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Novel Approach for Allocation of DG In Distribution System with Wind Power Integration Using Multi objective Hybrid Optimization

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Abstract**:** In the Global consumption of electrical energy is increasing, Hence The electricity consumption will be increased as a result of this demand. Therefore, efficient production, distribution, and usage of energy is consistently growing. Conventional power generation systems are developing across the world because power generation stations required to the integration of Distributed Generator(DG) and renewable energy sources.To improve system performance, these DGs are placed in appropriate buses or nodes of proper size and also Rather than integrating of single large DG to the integration of renewable generation, two or many small and correct size of multi DGs are placed. This paper explanations about the ideal location and size of DGs is examined in IEEE-33 and 69 bus systems ,The algorithm used for appropriate sizing and optimal placement of distributed Generation in distribution system with wind power generation integration using MOHOA (Multi-objective Hybrid Optimization algorithms) to improve the quality of Distributed Generation allocation. In this paper, In this research, hybrid Binary Particle Swarm Optimization with Shuffled Frog Leap Algorithm (BPSO-SFLA).Therefore we suggest an optimal location of DG in radial distribution system for loss reduction voltage improvement in addition with placement of DG and sizing DG in IEEE Radial Distribution System (RDS). Their accuracy and performance will be evaluated and compared to the conventional system. The MOHOA implemented in IEEE 33 and 69 bus by using MATLAB programme. By using the hybrid methodology solution, losses are reduced and difference of result can be checked by without DGs and with DGs.

Index Terms: Instantaneous, optimal sizing, Binary Particle Swarm Optimization, Shuffled Frog Leap Algorithm (BPSO-SFLA) and Renewable energy andMOHOA (Multi-objective Hybrid Optimization algorithms).

I.INTRODUCTION

The distribution system is crucial in the current electricity system. They've face several critical changes driven by a number of unified constrains, that reduction objectives ,are Greenhouse gas (GHG) network enhancement, power quality requirement, renewable integration, demand management and energy congestion and reliability[1,2].

In the existing system's efficiency is further lowered due to the substantial power losses in the transmission and distribution system. In order to avoid paying a penalty, distribution businesses typically attempt to keep real losses below the standard rate. Therefore, As for the result, the active power loss minimization of distribution systems has seen a dramatic increase in research papers. Typically, In order to increase the electrical system's stability and dependability (reliability), adequate reactive power support is necessary to sustain the voltage of the system at a prescribed level. In case like this, it is critical to implement a variety of innovative technology for best resource usage and resolution of reported faults in order to satisfy the load demand along with power quality target in a cost-effective manner. The optimal allocation of (DG) in power systems is one of the most recent techniques to deal with these difficulties in terms of cost and time.

The U.S. Electric Power Research Institute (EPRI) estimated that the yearly cost of outages caused by disruptions in the distribution system would be $100 billions [3]. DGs are becoming more integrated in distribution systems in order to provide technical support, economical, and ecological benefits. Improving power quality, load shifting, controlling voltage divergence, managing frequency, controlling voltage divergence, Load balancing and peak saving, facilitating the incorporation of renewable energy sources, and network expansion, and lowering overall costs are among these advantages [4].According to [5,6], DGs are planned to effectively address difficulties including energy oscillations, unexpected load shifts, and outages of distribution or transmission system. Even though Wind energy generation is more environmentally friendly, its dependence on renewable energy can threaten power distribution system stability. From papers [5,6], Energy oscillations, unexpected load shifts, and failures of distribution or transmission system are among problems that DGs are aimed to solve. We know that generating renewable energy is better for the environment., its dependence on renewable energy can threaten power distribution system stability. Some of the issues are given below:

Normally, In most power systems, voltage stability is studied. (on transmission level)

- In Distribution, because all of the substation's active and reactive power are assured, the distribution system is typical to design and has no stability issues.
- In distribution system doesn't experience the any ill effects of like stability issues, given that all its real and reactive supplies are ensure that flowing through the substation.
- In order to lower reactive power consumption of these Distributed generation units, compensation of reactive power (A capacitance of approximately 1/3 of the DG unit rating) in DG terminal unit.
- In the near and future, the DG units based on power electronic converters are available in a variety of configurations, expected to enter the distribution networks.

