RESTRUCTURING OF DISTRIBUTED GENERATION FOR OPTIMAL PLACEMENT IN REAL TIME DISTRIBUTION SYSTEM WITH DIFFERENT LOAD MODELS TO MINIMIZE LOSS USING GENETIC ALGORITHM.

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ABSTRACT

With the use of modern technology, the power grid has been smarter in recent years. Integration of renewable energy sources at the distribution side will enhance the advantages of a smart grid. Attributed to the growing awareness of electric power generation's environmental consequences and new technology used in many generations that is more environmental friendly than conventional plants, distributed generation (DG) is gaining traction. Because of the rising demand for electricity in developing countries, it is important to produce more energy with the aid of DG. Due to innovations such as increased competitiveness, real-time pricing, spot pricing, and accurate estimation of energy loss is critical for obtaining more technological and economic benefits. When determining the position and size of DG, load modeling is critical. Improper load modeling may result in poor results. This paper examines the impact of load models on the estimated energy loss in DG planning. With the brief information proposed method study effect of load models on the evaluation of energy loss based upon season pattern of a year. Comparative analyses of the traditional static load model and the Voltage Dependent Load Model (VDLM) for energy loss at different load levels are conducted using one of the substations supplying energy from a state grid for a 13 bus system. The findings suggest that the load model used will provide considerably better results than a conventional constant load model.

Keywords: Distributed generation, Load model, Energy losses, Voltage profile.

I. INTRODUCTION

Growth in the power environment is crucial for the country because it enables development in various sectors of the economy, including engineering, agriculture, commercial enterprises, and railways. The power grid is developing and changing into a stronger, more controllable grid than in the past, incorporating modern automated and intelligent technologies to replace the outdated power network, referred to as smart grid. In the power grid, the use of distributed generation (DG) is one of the smart grid's most notable features. The incorporation of DGs disrupts the network's power flow and voltage conditions. As a result, when deciding the position and scale of DG, power loss and voltage control are the most important considerations. The majority of electrical loads in a power grid are related to low-voltage control networks. Residential, agricultural, and manufacturing loads are also included in these electrical loads. The active and reactive power usage of loads in a delivery grid is influenced by the voltage and frequency deviations in the system. Also, various types of load have different active and reactive power characteristics. In order to obtain optimal and more precise data, the frequency deviation is ignored in the study, and instead the effects of voltage deviation on active and reactive load forces are taken into account [1-5].

The optimum location of DG for loss reduction has been studied using various classical and/or modern optimization approaches. Analytical formulation of the DG allocation dilemma. The technique for determining the best location to mitigate overall loss determines the best location for a single DG. However, the researchers concluded that the harm inflicted by various placements varies considerably, so this should be taken into account when deciding on a position [2]. This thesis introduces and tests an empirical approach for radial systems that can
be used for optimised DG positioning and resizing without the use of admittance impedance, or Jacobin matrix, and only with a power flow [3]. Traditional DG delivery paradigms differ by broadening the field of planning and engineering, as well as the sophistication of what must be considered. Many conventional path and thumb laws are no longer applicable. New laws and instructions, on the other hand, are probable [4]. Since the proposed approach is a non-iterative algorithm, there is no issue with convergence. Other considerations can influence DG placement in practise [5]. The optimal location problem of distributed generators in the distribution system has been explained using tabu search algorithms. To implement the TS challenge, many techniques, such as decomposition / coordination techniques, have been implemented [6]. The optimum size for various loading conditions, as well as the simulation approach for DG deployment, are discussed in this article. The distribution mechanism is put to the test under three different loads: peak, medium, and low, indicating that the failure is a result of the load [8]. The author proposes a fuzzy-GA approach for DG positioning in distribution systems [9], as well as a new Quantum Genetic Algorithm to mitigate device leakage and preserve the voltage profile [10].

The below is how the article is structured: Section 2 discuss problem formulation with modeling of loss and load, section 3 represented case study. The proposed methodology is view in section 4. The results of the Simulation and discussions are presented in Section 5 and finally, in Section 6, several pertinent observations are presented.

