A Flexible Renewable Smart Production with RDG, Considering Power Quality

Shashwat Dwivedi, A.S. Yadav, Rajesh Tyagi

Abstract*: *This report largely focused on the influence on the delivery system of the Renewable Distributed Generations (RDGs). DG's intercourse showed that the suggested the traditional method of radial distribution into a multiple DG scheme. The main contribution of this study is to reduce total power losses and increase the distribution system's power quality using RDGs. The Loss sensitivity factor (LSF) is used to find the RDGs. A heuristic search novel The Modified Bat Algorithm (MBA) is used to define the amount of the RDGs. MBA is largely focused on microbats' higher elastic modulus. The proposed MBA is measured on standard bus test systems IEEE 33 and 69.

Keywords: Renewable Distributed Generation (RDGs), Modified Bat Algorithm (MBA), Loss Sensitivity Factor (LSF).

I. INTRODUCTION

The electricity grid prepares operational component operations, Generate & Distribute. The loads are connected to the electrical grid either via the electricity transmissions system. Nearly 70% of latency issues supply chain,30% of the losses do occur in the transmitting system. Vital to the distribution network to bet on reducing losses by almost 7.5%. Distributed Generation (DG) is a small electrical technology that alters the power running. For the power loss, it is proposed that every compact DG should be formally modified within the distribution. Distribution system longitudinal support system, DG could be utilized to obtain low-level voltage power, and installations frequently located in the intermediate from the load order also fewer feeders are also linked. In this, solar and wind do the progressive periods spread. Photovoltaic (PV) energy system, the service of windmills and other DGs are usually established in rural areas. The processes spend all into the T&D operation, are required. One DG's goal is to minimize losses, costs, and greenhouse emissions. System DG used to build this voltage profile, reduce losses at the line, increase representation, better power quality by developing custom security. So DG selection has an individual vital part from that production system. Several loads are usually interpretive at the delivery mechanism. So, the power factor for the device lagged values toward nature. It causes Energy losses to grow, causes less voltage profile, also creates security problems within delivery networks. Total energy losses split into active also reactive energy losses. Given these impacts of reactive power losses only within the way, the active power losses hit the energy power transfer and appear in less energy factor. an outcome, loads inside each supply chain are complex to location and DG to lower power losses and increase the voltages among all the buses.

Revised Manuscript Received on June 30, 2020.

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A. Distributed Generation (DG)

DG plays a huge role in the supply connection. The smart distribution arrangement leads to significant device gain, energy loss minimization, and voltage form growth and consequently raising the efficiency of the aforementioned device. DG is called a producer of limited size T&G system. The purpose of DG deployment is to balance up for real energy. Recognizing the current too amidst the reduction of the climate method, the modifications of fossil fuel also the new electricity market legalization scheme demonstrate the need for more bendy electric driven solutions.

II. LITERATURE SURVEY

Some analysts are seeking the simultaneous allocation of renewable DG within the RDS from the literature. Different types of generations transferred and their descriptions are addressed. A multi-objective point was designated for transmission networks with DG that requires a broad range of innovative issues. Multi-criteria output had been provided as delivery systems with DG which requires a vast variety of technical concerns. The authors suggested an optimal arrangement and weight of the investigating expressions. Analyze the question of the influence of four DG modes in combination with power sources. The analyst has raised the issue of load fashion styles in the distribution system on DG scheduling. Evolved a DG method that included both typical also alternative types of potential assets for power-producing, selling energy, and playing the key role in the distribution systems as an alternative delivery mechanism allowing the decision of choices.

The studies have proposed the most effective multi-criteria mechanism for allocation of further than one DGs and shunt compressor banks collectively understanding load complexity from one of a typical power system quality perspective via altered particle swarm optimization approach. The paper developed the search algorithm Equilibrium with the multi placement of DGs. The response was indicated to the synchronized the placing of DGs and amplifiers with reconfiguration. Worked into utilized for the site of the DG crush method. Evaluation of the grid supply system with a time of different load edition turned into reference [13].

Fully optimized Quasi-oppositional instructional training is used to make the choice the region and width the more effective for multiple DG with multiple objective components in reference [1]. The Backtracking Search for Optimization Set of Rules (BSOA) was used with multi-type DGs in DS planning, BSOA turned into Dg allocation Proposed with myriad load flow.

