is modeled with a capacity of 0.58 kW and 12 panels of 50wp set at a suitable height of 10 ft as shown in *fig.4*.

A three-dimensional understanding of its branches and shadow-free solar leaves is intended by the models that are being given in *fig. 4(a), fig. 4(b)* and *fig 4(c)* respectively. By installing the solar tree replace with conventional one will have many benefits like less space occupies and more power output as shown in *figure 5* and it compared with existing algorithms as observed that AEO is suitable optimized method in *table1*.

The proposed solar tree reduces the overall space for installation for the required amount of power compared to the conventional solar PV system. This enables the farmers to utilize the land for cultivation without disturbing their requirement. The saving of agriculture land *s* shown in *figure6*.

And the efficiency of the power generation of solar tree is high than the traditional one. In address to agriculture, the irrigation is increased by getting continuous power supply and starting farming in more farming field. Finally, the farmers are profited through solar tree and stable in economic aspects.

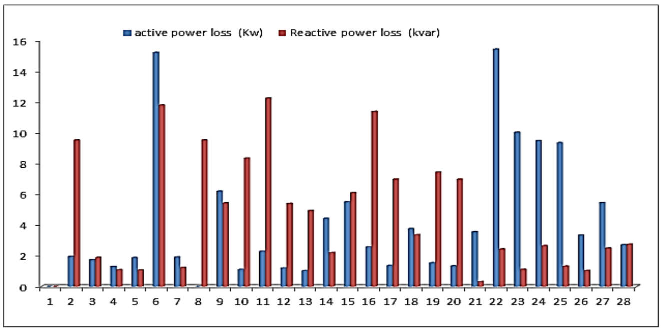

Figure 3: Active and Reactive Losses of 28-bus feeder

Table.1: Comparative Analysis of 28 bus Agriculture Feeder

Method	Bus Locations	DG Size in kW	Power Losses in kW		Required Solar PV Modules of 350 wp each	Area Occupied in sq.ft	In acres	Total area (acre)
			Without DG	With DG				
Load Flow [26]	22	530.2	68.83	39.83	1494	5230	0.12	0.43
	23	490.1		41.05	1391	4870	0.11	
	24	465.8		41.56	1314	4608	0.1	
	25	450.4		42.32	1277	4470	0.1	
APSO [26]	22	523.27	68.83	39.06	1494	5230	0.12	0.43
	23	487.11		40.51	1391	4870	0.11	
	24	460.85		41.6	1314	4608	0.1	
	25	447.71		42.3	1277	4470	0.1	
MPSO [26]	22	523.8	68.83	39.06,	1494	5230	0.12	0.43
	23	487.11		40.51,	1391	4870	0.11	
	24	460.57		41.60,	1314	4608	0.1	
	25	447.41		42.30	1277	4470	0.1	
AEO	22,	525.5	68.89	38.29\	1494	5230	0.12	0.43
	23,	485.11		39.49	1391	4870	0.11	
	24,	461.57		40.54	1314	4608	0.1	
	25	449.41		41.28	1277	4470	0.1	
AEO through proposed solar Tree	22,	525.5	68.89	38.29	63-STs	2016	0.046	0.167
	23,	485.11		39.49	58-STs	1856	0.042	
	24,	461.57		40.54	55-STs	1760	0.04	
	25	449.41		41.28	54-STs	1728	0.039	

4.1.1. Specifications of Solar Tree

To construct the proposed solar tree, the area of each panel is to be considered as 10 Sq. ft, power of each panel is configured with 350 Wp and the required total No. of cells is 72 of having 24V with dimensions of 1966x991x36 mm of 5mts height and 3mts of length of each tree. To fulfill the total power requirement, nearly 24 panels are required.