II. PROBLEM FORMULATION

Based on the system configuration, power failure in the delivery system is affected by a variety of causes, including loss levels across transmission and distribution cables, transformers, capacitors, insulators, and so on. The two elements of power losses are active and reactive power losses. For an increase in real power loss, the efficiency of delivering electricity to consumers decreases; as a result, real power loss typically attracts more attention from utilities. Reactive power, on the other hand, allows real power to be transmitted to customers at an appropriate voltage level through transmission and distribution lines. Since the active control flow in the device must be sustained at a certain level, reactive power loss cannot be overlooked. A power grid is made up of a series of buses that are linked by transmission lines. Charges are supplied from these buses, and electrical power is pumped into the bus to meet the load demand. The load on the power grid is heavily distributed and changes over time, making detailed simulation of the load impossible. The demand reported for all linked buses for a feeder is presumed to be equally divided in this analysis. The voltage profile and voltage reliability for a radial distribution system are improved by determining the location and size of the DG units in a way that minimises overall active power loss while still meeting the restrictions of a set number of DG units and total energy of the DG units.

The aim is to reduce overall power losses in radial distribution systems by finding and sizing distributed generation in the most efficient way possible. For a radial distribution system, the objective function, total active and reactive power loss, can be expressed mathematically as,

$$P_{\text{loss}} = \sum_{i=1}^{N_{\text{bus}}} I_i^2 R_i$$  (1)

$$Q_{\text{loss}} = \sum_{i=1}^{N_{\text{bus}}} |I_i|^2 X_i$$  (2)

where \(N_{\text{bus}}\) is the total number of lines in the system, \(|I_i|\) is the magnitude of line current flow in a branch \(R_i, X_i\) are the line resistance and line reactance respectively in ohms of the branch \(i\).

Minimize \(S_{\text{loss}} = \sum_{i=1}^{N_{\text{bus}}} (P_{\text{loss}} + Q_{\text{loss}})\)  (3)

The objective function must satisfy the organisational constraints. Equality Constraints and Inequality Constraints are two different types of operating constraints. The active and reactive power associated with the nonlinear power flow equations was used to describe the equality constraints. The formation of power balance constraints are
\[ P_i = P_{dgi} - P_{di} \quad (4) \]
\[ Q_i = Q_{dgi} - Q_{di} \quad (5) \]

Where \( P_i \) is the real power at bus \( i \) in kW
\( Q_i \) is the real power at bus \( i \) in kVAR
\( P_{dgi} \) is the real power generated by DG at bus \( i \) in kW
\( Q_{dgi} \) is the reactive power generated by DG at bus \( i \) in kVAR
\( P_{di} \) is real power demand of load at \( i \) bus in kW
\( Q_{di} \) is reactive power demand of load at \( i \) bus in kVAR

For satisfaction of the objective function inequality constraints lies between permissible limits, bus voltage and DG capacities limits as defined below.

Magnitude of voltage at bus should be
\[ V_{i_{\min}} \leq V_i \leq V_{i_{\max}} \]

where \( V_{i_{\min}} \) & \( V_{i_{\max}} \) are permissible minimum and maximum voltage at bus in PU.

The DG should be maintained within permissible limits, as the capacity of each DG may differ around its nominal value. It can be expressed as
\[ P_{dgi_{\min}} \leq P_{dgi} \leq P_{dgi_{\max}} \]
\[ Q_{dgi_{\min}} \leq Q_{dgi} \leq Q_{dgi_{\max}} \]

where
\( P_{dgi_{\min}} \) and \( P_{dgi_{\max}} \) are minimum and maximum real power generated by DG in kW
\( Q_{dgi_{\min}} \) and \( Q_{dgi_{\max}} \) are minimum and maximum reactive power by Distribution Generator in kVAR [14].