The Power Electronic converter is critical for matching DG unit characteristics to grid connection demands, active and reactive energy regulation, such as voltage frequency and harmonics reduction.

The main objectives are to improve stability of voltage while reducing radial distribution loss and to use a hybrid optimization approach to attain the best Distributed Generator allocation in the N-bus system. We can calculate active and reactive power losses, operational costs, and DG placement using this technique. Using the SFLA-ALO hybrid multi-objective optimization approach, we suggest an ideal location for DG in a radial distribution network in order to reducing the total losses and increase voltage. Their accuracy and performance will be compared to [5] the current system. The MATLAB software is used to perform this. By using hybrid approach Losses are decreased and the difference between the two results may be tested by inserting DG and not placing DG. In a radial distribution system, when losses are decreased, the voltage rises and the cost falls.

II. PROPOSEDWORK

A recent study revealed several novel notions that need different information formats or data manipulations in order to calculate the distinctive appearances of distribution networks. Distributed generation (DG) is the generation of electricity in a distributed system using renewable or Emissions of low-carbon sources. In recent years, the DG has become more effective for detecting its position in order to achieve the maximum power needs. There are several causes for concern, resulting in ever-increasing demands on the DGs. The main factors are the environmental pollution, commercial losses, increasing power quality and reliability of the power system. The major research The goal of Distributed generator installation in the distribution system, it is determine the best placement and size for the DGs so that power loss is minimized and voltage stability is maintained. To handle DG allocation issues, several algorithms have been presented, including the genetic algorithm, practical swarm optimization, ant colony, analytical approaches, and etc. These algorithms have produced improved DG allocation outcomes, but they are continually evolving in order to improve DG allocation further. Loss reduction, load balancing, and other problems are resolved via system reconfiguration, which is a non-linear enhancement issue. Another equally important aspect is that DG plays a crucial role in the distribution system's management. It's critical to maximize the benefits of its placement by optimizing its size and position. To increase the quality of DG allocation, numerous algorithms or methodologies are being updated, and hybrid algorithms are being created. In this research, Hybrid **Binary Particle Swarm Optimization with Shuffled Frog Leap Algorithm (BPSO-SFLA)** is proposed for the optimal location and sizing of the DG units in the IEEE 33bus and 69 bus radial distribution system in order to reduce power losses and maintains voltage stability

This strategy has been recognized as a compensation-based solution for resolving distribution load flow issues and allocation issues. Instead of branch currents, the upgraded power flow be implemented and displayed. There is no relationship between system control variables and system status. so, Applying the compensation-based methodology gets difficult. In this study, we propose implementing the Multi-objective Hybrid Optimization approach to optimize the distribution system DG allocation and size with Wind energy system integration don by using (MOHOA).

The main contributions of proposed work as follows:

The MOHOA (Multi-objective Hybrid Optimization algorithms) combines improved BPSO-SFLA algorithm. It allows for optimal DG placement, operation, and size and operation. It considers a variety of grid scenarios and desired performance, as well as functional strategies, the types of DGs, and the systems and approach's benefits and margins.The Optimal scheduling determines the DGs size and location with wind energy system and plans for exact location, this issue objected to technological limits, while reducing total energy losses and there constraints.

- DGs can be sized to meet large energy demands in the most efficient way possible., the enhancement of the advantages of integrating wind energy with distributed energy, the support of energy quality control, and the reduction of distribution system expansion costs.
- The multi-objective is considered for proper DG selection, intelligent DG, recharge & discharge, operation, location, and size as well as worries about power quality.

III. FORMULATION OF PROBLEM

Constraints:

The main objective functions are:

$$\min\ f = \min(T_{loss}) \tag{1}$$

Whereas, T_{loss} -the total loss of power in radial distribution.