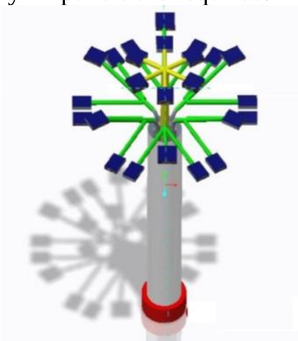

Figure 4(a): Front View

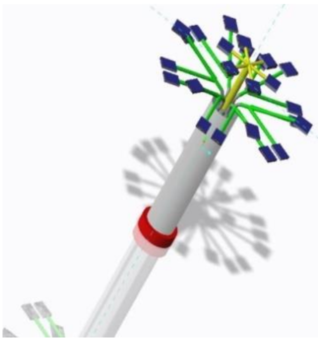

Figure 4(b): Left Side View

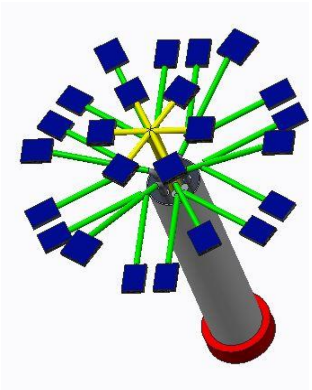

Figure 4(c): Right Side View
Figure 4: Proposed 8.4 kW Solar Tree

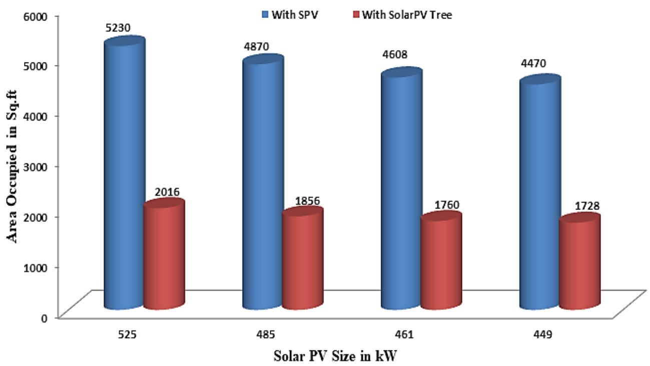

Figure 5: Comparison of occupied area with SPV & Solar Tree

International Journal of
Electrical and Electronics Research (IJEER)
Research Article | Volume 11, Issue 3 | Pages 781-787 | e-ISSN: 2347-470X

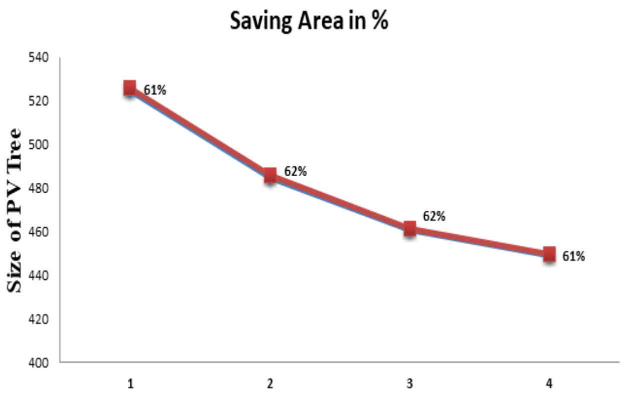

Figure 6: Agriculture area Saving in %

4.2 Discussions

(a) As demonstrated for the 28-bus system and recommended for any RDN, a new AEO strategy is presented to enhance the agricultural industry.

(b) Agriculture feeder performance is greatly enhanced by the improvement of voltage profile, the reduction of losses, and the provision of quality of supply.

(c) When compared to a typical solar system, the new solar tree model will deliver more irrigation in rural areas such as agricultural fields while using less space. These solar trees also function as independent DGs.

(d) Although installing solar trees in agricultural regions is more difficult and expensive.

CONCLUSIONS

A new optimization method namely, Artificial Eco-System based Optimization Technique (AEO) is presented and applied to the standard 28 agriculture feeder. The best location to incorporate DG and the size of DG is identified using AEO technique to enhance the performance of feeder by reducing the losses. A proposed solar tree is design based on size obtained from AEO and incorporated in the system to sustain the agriculture feeder for many aspects. The voltage profile, active and reactive power loss is observed without and with DG in the system. The no. of solar modules required in the solar tree will be same as per the wattage, but the land required is low as 0.167 acres compared to conventional solar PV system as 0.43 acres. During the comparative analysis, much area occupied during installation of the traditional solar PV system is reduced after replacing with solar tree, which leads to many beneficiaries to end user.