2.1. Modeling of Load

From a techno-economic perspective, the utility benefits from the reduction of power shortages in the transmission and distribution networks installing a DG would result in a reduction in losses, which would have a significant effect on utility benefits. Reduced losses may boost benefits, but increased losses due to DG installation can have the opposite effect.

A fixed PQ load is typically modelled in steady-state power measurement, and it is independent of voltage or frequency.

In fact, loads are not precisely fixed PQ on any feeder; instead, the Mixed load paradigm combines residential, industrial, and commercial loads. The delivery method, though, can see mixed loads depending on the type of the region being supplied.

Since the load is voltage sensitive, it is referred to as a Voltage-Dependent Load Model (VDLM). VDLMs are classified into three categories: domestic, industrial, and commercial. The IEEE Task Force
has described voltage based load models for residential, commercial, and industrial applications for dynamic efficiency. [11, 12]

\[ P_L = P_o V^\alpha \]

\[ Q_L = Q_o V^\beta \]

Where,

- \( V \) is voltage magnitude at bus
- \( \alpha \) exponential for active power
- \( \beta \) exponential for reactive power
- \( P_o \) Active power at normal voltage
- \( Q_o \) Reactive power at normal voltage

0.25 < \( \alpha \) < 2.0

3.0 < \( \beta \) < 4.0

0.9 < \( V \) < 1.1 pu

<table>
<thead>
<tr>
<th>Season</th>
<th>period</th>
<th>Residential</th>
<th>Commercial</th>
<th>Industrial</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>( \alpha )</td>
<td>( \beta )</td>
<td>( \alpha )</td>
</tr>
<tr>
<td></td>
<td>Day</td>
<td>0.72</td>
<td>2.96</td>
<td>1.25</td>
</tr>
<tr>
<td></td>
<td>Night</td>
<td>0.92</td>
<td>4.04</td>
<td>0.99</td>
</tr>
<tr>
<td>Winter</td>
<td>Day</td>
<td>1.04</td>
<td>4.19</td>
<td>1.50</td>
</tr>
<tr>
<td></td>
<td>Night</td>
<td>1.30</td>
<td>4.38</td>
<td>1.51</td>
</tr>
</tbody>
</table>

Case I Without DG

![Diagram of Distribution System Without DG](source)

The real and reactive power losses without DG for the system shown in fig. 1 are as follows:

\[ P_{\text{LosswdDG}} = I_L^2 r l \]  

\[ Q_{\text{LosswdDG}} = I_L^2 x l \]  

The complex power of load is given by \( S_L = P_L + jQ_L \)

The current observed by the load

\[ I_L = \frac{P_L - jQ_L}{\sqrt{3}V_L} \]
the complex power supplied by DG is given by \( S_{DG} = P_{DG} + jQ_{DG} \)

The output current by DG is given by

\[
I_{DG} = \frac{P_{DG} - jQ_{DG}}{\sqrt{3}V_r}
\]

where

\( r, x \) are the line resistance and line reactance respectively in ohms per kilometer of the conductor, \( l \) is the total length of conductor, \( V_r \) is the receiving end voltage, \( P_L, Q_L \) are the real and reactive power of load, and real power and reactive power supplied by the DG is \( P_{DG}, Q_{DG} \).

Case IIDG at Substation Bus

When the DG is attached to the source bus as seen in fig. 2, the current flowing through the feeder remains constant, but the current drawn from the source is limited by the amount of current pumped by the DG. The load's power would be exchanged between the DG and the source. Consequently

\[
P_L = P_{Source} + P_{DG}
\]

And

\[
Q_L = Q_{Source} + Q_{DG}
\]
When the DG is attached outside of the substation, as seen in fig. 3, the current flowing through the feeder from the source bus to the DG connected point will decrease by the amount of current pumped by the DG at that point. The load’s power requirements, on the other hand, would be met by both the source and the DG. The power loss can be measured as follows:

Total loss = Loss up to DG point + Loss from DG point to Load bus

\[ P_{\text{LossDG}} = (I_L - I_{DG})^2 rd + I_L^2 r(l - d) \]  \hfill (11)

\[ P_{\text{LossDG}} = \left( \frac{(P_L - P_{DG})^2}{3V_r^2} + \frac{(Q_L - Q_{DG})^2}{3V_r^2} \right) r + \frac{P_L^2 + Q_L^2}{3V_r^2} r(l - d) \]  \hfill (12)

\[ P_{\text{LossDG}} = \frac{r}{3V_r^2} \left[ \left( P_L^2 + Q_L^2 \right) + \left( P_{DG}^2 + Q_{DG}^2 - 2P_L P_{DG} - 2Q_L Q_{DG} \right) l \right] \]  \hfill (13)

Similarly

\[ Q_{\text{LossDG}} = \frac{x}{3V_r^2} \left[ \left( P_L^2 + Q_L^2 \right) + \left( P_{DG}^2 + Q_{DG}^2 - 2P_L P_{DG} - 2Q_L Q_{DG} \right) l \right] \]  \hfill (14)

Positive sign indicates that the loss will decrease with power injection by DG. Equation (13) and (14) shows the power loss with DG for a fixed load model.

While for voltage dependent load model, the loss can be obtain by substituting eq (1) and (2) in (13) and (14).

\[ P_{\text{LossDG}} = \frac{r}{3V_r^2} \left[ \left( P_o V^{\alpha_d} \right)^2 + \left( Q_o V^{\alpha_d} \right)^2 \right] l + \left( P_{DG}^2 + Q_{DG}^2 - 2P_o V^{\alpha_d} P_{DG} - 2Q_o V^{\alpha_d} Q_{DG} \right) d \]  \hfill (15)

\[ Q_{\text{LossDG}} = \frac{x}{3V_r^2} \left[ \left( P_o V^{\alpha_d} \right)^2 + \left( Q_o V^{\alpha_d} \right)^2 \right] l + \left( P_{DG}^2 + Q_{DG}^2 - 2P_o V^{\alpha_d} P_{DG} - 2Q_o V^{\alpha_d} Q_{DG} \right) d \]  \hfill (16)

Since \( V_r, \alpha, \beta, P_{DG} \) and \( Q_{DG} \) are independent variables It can be seen from (15 and 16) that it is difficult determine whether the loss is reduced or increased. The power losses in a distribution network where DG has been connected, with the help of different load models is a nalized.

III. THE CASE SYSTEM

Maharashtra’s state utility corporation distributes electricity in the state. As seen in fig. 4, one of the grid connected at 33 kV voltage level substation is selected for case analysis. Wind generation is currently attached to a substation bus. 33 kV feeders are attached to different area substations for further delivery of electric energy available from sources and wind energy.
In most power systems, the load is voltage sensitive and can be classified as domestic, manufacturing, or commercial. The method should only be viewed for residential customers when assessing the impact due to residential load. Furthermore, to obtain the influence of industrial and commercial customers, the system's consumers should be industrial and commercial consumers, respectively. In fact, it is impossible to differentiate buses by customer type. In other words, depending on the region to be served, each bus can have a mix of various customer categories. Buses are divided into three categories in this study: residential, commercial, and manufacturing. In addition, the load pattern varies depending on the season. Figure 5 depicts a normal annual load profile for the chosen substation, indicating a winter peak and summer minimum load requirement. The daily demand profile, on the other hand, varies with the seasons, as shown by the load curve in figure 6. The profiles for the day of winter maximum demand on January 21st, a regular winter day, the summer minimum demand on June 21st, and the summer maximum demand on June 21st, and a typical summer day can be seen. Summer night load levels are considered low, summer day and winter night load levels are considered average, and winter day load levels are considered peak.
Fig. 6 Daily load demand for summer and winter season

Both buses carry a combination of industrial, commercial, and residential passengers. For the purposes of the optimization problem, bus numbers 3 and 4 are considered manufacturing, bus numbers 2 and 5 are considered commercial, and the remaining buses are considered residential. Table 2 shows the resistance and reactance of each line, as well as the load demand for each bus.