From either the study, highest possible use will be made of these application development techniques are used to determine the size, area of DG to minimize loss and voltage progress in the radial distribution system [15-32]. Many of them, indeed, are influenced by the local optimal solutions and need more approximation computational effort. The potency and effectiveness of the advanced process are inquired with approved IEEE buses along beside 33-bus and 69-bus test procedures. The outcomes were found referred to as the heuristic-based algorithms which do already built to be higher than other current techniques. MBA proves it's used for all problems of enhancement.

III. REVIEW CRITERIA

Probability distribution functions (PDF) do apply to theoretically denote the stochastic expression of electricity generation (wind velocity and solar irradiance).

A. Solar Modelling

Having followed Beta PDF [16-17], mention is made of the probability aspect of solar irradiance. Beta spread for solar irradiance s^t (kW/m2) is given by 't' over time process,

$$fs^t = \frac{T(\alpha^t+\beta^t)}{T(\alpha^t)\cdot T(\beta^t)} * (s^t)a^{t-1} * (1-s^t)^{\beta t-1} \text{for} \alpha^t > 0\,;\ \beta^t > 0 \quad (1)$$

Where the parameters of the form at 't' are α^t and β^t; and T represents the function Gamma. Beta PDF form parameters can be determined using suggestion (μ_s^t) and standard irradiance deviation (σ_s^t) for the respective time segment.

$$\beta^t = (1-\mu_s^t)\cdot\left(\frac{\mu_s^t.(1+\mu_s^t)}{(\sigma_s^t)^2} - 1\right) \quad (2)$$

$$\alpha^t = \frac{\mu_s^t * \beta^t}{(1-\mu_s^t)} \quad (3)$$

B. Wind Modelling

Weibull PDF has been chosen in references to explain stochastic behavior of wind speed over a predefined time span. Can be expressed as Weibull distribution for wind speed v^t(m/s) in the t^{th} time segment.

$$f_v^t(v) = \frac{k^t}{c^t}\left(\frac{v^t}{c^t}\right)^{kt-1} \cdot \exp\left(-\left(\frac{v^t}{c^t}\right)^{kt-1}\right) \text{ for } c^t > 1; k^t > 0 \quad (4)$$

The parameter of shape (k^t) and part of scale (c^t) shall be determined as follows at the t^{th} time point.

$$k^t = \left(\frac{\sigma_v^t}{\mu_v^t}\right)^{1.086} \quad (5)$$

$$c^t = \frac{\mu_v^t}{T(1+\frac{1}{k^t})} \quad (6)$$

μ_v^t and σ_v^t are proposed as well as conventional wind speed deviation at phase 't.'

IV. CONTEMPORARY ISSUES SOLUTION

A. Load-Flow Overview

During this circulation arrangement, it is used to find that power loss involves voltage format every segment with proper evaluation load variation. Fig 1 displays each one-line Initial distribution lay-out network.

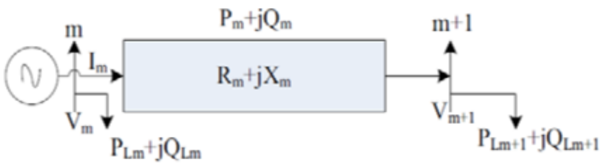

Fig. 1: Single Line System Distribution

In attempt using the formula given, the active and reactive power failure within the line segment around buses m and m+1 is measured

$$P_{T,loss} = \sum_{m=1}^{nb} P_{loss}\,(m, m+1) \quad (7)$$

The main purpose function (F) is

$$F = \min\,(P_{Tloss}) + \max\,(\text{VPE}) \quad (8)$$

Where P_{Tloss} signifies total power loss, VPE is an improvement of the voltage profile.