Equality constraints:

Power balance equations:

In each time period t, The Equation Includes Active and reactive power at each node i.

$$P_i^t = P_{G_i}^t - P_{L_i}^t + P_{d_i}^t - \mathrm{P}_{\mathrm{ch_i}}^{\mathrm{t}}$$

$$\theta_{ik}^t = \theta_i^t - \theta_k^t$$

$$P_i^t = \sum_{i=1}^{n} V_i^t V_k^t \left[G_{ik} cos\left(\theta_{ik}^t\right) + B_{ik}\, sin\left(\theta_{ik}^t\right)\right] \tag{2}$$

$$Q_i^t = Q_{G_i}^t - Q_{L_i}^t + Q_{d_i}^t - \mathrm{Q}_{\mathrm{ch_i}}^{\mathrm{t}}$$

$$\mathrm{Q_i^t} = \sum_{\mathrm{I}=1}^{\mathrm{n}} \mathrm{v_i^t V_k^t}\left[\mathrm{G_{ik}\, Sin}\left(\theta_{ik}^t\right) + \mathrm{B_{ik}\, Cos}\left(\theta_{ik}^t\right)\right] \tag{3}$$

Energy balance equations for DG:

It contains energy balance equations for each one DGi In each period t,

$$B_i^t = B_i^{t-1} + \left(\eta_{\mathrm{ch_i}} \mathrm{P}_{\mathrm{ch_i}}^{\mathrm{t}} - \frac{P_{d_i}^t}{\eta_{d_i}}\right)\Delta t \tag{4}$$

In equality constraints:

Limits for voltage magnitudes:

$$V_i^{min} \leq V_i^t \leq V_i^{max} \quad (5)$$

Active and reactive generation power's limits :

$$P_{G_i}^{min} \leq P_{G_i}^t \leq P_{G_i}^{max} \quad (6)$$

$$Q_{G_i}^{min} \leq Q_{G_i}^t \leq Q_{G_i}^{max} \quad (7)$$

Limits of Branch current :

$$\left(I_{ij}^t\right)^2 \leq \left(I_{ij}^{max}\right)^2 \quad (8)$$

$$\left(I_{ji}^t\right)^2 \leq \left(I_{ji}^{max}\right)^2 \quad (9)$$

DGs charging and discharging power limits:

$$P_{d_i}^{min} \leq P_{d_i}^t \leq P_{d_i}^{max} \quad (10)$$

$$\mathrm{P}_{\mathrm{ch_i}}^{\mathrm{min}} \leq \mathrm{P}_{\mathrm{ch_i}}^{\mathrm{t}} \leq \mathrm{P}_{\mathrm{ch_i}}^{\mathrm{max}} \quad (11)$$

$$Q_{d_i}^{min} \leq Q_{d_i}^t \leq Q_{d_i}^{max} \quad (12)$$

$$\mathrm{Q}_{\mathrm{ch_i}}^{\mathrm{min}} \leq \mathrm{Q}_{\mathrm{ch_i}}^{\mathrm{t}} \leq \mathrm{Q}_{\mathrm{ch_i}}^{\mathrm{max}} \quad (13)$$

Limits for DG Energy:

$$B_i^{min} \leq B_i^t \leq B_i^{max} \quad (14)$$

During, at what time the DG is functioning, constraint (10) and (11) must be satisfied. The problem of particle swarm optimization power flow is defined as a sparse and complete model, as shown above., therefore, the Lagrange multiplier LMP_i^tConnected to the Active power flow equation at bus i.The change of the overall production cost with regard to the variation of injected active power is represented by period t. at the same bus, i.e., it is the Locational Marginal Price (LMP) at bus I In time period t.

$$LMP_i^t = -\frac{\partial PC^t}{\partial P_i^t} \quad (15)$$

As per the formulation of the particle swam optimization described above, LMP_i^tcomprises of the impacts on both Active power losses and congestions.

Assessment of sensitivity:

The best and worst candidate buses for installed DGs are found using the data provided by the Locational marginal pricing LMP_i^t it above. Buses that are the best and worst candidates bus for installing DGs have been identified. The best possibilities are buses with the highest Lagrange multipliers, as any changes in real injected power has a bigger influence on the producing cost than buses. As a consequence, If the ESSs are installed on the best candidate buses, they will possess a greater impact on manufacturing costs. The technique is discussed in detail as follows.