<table>
<thead>
<tr>
<th>Bus No</th>
<th>R Ω</th>
<th>X Ω</th>
<th>P_L</th>
<th>Q_L</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0848</td>
<td>0.0849</td>
<td>1013.87</td>
<td>343.32</td>
</tr>
<tr>
<td>3</td>
<td>1.355</td>
<td>1.357</td>
<td>5767.84</td>
<td>512.02</td>
</tr>
<tr>
<td>4</td>
<td>2.372</td>
<td>2.374</td>
<td>1576.02</td>
<td>94.40</td>
</tr>
<tr>
<td>5</td>
<td>4.404</td>
<td>4.409</td>
<td>2550.76</td>
<td>1498.05</td>
</tr>
<tr>
<td>6</td>
<td>9.484</td>
<td>9.495</td>
<td>4390.36</td>
<td>2229.60</td>
</tr>
<tr>
<td>7</td>
<td>7.114</td>
<td>7.123</td>
<td>1013.87</td>
<td>343.32</td>
</tr>
<tr>
<td>8</td>
<td>4.404</td>
<td>4.409</td>
<td>2550.76</td>
<td>1498.05</td>
</tr>
<tr>
<td>9</td>
<td>9.483</td>
<td>9.495</td>
<td>4390.36</td>
<td>2229.60</td>
</tr>
<tr>
<td>11</td>
<td>7.448</td>
<td>7.457</td>
<td>1013.87</td>
<td>343.32</td>
</tr>
<tr>
<td>12</td>
<td>2.723</td>
<td>2.726</td>
<td>2550.76</td>
<td>1498.05</td>
</tr>
<tr>
<td>13</td>
<td>5.759</td>
<td>5.766</td>
<td>2550.76</td>
<td>1498.05</td>
</tr>
</tbody>
</table>

For the proposed system, 13 buses and two additional buses are powered by wind turbines located at a substation, with outputs of 2543.062 kW, 596.77 kVA and 3218.062 kW, 798.395 kVA, respectively. To observe the effect of this generation on loss and bus voltage, the load flow of the system shown in fig. 4 was carried out using a 33kV base voltage and a base MVA of 100 MVA.

IV. GENETIC ALGORITHM

The Genetic Algorithm is a direct tool for global optimization and search. It belongs to the Evolutionary Algorithms category. The key three principals used in evolutionary algorithms are reproduction, natural selection, and population diversity, which is sustained by the disparity between each generation and the last. By selection and other operators including crossover and replication, the GA keeps a population of individuals (chromosomes) for evolution. Any member of the society is adopted (fitness) and assessed in the community. That is, the function that is optimised is evaluated for each entity in terms of optimization. The better solutions in next population is obtained through crossover and mutation by the selection of the best gene combinations (individuals)[13].

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Algorithm Proposed as below:

The suggested method for determining the optimum position of DG in a radial distribution is based on multi-objective GA[13].

Step 1: Prepare the line, load the data, and send it to the user as an input.

Step 2: Do a load flow analysis and determine the delivery mechanism.

Step 3: Create an initial population at random and set the iteration count to zero.

Step 4: Determine the DG's maximal size and location (no. of bus).

Step 5: If the bus voltage is not within the chromosome's designated range, the chromosome is infeasible and should be discarded.

Stage 6: Determine the value of the fitness function for each chromosome, which is the value of the objective function F in this situation (5).

Step 7: Sort the objective function values from lower to higher, excluding the unfit values and keeping the most fit.

Step 8: To produce a new set of chromosomes, use the preserved chromosome to execute Mutation and Mating operations.

Step 9: Determine the fitness values of the newly formed chromosomes.

Phase 10: Boost the number of iterations by one and repeat steps 5 through 9 before the number of iterations exceeds the limit.

V. RESULT AND DISCUSSION

The proposed case study examined load flow analysis in the context of the above-mentioned distribution system. GA optimization strategy with 120 population scale, 25 generations, and 0.8 crossover fraction is used to determine the position and value of DG for out of substation.