B. Loss Sensitivity Factor (LSF)

It is classified as maintaining the loss of power in certain voltage limits. Utilizing Loss Sensitivity factor, an optimum position for the RDG setup can be defined. The search space and consumption of time for optimization paintings will be significantly reduced by this process. LSF is computed at each bus through

$$\text{LSF}_{m,m+1} = \frac{\partial Ploss(m,m=+1)}{\partial Q(m+1,eff)} = \frac{2Q_m+1,eff * R_{m,m+1}}{|V_{m,m+1}|^2} \quad (9)$$

C. BAT Algorithm

Actual review of Bat Algorithms

Now for several days, nature-inspired algorithms have crept back a powerful function in algorithms to resolve in a simple option complex power system optimization issue. The meta-heuristic algorithm called "Bat Algorithm" was captivated by a new creation. Xin-She Yang, 2010 developed it based on the beliefs of natural bats making sound-waves for locating their food sources. Bats seem to be wildlife motivators as they're the only vertebrates with wings and the potential to increasingly echolocate theirs relies on. Generally, it generates a sound signal named echolocation to identify the surroundings to them and they can make their way even in total blackness.

Bat algorithm could be established by internalizing scarce of the bats' physical attributes including three rules that are set out below.

- Each bat detects gap permitting echolocation activity too also recognizes the disparities among food/prey and environment obstacles using echolocation activity in some secret way.
- Each bat flies with velocity V_i position X_i arbitrarily, with a frequency f_{min} modifying including wavelength λ and loudness A_0 to track prey. Bat has the strength to monitor the recurrence (or wavelength) of its released pulse also the valuation of pulse radiation r within the range of [0, 1] turning on the contiguity of its target.
- The intensity can occur in multiple ways, although. Here's where the sound is predicted to deviate from a large positive value A_0 to a minimum constant value A_{min} .

The regulations for modifying simulated bats' position X_i and velocities V_i are formerly known. The directions can be used to remain modernizing frequency, velocity, and position as offered herewith:

$$f_i = f_{min} + (f_{max} - f_{min})^{\beta} \quad (10)$$

$$v_i^t = v_i^{t-1} + (x_i^{t-1} - x^*) f_i \quad (11)$$

$$x_i = x_i^{t-1} + v_i^t \quad (12)$$

In which $\beta \epsilon (0,1)$ is newly a vector space plucked from a homogenous arrangement, and wherever x* does the current general finest site (solution) that's also situated at each matter after going to compare all resolutions amidst total n bats. Essentially, a frequency which does pick uniformly of $[f_{min}, f_{max}]$ is allocated to any bat at random. Being a fine scale of standard PSO and fast local search ordered by pulse scale and loudness, MBA can be pointed-out.

D. Modified Bat Algorithm (MBA)

The idea (MBA) could be extracted by incorporating actual BA also harvesting methodologies with pathogenic fabrication. In MBA every way of bacterial foraging order (BFO) is motivated to generate unusual solutions doing the equations. A full BFO explanation can be found at [33]. In the MBA bat motion choice is defined by the health purpose value. If a bat flies towards its optimum fitness value then swimming is the form of bat movement. Otherwise, the bat opposes the bacterium's chemical-tactical motion. This following Eq 13 shows the makeshift-tactic movement of the bacterium.

$$x_i^t = x_i^{t-1} + v_i^t \frac{\Delta_i}{\sqrt{\Delta_i^T \Delta_i}} \quad (13)$$

above, v_i^t is present time phase t velocity, including Δ_i is the random number formed in the range [-1, 1]. Just swimming style action is possible in original BA but swimming as well as tumbling are taken in MBA.

Tumbling means bat moving in several regions (in opposite direction) from the bat 's earlier direction. Chemo tactic bat activity occurs until a bat moves in the direction of its target (i.e. fitness increases/decreases).

Steps on Conduct initiated Research using MBA

- Initialize system data also each load flow of distributing sources.
- Get the energy losses from the bottom case, the Loss Sensitivity Factor (LSF), and the voltage value at each bus.
- Determine the situations of the RDGs using MBA.
- Means allowing (lower and higher) for limitations, control specifications of algorithms (pulse duration, pulse frequencies and sound) and highest iteration no.
- Initiate every bat in the achievable area by random population. The individual bat shows an ideal supporting size for the RDGs in the source.
- Set the features of robustness value. In that phase, the configuration load flow theorem is done to estimate the logical value of the potential losses with particular consequence roughly bat including the source voltage of the actual functionality.
- Choose the finest bat in the group, i.e. that has the smallest energy loss value.
- Use comparisons (10) to (12) will update the Bat group.
- Overrun the load flow also write down with the latest bat group, the active energy loss, and the reactive loss.
- Cantered on chemotactic bacterium movement (Concept is derived of [36]), generate new solutions with the help of comparison (13).
- Analysis to see if the conditions for the deductions are met. Status for the assumption might be the maximum number of repetitions to update the bat group or a particular content that the objective function will appear over the lowest. If that is fulfilled then stop that algorithm going to step no 5 otherwise.
- Show the Goal function best values.