A reference case of optimal power flow (without DG installed) is calculated. The Lagrange multiplier is calculated in this wayLMP_i^t for every bus i each hour t. Limitations on DGs, including equations (4) and (10-14) are detached From the Optimal power flow problem[2].The following factor$df_i$is calculated for each bus i.

$$df_i = \sum_{t=1}^{T} \left|LMP_i^t\right| \quad (16)$$

The highest values denotes the most apt buses for DGs installation., while the lowest values indicate the candidates who are less sensitive. The above parameter considers the influence of the DGs throughout the whole time horizon, not just for a particular hour. Secondly, Given the entire number of DGs available, they are linked to the system at the best candidate buses, and the OPF issue is solved, including all constraints. A series of tests are conducted in the following section to describe the time-shifting and congestion reduction functions. Manufacturing costs, total quantity of curtailed wind power, and hourly LMP change are computed and plotted in figure in each case.

$V_{i\min}$ and $V_{i\max}$ are the mini. and max. Voltages of the i^{th} bus, respectively. Similarly $I_{\max}$ is the max. value of branch current. The results of two algorithms are evaluated in this research in order to reduce the total energy loss within the constraints.

IV. Binary Particle Swarm Optimization

Particle swarm optimization (PSO) is a population-based search algorithm and the working procedure is based on the social behavior of bees, birds, and schools of fishes.PSO approaches issue solving via the view of social interaction. It employs a swarm of particles that move around in the search space in quest of the optimum solutions. Each particle is considered as a point in an N-dimensional space that modifies its "flying" in response to its own and other particles" flying experiences. Each particle does have a fitness rating and a velocity that controls its trajectory. Particles are now following two best solutions, p best and g best. Every particle maintains track of its coordinates with in solution space, which are connected with the particle's best solution so far. Personal best, or Pi best, is the name given to this number. The best value acquired so far by each particle in the vicinity of that particle is also another value recorded by the PSO. This value is called Pgbest.

The primary principle behind PSO is to accelerate each particle toward its Pbest and Gbest positions at each time step using a random weighted acceleration. The PSO procedure is then repeated few time or until the target performance index is attained with a minimum error. The particle's personal best and global best are changed in the binary PSO.The main variation among the binary PSO and real-valued PSO has been that the particle velocities are defined in terms of the probability of a bit changing to one. Small numbers for Vmax in binary PSO encourage exploration. If Vmax = 0, The search then becomes a pure random search.

V. Shuffled Frog Leap Algorithm (SFLA)

The shuffled frog-leaping algorithm (SFLA) was developed to fix the problems involving combinatorial optimization. The SFLA is a natural memetics-inspired population-based collaborative search metaphor. Local search and worldwide information sharing are both incorporated into the algorithm. The SFLA has virtual population of frogs which interacts and is distributed into various memeplexes . The virtual frogs serve as hosts or carriers of memes, which are cultural evolution units. In each memeplex, the algorithm does an independent local search at the same time. A particle swarm optimization-like strategy, tailored for discrete issues but stressing a local search, is used to finish the local search. In a strategy similar to that employed in the shuffled complex evolution algorithm, the virtual frogs are systematically mixed up and rearranged into new memeplexes to assure global evaluation. Furthermore, random virtual frogs are produced and replaced in the population to create the chance for random production of enhanced information. The algorithm is tested on numerous test functions that present complexities common to several global optimization issues. The algorithm's efficacy and applicability have also been proved by applying it to the calibration of a groundwater model.