Centered on the injection of wind generation, two cases are considered, the load flow analysis is completed, and the findings are outlined below.

Case I Without DG
The proposed distribution system is tested for load flow analysis without considering any DG connected with constant PQ model, voltage dependent load model and further with these both models GA is applied for winter days.

![Fig. 8 Real power loss variation with different load model without DG](image1)

![Fig. 9 Real power loss variation for different load models with existing DG at source](image2)

The loss is higher when the device is measured with constant load, but it decreases when the voltage dependent load model is used for mixed load and separately for residential, commercial, and industrial loads, as seen in fig. 8. The loss difference with DG attached to source bus is seen in Fig. 9, which also shows that when constant load is assumed, the loss is much higher.

![Variation in Total Power Loss](image3)
Figure 10 shows that the original DG at the root causes more failure than the DG installed by evolutionary optimization. Due to the impossibility of having category-specific feeders, the following results were obtained by considering voltage-dependent mixed load and applying evolutionary optimization GA.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Load Model</th>
<th>DG1</th>
<th>DG2</th>
<th>Total Active Size kW</th>
<th>Total Reactive Size kVAR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Location</td>
<td>Active Size kW</td>
<td>Reactive Size kVAR</td>
<td>Location</td>
</tr>
<tr>
<td>1</td>
<td>Constant PQ</td>
<td>12</td>
<td>6686.07</td>
<td>3867.62</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>Residential</td>
<td>9</td>
<td>6810.42</td>
<td>630.97</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>Commercial</td>
<td>12</td>
<td>6579.86</td>
<td>219.06</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>Industrial</td>
<td>9</td>
<td>8389.99</td>
<td>961.70</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>Mixed PQ</td>
<td>6</td>
<td>7221.21</td>
<td>1076.32</td>
<td>7</td>
</tr>
</tbody>
</table>

From Table 3 the required active and reactive size of DG obtain minimum in mixed PQ model which is actual case at any real time power distribution system.

Fig. 11 Variation of Real Power Loss for VDLM with and without DG

Fig. 11 Variation of Reactive Power Loss for VDLM with and without DG
Table 4 Active and reactive power loss reduction by DG placement for different load model

<table>
<thead>
<tr>
<th>Load Model</th>
<th>Active Power Loss kW</th>
<th>Reactive Power Loss kW</th>
<th>Total Loss kW</th>
<th>% Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant Load Model</td>
<td>3010.162</td>
<td>3013.676</td>
<td>4259.497</td>
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</tr>
<tr>
<td>Voltage Dependent Load Model</td>
<td>1452.543</td>
<td>1454.254</td>
<td>2055.417</td>
<td>51.74535</td>
</tr>
<tr>
<td>VDLM with DG at Source</td>
<td>1452.543</td>
<td>1454.254</td>
<td>2055.417</td>
<td>51.74535</td>
</tr>
<tr>
<td>VDLM with DG by GA</td>
<td>195.9672</td>
<td>196.2094</td>
<td>277.3108</td>
<td>93.48981</td>
</tr>
</tbody>
</table>

As it is illustrated in table 4 DG placement reduces with use of voltage dependent load model up to 93.50%. Furthermore, if DG is installed at the source bus, the loss remains unchanged in the second and third cases, while table 4 shows that DG implementation in the fourth case results in the greatest loss reduction relative to the other cases. In addition to decrease in the power losses for distribution networks, proper DG planning also improves the overall network voltage magnitude profiles shown in table 5.