To minimize objective function estimation these steps order be followed.

V. SIMULATION RESULTS

MBA has been practiced to seek out just how conventional DG is shaped moreover performs IEEE-33,69 test bus systems.

IEEE 33 Test Bus System

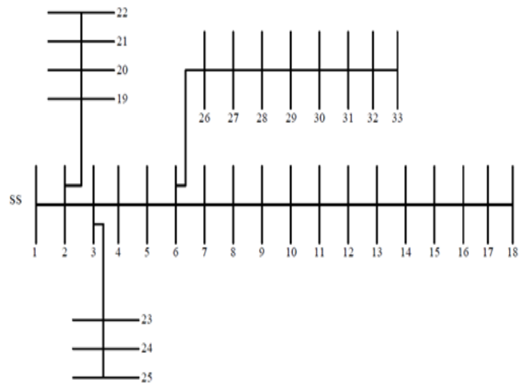

Fig 2: Single Line Diagram of IEEE 33 Test Bus System

Radial distribution method is shown in Fig, beside 33 buses and 32 branches. 2. The line voltage, radial delivery network actual load is 12.66 kV, 3.72 MW. Initial energetic power losses are 210.98 kW earlier than DG arrangement. Unit line and bus data do take from the references [34]. The 30th bus is classified as the most preferred place to mount DG on this system.

Table-1: 33 Bus test system performance analysis

	Without DG	With Single DG		With Two DG	
		solar	wind	solar	wind
Optimal size (kW) & Location	-	1200(13)	1500(30)	800(14) 1150(30)	800(14) 1100(30)
Power Factor	-	Unity	0.7682	Unity	0.9032, 0.7399
P_{loss}(kw)	210.98	125.20	0.7136	87.37	28.96
% reduction in P_{loss}	-	40.66	66.17	58.58	86.27
CVD	1.6229	0.6475	0.3473	0	0
V_{min} (P.U.)	0.9037	0.9266	0.9388	0.9668	0.9798
VSI_{min}(P.U.)	0.6610	0.7313	0.7707	0.8654	0.9132
Computation time (s)	-	7.5	7.8	9.5	10.02

While, using one form RDG, the MBA is used to compare with the different solar and wind techniques. By using MBA approach Solar is compared with GA, EVPSO, PSOPC, AEPSO, ADPSO, DAPSO, Analytical, BSOA. Wind is contrasted to GA, BSOA using method proposed by MBA. The method proposed gives the best outcome and power loss rate. And also, the highly efficient MBA approach relative to the other optimization strategies presents the data below table 2.

Table-2: Real outcomes Correlation for Various Techniques Using RDG (One Type)

DG Type	Technique	DG Installation		Power loss	
		Size (kVA/p.f)	Bus	Value(kw)	Percentage
-	Without DG	-	-	210.98	-
PV	GA[21]	2580/1	6	105.481	48.21
	EVPSO [22]	763/1	11	140.19	33.55
	PSOPC [22]	1000/1	15	136.75	35.18
	AEPSO [22]	1200/1	14	131.43	37.70
	ADPSO[22]	1210/1	13	129.53	38.60
	DAPSO[22]	1212/1	8	127.17	39.7
	Analytical [20]	2490/1	6	111.24	47.27
	GA[21]	2380/1	6	132.64	37.13
	GA[21]	1000/1	18	142.34	33.29
	BSOA[23]	1857.5/1	8	118.12	44.01
	Proposed method	**1200/1**	13	**125.20**	**40.66**
WT	GA[21]	2980/0.95	6	72.68	64.32
	BSOA[23]	2265.24/0.82	8	82.78	60.76
	Proposed method	**1500/0.7682**	30	**71.36**	**66.17**