Power flow calculation

From the power flow analysis we calculated by the following set of simplified the equations are follows

$$P_{Loss}(i,i+1) = R_{Li+1} * \frac{\left(P_i^2 + Q_i^2\right)}{\left|V_i^2\right|} \qquad (17)$$

$$Q_{Loss}\left(i,i+1\right) = X_{Li+1} * \frac{\left(P_i^2 + Q_i^2\right)}{\left|V_i^2\right|} \qquad (18)$$

$$P_{i+1} = P_i - P_{Li+1} - R_{Li+1} * \frac{\left(P_i^2\right)}{\left|V_i^2\right|} \quad (19)$$

$$Q_{i+1} = Q_i - Q_{Li+1} - X_{Li+1} * \frac{\left(P_i^2 + Q_i^2\right)}{\left|V_i^2\right|} \quad (20)$$

Where P_i -Active power and

Q_i -reactive powers flowing.

The bus i, and P_{Li} and Q_{Li} are the Active and reactive load powers at bus i. Ri, i+1 and XLi+1, corresponding resistance and reactance of the bus-to-bus row segment I and i+1. The power losses between buses I and i+1 can be calculated as:

The active, reactive and total power loss of the feeder $P_{T,Loss}$, $Q_{T,Loss}$ and P_{Loss} can be calculated by adding up losses for all feeder lines as follows:

$$P_{T,Loss} = \left[BIBC\right] * P_{Loss}\,(i, i+1) \quad (21)$$

$$Q_{T,Loss} = \left[BIBC\right] * Q_{Loss}\,(i, i+1) \quad (22)$$

$$P_{Loss} = \sqrt{P_{T,Loss} + Q_{T,Loss}^2}\,. \quad (23)$$

VI. TEST SYSTEM RESULTS AND DISCUSSION

To evaluate the efficiency and resilience of the proposed BPSO-SFLA algorithm, it was applied to IEEE 33bus and IEEE 69bus systems and compared to existing approaches.To match the test systems for wind and the load data are scaleddownward.Wind data is obtained from a wind farm, and load data is applied to a regular winter day's load..

Case Studies:In three cases, the impact of DG and wind system integration is examined.and compared to Prove Effective DG of the hybrid Binary Particle Swarm Optimization withShuffled Frog Leap Algorithm approach proposed.Their relevant voltages, index of stability and cost information are analyzed in the fallowing cases.

Case-1 The whole wind energy although without A periodical probabilistic loading flow test of the 33 and 69 Bus systems is used to evaluate for DG installation.
Case-2The entire wind energy distribution is considered in a periodic probabilistic loading flow test of the 33 and 69 Bus designs, but with Multi DG installation.

Simulation results:

Initially, a load flow solution is produced using the BPSO and SFLA optimization techniques, after which it is examined and the power flow and losses are investigated. Their respective voltage profile, stability index and Economic cost details are shown.

IEEE 33 Bus radial Distribution system

CASE 1: (i) Before DG placement 33 BUS radial distribution.

In 33 bus system total real power demand 1.6KV and 100KVA system is taken and in this 3 genaration systems.. The LMP activepower at each bus in each hour is calculated using the Optimal power flow formulation provided in this Section. The parameter df_i is then calculated for each bus i, including the load buses and wind bus.Before DG placement of 33 bus system is represented in Fig.1, and the resultant values are listed in Table. 1.