Table 5: Bus Voltage profile

<table>
<thead>
<tr>
<th>Bus No/Load Model</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant Load Model</td>
<td>1.00</td>
<td>0.99</td>
<td>0.99</td>
<td>0.99</td>
<td>0.92</td>
<td>0.86</td>
<td>0.94</td>
<td>0.84</td>
<td>0.86</td>
<td>0.97</td>
<td>0.96</td>
<td>0.83</td>
<td>0.81</td>
</tr>
<tr>
<td>Voltage Dependent Load Model</td>
<td>1.00</td>
<td>0.99</td>
<td>0.99</td>
<td>0.99</td>
<td>0.95</td>
<td>0.92</td>
<td>0.95</td>
<td>0.90</td>
<td>0.92</td>
<td>0.97</td>
<td>0.96</td>
<td>0.91</td>
<td>0.89</td>
</tr>
<tr>
<td>VDLM with DG at Source</td>
<td>1.00</td>
<td>0.99</td>
<td>0.99</td>
<td>0.99</td>
<td>0.95</td>
<td>0.92</td>
<td>0.95</td>
<td>0.90</td>
<td>0.92</td>
<td>0.97</td>
<td>0.96</td>
<td>0.91</td>
<td>0.89</td>
</tr>
<tr>
<td>VDLM with DG by GA</td>
<td>1.00</td>
<td>0.99</td>
<td>0.99</td>
<td>0.99</td>
<td>0.98</td>
<td>0.99</td>
<td>0.99</td>
<td>0.98</td>
<td>0.97</td>
<td>0.98</td>
<td>0.98</td>
<td>0.97</td>
<td>0.96</td>
</tr>
</tbody>
</table>

Fig.12. Variation in bus voltage without and with DG for different load model.

Table 6: Tail end Bus Voltage profile

<table>
<thead>
<tr>
<th>Load Model/ Bus No</th>
<th>8</th>
<th>11</th>
<th>13</th>
<th>% rise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant Load Model</td>
<td>0.8415</td>
<td>---</td>
<td>0.9656</td>
<td>0.8134</td>
</tr>
<tr>
<td>Voltage Dependent Load Model</td>
<td>0.9093</td>
<td>8.0611</td>
<td>0.9695</td>
<td>0.4065</td>
</tr>
<tr>
<td>VDLM with DG at Source</td>
<td>0.9093</td>
<td>8.0611</td>
<td>0.9695</td>
<td>0.4065</td>
</tr>
<tr>
<td>VDLM with DG by GA</td>
<td>0.9847</td>
<td>17.0188</td>
<td>0.9827</td>
<td>1.7723</td>
</tr>
</tbody>
</table>

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The bus voltage and tail end voltage do not change with the introduction of DG at the source bus second and third cases, as seen in tables 5 and 6. In the fourth example, using an evolutionary algorithm like GA, it can be shown that positioning DG in the correct position with the right size improves the bus and tail end bus voltage profiles significantly.

### Table

<table>
<thead>
<tr>
<th>Load Model</th>
<th>0.8415</th>
<th>0.9656</th>
<th>0.8134</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage Dependent Load Model</td>
<td>0.9093</td>
<td>0.9695</td>
<td>0.8976</td>
</tr>
<tr>
<td>VDLM with DG at Source</td>
<td>0.9093</td>
<td>0.9695</td>
<td>0.8976</td>
</tr>
<tr>
<td>VDLM with DG by GA</td>
<td>0.9847</td>
<td>0.9827</td>
<td>0.9696</td>
</tr>
</tbody>
</table>

Many techno-economic advantages can be gained by placing DG in the right place with the right scale in the delivery chain. The test system considered for this study is a wind energy system to meet load demand. Initially, the device was tested with and without the wind generator, using a constant load model and a voltage based mixed load model. The results show that installing DG at the source bus, where it is now, has little impact on failure, and that there is no voltage change on either bus. Then, using the GA optimization technique, work is done on loss minimization. The GA optimization method's simulation findings indicate a substantial reduction in power loss of up to 93.48 percent. In addition, an unprecedented increase in tail end node voltage of up to 19.19 percent was observed, which a realistic challenge for most rural delivery networks is and as a result, it's crucial from the customer's perspective. The proposed study is a practical approach to an issue in rural areas, such as reducing actual power loss and improving tail end voltage.

### REFERENCES


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