A. Single DG

The select position and estimating for single DGs are defined by MBAs are presented in Table 1. Bus number 13 does the place for DG set for Solar with an area of 1200 kW. The aim of the intensifying voltage deviation is decreased from 1.6229 to 0.6475. The power losses fell to 125.20 kW with a percentage of 40.66. The least voltage is higher from 0.9037 percent to 0.9266 percent. Bus number 30:

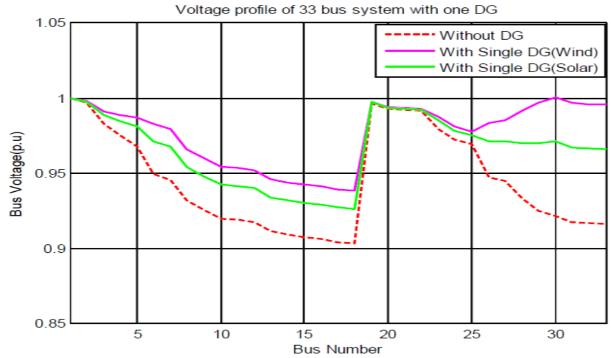

Fig. 3: 33 Bus System Volt. Profile of Single DG

DG design for WT style with a size of 1500kw. The worth of cumulative tension deviation is decreased to 0.3473. The power losses are minimized to 71.36 kW. The minimum voltage is lifted to 0.9388 P.U. which is within the set limits. Moreover, in phrases of voltage profiles and VSI the designed WT type provides high consequences than PV type. Due to the availability of reactive power generation, the occupied power loss is also decreased more frequently than not within the WT case. Solar's measurement time is 7.5 and the wind turbine was 7.8. Fig 3 indicates 33-bus System's voltage profile improvement.

B. Two DG Places

The optimum area and size for two DG installations are calculated by an MBA as given in Table 1. Bus numbers 14 and 30 are the place for DG set up for solar with a size of about 800 kW and 1150 kW. The value of the cumulative voltage deviation is falling from 1.6229 over 0. The power losses continued reduced by 58.58 percent to 87.37 kW. minimum voltage from 0.9037 percent to 0.9668 percent is greater. Bus number 14 and 30 is the DG set up for WT type, with a size of 800 kW and 1100 kW. The value of cumulative tension deviation is reduced to 0. The power losses fell to 28.96 kW, with 28.96 percent. The minimum voltage is increased to 0.9798 P.U., which is inside the ends set. Solar's calculation time is 9.5 also that wind turbine was 10.02. Fig 4 shows a 33-bus system's improvement in voltage profile.

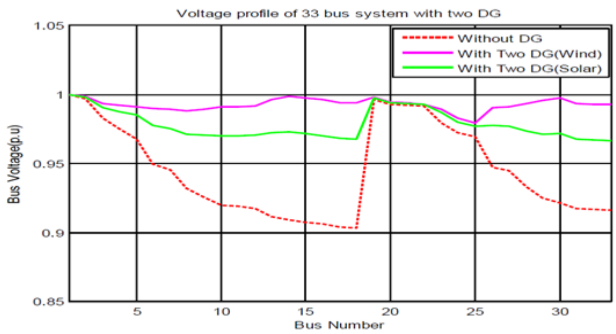

Fig. 4: 33 Bus System Volt. Profile of Two DG

Thus, using two forms of RDG, the MBA is used to compare with the various solar and wind techniques. By MBA process Solar is compared with GA, EVPSO, PSOPC, AEPSO, ADPSO, DAPSO, Analytical, BSOA. By using the proposed MBA form, Wind is contrasted with BSOA. The wind is compared with BSOA by doing MBA proposed program.

The proposed process gives better outcomes and a percentage of the power loss. Also, the MBA program having high efficiency compared to various other optimization techniques the outcomes are shown above table 3.