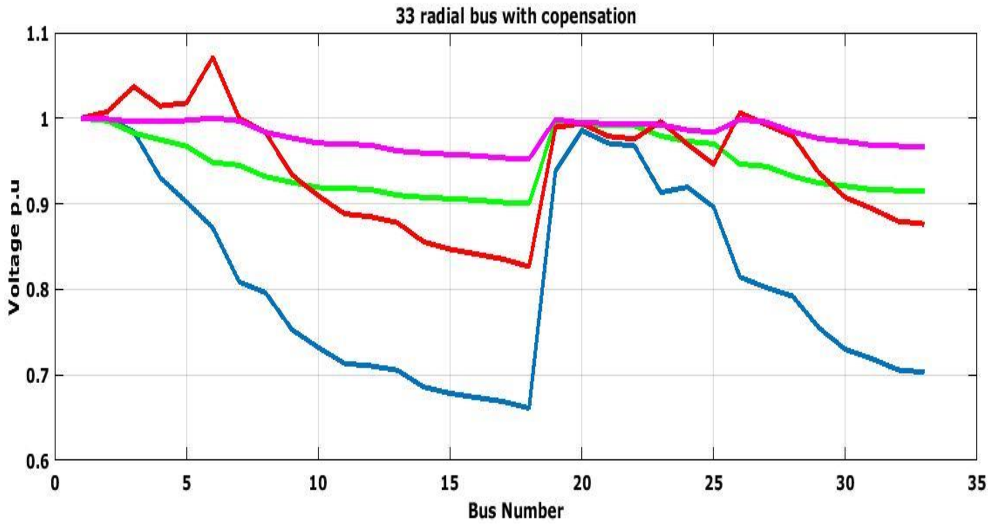

Figure 1: 33 Radial bus with voltage stability compensation

Table 1: 33 Radial bus details without DG connection

33 Radial Bus Details	Obtained Value	Bus node
Total real demand (Kw)	3715.0000	-
Total reactive demand (KVar)	2511.000	-
Minimum voltage and bus	0.9036 V(pu)	6
Minimum voltage 1and bus	0.9546 V(pu)	18
Minimum stability index and bus	0.6686 V(pu)	6
Minimum stability index 1 and bus 1	0.8323 V(pu)	18
Total Active power loss atbase case	0.503 Kw	-
Cost before DG placement (Rs/KW)	6.1095e+04	-

CASE 2: (i) With Multi DG placement in 33 BUS radial distribution.

From the OPF formulation portrayed the first Five buses (6, 10, 9, 13 and 7) with maximum values of LMPs are considered as the best candidate bus to install the DG. Similarly lowest values of LMPs are worst candidate buses (11, 4, 12, 18 and 2) among this bus 18 is the lowest candidate bus. Similarly, two cases where one is best case and another is worst case of The quality of the Sensitivities estimated is evaluated using the DGs that have been inserted in the system. The tests are divided into different categories For a total of 24 hours, the optimization problem is executed.The DG operation for Case 2, with one DG linked to bus 6 (the best candidate bus) and one DG attached to bus 18 (the worst candidate bus), is represented in Fig.2, and the resultant values are listed in Table. 2.

Table 2: 33 Radial bus details with DG connection (6, 18)

33 RADIAL BUS DETAILS	Obtained Value	DG connected at Bus Node
Total real demand (Kw)	3715.0000	-
Total reactive demand (KVar)	2305.000	-
Total DG-1 placement (Mw)	3016.533	6
Total DG-2 placement (Mw)	2840.539	18
Total Active power loss in base case (Kw)	0.503	-
Total Active power loss index with 1DG placement case at bus	0.178	6
Total index Active Power with 2DG placement case at bus	0.134	18
Total index with dg placement case	0.178 V(pu)	6 ,18
Minimum voltage(V(p.u)) and bus	0.9196	6
Minimum stability index and bus	0.8323	6
Minimum voltage1 and bus bus1	0.9546 18	18