Author Contributions: Kamal Kumar U is contributed to resource data and analysis data, implementation of algorithms, the conduct of experiments and Varaprasad. J, guided to frame the paper and concept.

Conflicts of Interest*:* The author declare no conflict of interest.

REFERENCES

[1] S.Kumar, T. Kaur, "Development of ANN based model for solar potential assessment using various meteorological parameters", Energy Procedia, Vol. 90 pp. 587 – 592, 2016, doi:10.1016/j.egypro.2016.11.227

[2] A.A. Ghoneim, "Design optimization of photovoltaic powered water pumping systems" Energy Conversion and Management, Vol.47, issues.11–12, pp. 1449-1463, 2006, doi: 10.1016/j.enconman.2005.08.015.

[3] D. Zhou and Abdullah, "The acceptance of solar water pump technology among rural farmers of northern Pakistan: A structural equation mode", Cogent Food & Agriculture,Vol.3:1, pp.1-17 , 2017, doi:10.1080/23311932.2017.1280882.

[4] S. Mekhilef, S.Z.Faramarzi, R.Saidur, Z.Salam, "The application of solar technologies for sustainable development of agricultural sector", Renewable and Sustainable Energy Reviews, Vol.18, pp.583-594,2013, doi:10.1016/j.rser.2012.10.049.

[5] A. A. Hassan, F. H. Fahmy, A.Shafy A, Nafeh & A.Mohamed, Abu-elmagd, "Genetic single objective optimisation for sizing and allocation of renewable DG systems", International Journal of Sustainable Energy, Vol.36, issue.6, pp.545-562,2017, doi: 10.1080/14786451.2015.1053393.

[6] M.C.V.Suresh, E.J.Belwin, "Optimal DG placement for benefit maximization in distribution networks by using Dragonfly algorithm", Renewables Vol.5, issue.4, pp.1-8, 2018, doi:10.1186/s40807-018-0050-7.

[7] D.B. Prakash, C. Lakshminarayana," Multiple DG placements in radial distribution system for multi objectives using Whale Optimization Algorithm", Alexandria Engineering Journal, Vol.57, issue.4, pp. 2797-2806, 2018, doi:10.1016/j.aej.2017.11.003.

[8] C.Djabali, T.Bouktir T,"Simultaneous allocation of multiple distributed generation and capacitors in radial network using genetic-salp swarm algorithm". Electrical Engineering & Electromechanics, No. 4, pp. 59-66, 2020, doi:10.20998/2074-272X.2020.4.08.

[9] V.V.Kyryk, O.S.Bohomolova, "Justification of optimal location of connection of the distributed generation source and value of its power", Electrical Engineering & Electromechanics, 2019, No.2, pp. 55-60, 2019, doi:10.20998/2074-272X.2019.2.08.

[10] M. A. S. Masoum, M. Ladjevardi, A. Jafarian, E. F. Fuchs, "Optimal placement, replacement and sizing of capacitor Banks in distorted distribution networks by genetic algorithms", IEEE Transactions on Power Delivery, Vol. 19, issue. 4, pp.1794-1801, 2004, doi: 10.1109/TPWRD.2004.835438.

[11] Emhamed Alzaroog, Mohsen Ben Ammar, Mohamed Ali Zdiri and Hsan Hadj Abdallah, "An Advanced Artificial Neural Network Energy Management in Standalone PV Systems", International Journal of Electrical and Electronics Research (IJEER), Volume 10, Issue 4,Pages 1005-1012, e-ISSN: 2347-470X, 2022.