Table-3: Various outcomes

DG Type	Technique	DG Installation size (kVA/p. f)	Bus	Power loss Value(kw)	%age
-	Without DG	-	-	224.94	
PV	GA [21]	837.5/1 1212.2/1	13 29	82.7	60.8
	PSOPC [22]	916/1 767/1	8 12	111.45	47.17
	EVPSO [22]	540/1 569/1	14 31	108.05	48.78
	AEPSO [22]	600/1 600/1	14 29	106.38	49.57
	ADPSO [22]	550/1 621/1	15 30	106.24	49.64
	DAPSO [22]	1227/1 738/1	13 32	95.93	54.53
	GA [22]	1718/1 840/1	6 8	96.580	54.22
	BSOA [23]	880/1 924/1	13 31	89.34	57.65
	Proposed Method	**800/1 1150/1**	**14 30**	**87.37**	**58.58**
WT	BSOA [23]	777/0.89 1032/0.7	13 29	31.98	84.84
	Proposed method	**800/0.9032 1100/0.7399**	**14 30**	**28.96**	**86.27**

C. IEEE 69 Test Bus System

It is a large-scale evaluation product built up of 69 buses and 68 sections with a measured power load of 3.8 MW. The loss of electrical energy without any sustainable energy DG being imposed in the radial distribution system is 225 kW. The system line and bus data are deduced from either the citations. The 61st bus is determined on this system even as region most suitable to place in RDG.

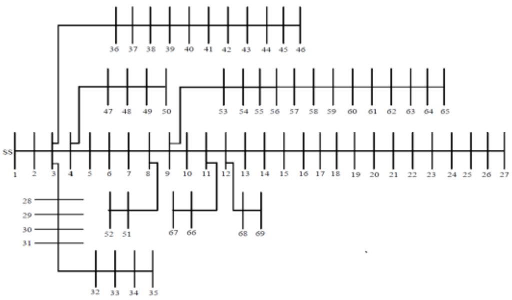

Fig. 4: IEEE 69 Test Bus System Single Line Diagram

Table-4: Analysis and results of 69 bus test system

	Without DG	With Single DG Solar	With Single DG Wind	With Two DG Solar	With Two DG Wind
Optimal size (kW) & Location		1800(61)	1800(61)	530(18) 1720(61)	500(18) 1700(61)
Power Factor		Unity	0.8106	Unity	0.8192, 0.8169
P_{loss} (kW)	225	83.4	23.19	71.81	7.32
% reduction in P_{loss}		62.93	89.69	68.08	96.74
CVD	0.7327	0	0	0	0
V_{min} (P.U)	0.9090	0.9678	0.9723	0.9758	0.9936
VSI_{min} (P.U)	0.6822	0.8771	0.8936	0.9061	0.9587
Computation time (s)		8.35	8.56	11.35	11.89

D. Single DG Place

The optimum region and size for single DG placement are determined by the MBA essentially given in table 4. Bus schedule 61 is the position for DG, which has a solar capacity of 1800 kW. The price of the accumulated running voltage is made of 0.7327 to 0. The voltage drop by 62.93 percent does reduce to 83.4 kW. The voltage level from 0.9090 p.u to 0.9678 p.u is also leading. The bus schedule 61 is the DG arranged for WT type, with a scale of 1800 kW. The significance of the entire voltage contrast is decreased over 0. With the percent of 89.69, the amount of power is down to 23.19 kW. The lowest possible voltage is increased to 0.9723 p.u that is within the set limits.