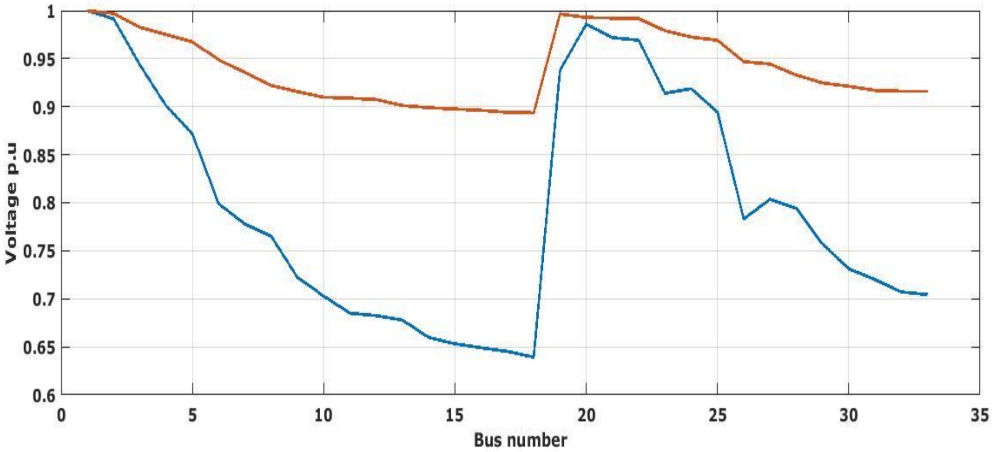

Figure 2: 33 Radial bus with voltage stability compensation

The table-I and II exhibit the voltage, index of stability, and cost data for case-1 and case-II, respectively. Case-II With the addition of wind power, the system stability margin and power loss are reduced. The lowest voltage P.Uvary from 0.9036 - 0.9196. Total Active demand (KW) is 3715 and reactive power demand is reduced 2511KVar to 2305KVar.

IEEE 69 Bus radial Distributionmethod.

To again examine the sensitivities of DGs position and size in congestion relieve application in a huge system,On a modified IEEE 69-bus system, a comprehensive series of testing is carried out.

CASE 1: (i) Without DG placement in 69 bus system.

Table 3: 69 Radial bus details without DG connection

69 RADIAL BUS DETAILS	Obtained Value	Bus Node
Total real demand	6885.000	-
Total reactive demand	3920.300	-
Minimum voltage and bus	0.7239	43
minimum voltage1 and bus1	0.8434	22
Minimum stability index and bus bus	0.2897	41
Minimum stability index1 and bus bus1	0.5077	22
Total real power loss base case	6.802	-
Total index with dg placement case	1.478	53
Cost before DG placement (in rupees/Mw)	5.1689e+04	-

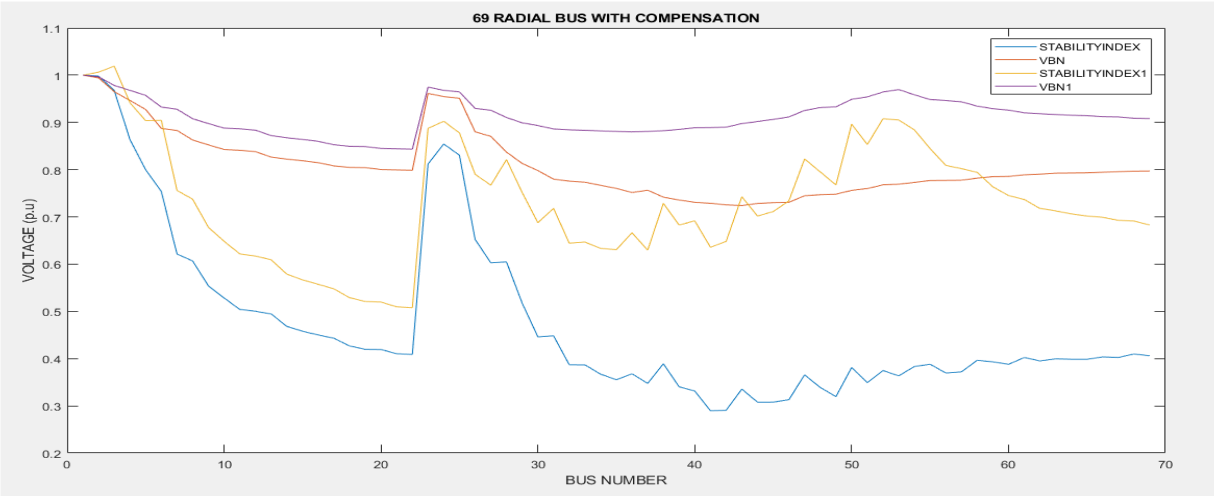

Figure 3 : 69 Radial bus with voltage stability compensation

CASE 2: (i) With Multi DG placement in 69 bus system.