[12] Spandan Srivastava, Charu Lata, Prateek Lohan and Rinchin W. Mosobi, "Comparative Analysis of Particle Swarm Optimization and Artificial Neural Network Based MPPT with Variable Irradiance and Load",International Journal of Electrical and Electronics Research (IJEER),Volume 10, Issue 3, Pages 460-465, e-ISSN: 2347-470X, 2022.

[13] F.Hyder, K.Sudhakar, R. Mamat, "Solar PV tree design: A review", Renewable and Sustainable Energy Reviews, Vol.82, part.1, pp.1079-1096, 2018, doi:10.1016/j.rser.2017.09.025.

[14] S.A. Swastik, K. Bhamburkar, B.Ajay, A. Ashish," Solar Tree: A Source of Energy- A Review", International Research Journal of Engineering and Technology, Vol.5, issue.4, pp.514-516, 2018.

[15] Varaprasad Janamala , "Solar PV Tree: Shade-Free Design and Cost Analysis Considering Indian Scenario", Walailak Journal of Science and Technology (WJST),Vol.18, issue 8, pp.1-9, 2021.

[16] V. Avdic, A. Muminovic, N. Pervan, P. Tasic, S. Zecevic, "Implementation of the Project "Solar tree" in Sarajevo", Green Design Conference At: Sarajevo, Bosnia and Herzegovina Vol.2nd, 2013.

[17] S.MadhuPriya, K.Divya, "SOLAR TREE – An artistic design to arrange Solar Panels", International Journal & Magazine Of Engineering, Technology, Management And Research, 2014.

[18] V. Avdic, S. Zecevic, N. Pervan, P.Tasic, A.J.Muminovic, "Different Design Solutions of Solar Trees in Urban Environment", International Green Design Conference, Vol.2nd pp. 01-05, 2013.

[19] S.N. Maity, "Development of solar power tree – an innovation that uses up very less land and yet generates much more energy from the sun rays by SPV method", Journal on Environmental Nanotechnology, Vol. 2, pp. 59–69, 2013.

Research Article | Volume 11, Issue 3 | Pages 781-787 | e-ISSN: 2347-470X

[20] S. Gupta, M. Gupta, "The benefits and applications of solar tree with natural beauty of trees", SSRG International Journal of Electrical and Electronics Engineering (SSRG-IJEEE) –EFES, pp. 29-34, 2015.
[21] G. Pavan, T. R. Pratap, A.K.Singh, "Design of Fibonacci Sequence-Based Solar Tree and Analysis the Performance Parameter of Different Phyllotaxy Pattern Based Solar Tree: An Experimental Approach", 62nd International Scientific Conference on Information Technology and Management Science of Riga Technical University (ITMS), 2021, doi:10.1109/ITMS52826.2021.9615248.
[22] M.D.Patil, R.M.Santosh," Design and development of solar tree for domestic applications", International Journal of Engineering Sciences & Research Technology Vol.5, No.8, 2016.
[23] A. Eid, S. Kamel, A. Korashy, T. Khurshaid, "An Enhanced Artificial Ecosystem-Based Optimization for Optimal Allocation of Multiple Distributed Generations", IEEE Access, Vol. 8, pp. 178493-178513, 2020, doi: 10.1109/ACCESS.2020.3027654.
[24] M. Ćalasan, M. Micev, Z. Djurovic, H.M.A. Mageed,"Artificial ecosystem-based optimization for optimal tuning of robust PID controllers in AVR systems with limited value of excitation voltage", The International Journal of Electrical Engineering & Education, July 2020. doi:10.1177/0020720920940605
[25] W.Zhao, L.Wang, Z. Zhang, "Artificial ecosystem-based optimization: a novel nature-inspired meta-heuristic algorithm". Neural Computing and Applications, Vol. 32, issue.13, pp.9383-9425, 2020, doi: 10.1007/s00521-019-04452-x.
[26] O. M. Mansoor, R.Harikumar, M.F.Kasim, "Siting and Sizing of Distributed Generation by Adaptive Particle Swarm Optimization", Int. Conf. on Emerging Trends in Electrial Engineering, pp.1-8, 2014.