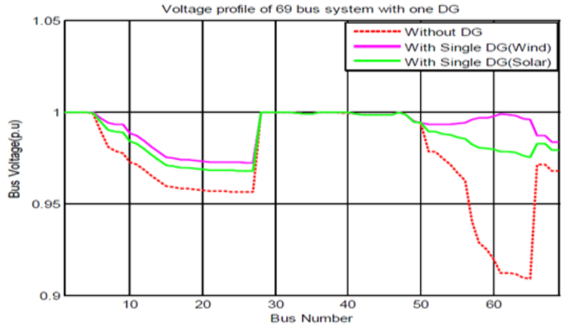

Fig. 5: 69 Bus System Voltage Profile with One DG

Table- 5: Single DG Place

DG type	Technique	DG installation Size (kVA/ p. f)	Bus	Power loss Value(kW)	Percentage
-	Without DG	-	-	224.94	-
PV	ABC [25]	1900/1	61	83.31	63.96
	GA [21]	1872/1	61	83.18	63.02
	Analytical [26]	1807.6 /1	61	81.44	63.79
	Analytical [26]	1807.6 /1	61	92	59.1
	Grid search [26]	1876.1 /1	61	83	63.1
	GA [21]	1794/1	61	83.4252	62.91
	PSO [22]	1337.8 /1	61	83.206	63.01
	CSA [22]	2000/1	61	83.8	62.74
	SGA [22]	2300/1	61	89.4	60.3
	BB-BC [24]	1872.5 /1	61	83.2246	63
	Proposed method	**1800/1**	**61**	**83.4**	**62.93**
WT	GA [21]	2155.6 /NR	61	38.458	82.9
	CSA [22]	2300/ NR	61	52.6	76.6
	PSO [22]	2300/ NR	61	52.6	76.6
	BB-BC [24]	2223/0 .81	61	23.1737	89.697
	Proposed method	**1800/0 .8106**	**61**	**23.19**	**89.69**

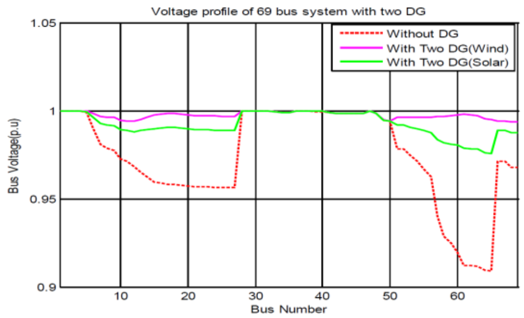

Fig. 6: 69 Bus System Voltage Profile with Two DG

E. Two DG Places

The optimal region and spacing for dual DG deployments are calculated by MBA as mentioned in figure 4. Bus route 18 and 61 is the place for DG arranged for Solar with a scale of 530 kw and 1720 kW. The value of the aggregate voltage deviation is reduced from 0.7327 to 0. The power loss has declined with a percentage of 68.08 to 71.81 kW. The voltage level from 0.9090 percent to 0.9758 percent is higher. Bus route 18 and 61 are the DG arranged for WT form, with a size of 500 kw and 1700 kw. The value of cumulative tension deviation is decreased to 0. The power losses have been back to 7.32 Kw with 96.74 percent. The minimum voltage is raised to 0.9936 p.u and is within the defined parameters. The solar computational time is 11.35 and the wind computational time was 11.89. Figure 6 indicates a 69-bus increase in the voltage profile.

Utilizing single type RDG, the MBA is therefore also used to try comparing with the multiple solar and wind methodologies. While using the MBA technique Solar is evaluated with ABC, GA, SGA, PSO, CSA, Grid scan, BB-BC, Analytical. While using the suggested model MBA, Wind is evaluated with GA, CSA, PSO, BB-BC. The approach employed gives a better outcome and power loss percentage. But also, the highly efficient MBA strategy comparison to the other optimization methods displays the effects underneath table.

Table- 6: Two DG Places

DG Type	Technique	DG Installation		Power loss	
		Size (kVA/p. f)	Bus	Value(kW)	Percentage
-	Without DG	-	-	224.94	-
PV	GA [20]	1777/1 555/1	61 11	71.7912	68.08
	GA [19]	6/1 1794/1	1 62	84.233	62.55
	CSA [19]	600/1 2100/1	22 61	76.4	66
	SGA [19]	1000/1 2400/1	17 61	82.9	63.1
	PSO [19]	700/1 2100/1	14 62	78.8	64.97
	Proposed method	**530/1 1720/1**	**18 61**	**71.81**	**68.08**
WT	CSA [19]	800/NR 2000/NR	18 61	39.9	82.26
	SGA [19]	600/NR 2300/NR	18 62	44	80.4
	PSO [19]	900/NR 1900/NR	18 62	42.4	81.15
	Proposed method	**500/0.8192 1700/0.8169**	**18 61**	**7.32**	**96.74**

VI. CONCLUSION

This work was about integrating MBA and LSF in radial distribution networks. For this work, the attention was on green DG systems. The multi-objective feature aims at reducing total power losses, developing voltage profiles, and improving distribution systems' VSI. The MBA is being used to determine the size of the RDG system. On IEEE 33 and 69 regional distribution networks with various distribution systems the current MBA procedure is a study. The simulated outcomes over many DG systems increased the power loss and increase the improvement of the bus voltages. This study focused on the loss of active and also reactive power. Using MBA, the multiple DG system is extremely efficient.

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