From the Optimal power flow formulation described the first 5 buses (7, 12, 8, 13 and 41) The bus with the greatest Lagrange multiplier values is chosen as the best option for installing the DGs.. Similarly lowest values of LMPs are worst candidate buses (13, 15, 32, 43 and 22) among this bus 18 is the lowest candidate bus. Similarly, To analyse the quality of the Sensitivities computed, two situations are studied, one being the best case and the other being the worst case of DGs being inserted in the system.. The tests are divided into categories. The optimization problem will be executed for 24 hours.The setupof the DG in Case 2, with one DG attachedto bus 41 (the best candidate bus) and one DG attached to bus 22 (the worst candidate bus), is illustrated in Fig.4 and the resulting values are listed in the table. 4.

Table 4: 69 Radial bus details with DG connection (DG is connected at 41 and 22 bus)

69 RADIAL BUS DETAILS	Obtained value	DG connected at Bus Node
Total real demand (Kw)	6885.0000	-
Total reactive demand (KVar)	3815.000	-
Total dg_1 placement at 41	3142.161	-
Total dg_2 placement at 22	1327.930	-
Total Active power loss at base case	6.802	-
Total Active power loss index with 1DG placement case at bus	1.478	41
Total index Active power loss with 2DG placement case at bus	0.764	22
Minimum voltage(V(p.u)) and bus	0.7239	41
Minimum voltage1(V(p.u)) and bus bus1	0.8434	22
Minimum stability index and bus	0.2897	41

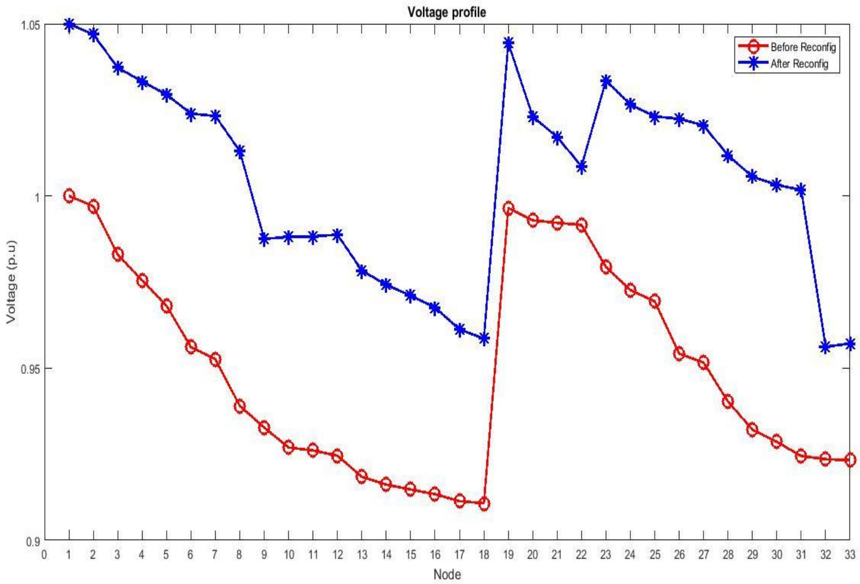

Figure 4 : 69 Radial bus with DG voltage stability compensation

Their Corresponding values of voltage, stability index and cost information for case-1 and case-II are displayed in the table-III and IV. Case-II With the addition of wind power, the systemsteadiness margin and power loss are reduced.The minimum value of voltage (P.U) vary from 0.2892 to 0.7239. Total real demand (KW) is 6885 and reactive power demand is reduced to 3920.3 to 3815.0KVar.

VI.CONCLUSION

Concerning the critical factors of DG sizing and allocation, the convergence criteria and DG size allocations with economical operation should also be considered in DG allocation. In this paper from based on the computed data that the proposed approach has demonstrated a stronger capacity to minimise losses as well as enhance the voltage profile.with respect to DG Placement, capacity and economical DG size using Hybrid BPSO-SFLA algorithm and also thismethod saves time during iteration.. The projected results of 69 radial buses demonstrate that the new system outperforms the current system.The proposed conclusions from results of 69 radial buses show that they improve the performance of existing system. MATLAB software was used to evaluate and analyse the 69 Radial Bus systems with and without DG, as well as the existing system.As a result, the increase the voltage profile, improve the stability index, and reduce the cost price, decrease in loss, all of which are multi-objectives of our suggested system, all are enhanced.

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