Reactive Power DG Replacement by Optimization Approaches

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Abstract- The electricity cost is calculated based on different proportions such as 50% for fuel consumption, 25% for distribution, 20% for generation, and % for transmission which has created an alert to use or generate the alternative resources of power. For the levels of distribution, the ratio of reactance to resistance (X/R) is low when compared to levels of transmission which has resulted in high power losses and voltage magnitude dip along the distribution (radial) lines. The distribution systems must be able to provide energy/electricity to each consumer at an appropriate form of voltage rating. The modern forms of power are complex in nature with multiple load centres and generating stations interconnected through the transmission and distribution networks. The main objective of the energy based power system is energy generation and to deliver the energy/power at to its customers at its rated voltage-based value with minimum losses.

Keywords- Power, dg, losses,reactive power

I. INTRODUCTION

The energy plays a vital role for all the humans as the it can neither be created nor it get destroyed but it can move/transform from one place to other. The modern living has realized the increased importance of energy as the life is moving faster, there is big need for fast communication, fast transport and manufacturing processes. So, energy industry forms one of the biggest consumer market [1, 2]. The use of electric power system requires an alternative generation because of its large demand by the consumers. The electricity cost is calculated based on different proportions such as 50% for fuel consumption, 25% for distribution, 20% for generation, and % for transmission which has created an alert to use or generate the alternative resources of power. For the levels of distribution, the ratio of reactance to resistance (X/R) is low when compared to levels of transmission which has resulted in high power losses and voltage magnitude dip along the distribution (radial) lines. The distribution systems must be able to provide energy/electricity to each consumer at an appropriate form of voltage rating. The modern forms of power are complex in nature with multiple load centres and generating stations interconnected through the transmission and distribution networks. The main objective of the energy based power system is energy generation and to deliver the energy/power at to its customers at its rated voltage-based value with minimum losses [3]. In case of heavy loading condition, the reactive form of power flow is the major cause of losses, thus reducing the levels of voltage simultaneously. So, there is occurs a big need to minimize real losses of power and to improve the level of voltage in distribution systems. The optimized form of network configuration represents a topological feeder structure by changing the open/closed sectionalizing status and tie-line switches with minimized losses, saving the distribution system radial structure [4, 5].

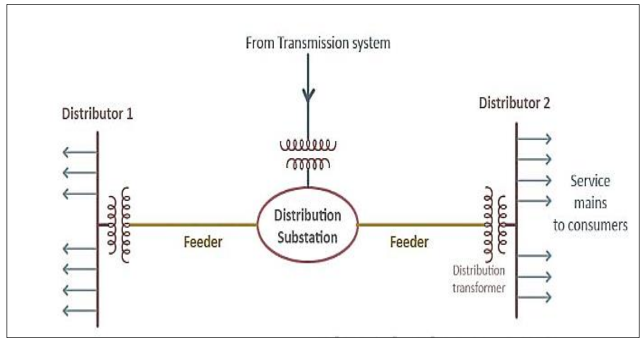

Fig.1: Simple radial AC power distribution system[13]

The electrical power distribution represents the final stage of power delivery. It usually carries power or electricity from the transmission system to its customers on individual basis. When the distribution system gets connected to transmission system, it lowers the transmission voltage to a medium form of voltage lying between 2KV and 35KV with the help of transformers used in the system [6]. The primary lines of distribution carries medium voltage to the transformers in the distribution section placed near customer's location.The distribution transformers again performs the voltage reduction for its utilization process in distinct areas such as household appliances, lighting, industrial equipment etc. Some of the consumers gets the supply from single (one) transformer through secondary-based distribution lines. The residential and the commercial consumers are linked to secondary distribution lines through the service-drop mechanism. The highly demanding consumer may be linked to primary level of distribution or sub-transmission level on direct basis.

The high level of power loss in distribution and transmission system results in reduction of existing system's efficiency [7]. The study has indicated that the losses of distribution power owed or unsettled to Joule effect justifies 13% of the energy generated. The effect defines the lost energy (heat dissipated) in a conducting material. Fig.1 indicate the losses of transmission and distribution in total power output percentage for several countries including the power theft/ pilferage. The data provided by the World Bank indicates a worldwide study of transmission and distribution losses (annually) that accounts for 8.12% of the transmitted electricity. The loss of transmission and distribution for Haiti carries 55.39% loss which created a huge impact on the financial status of the country including the overall efficiency and performance of the system [9]. Thus the major challenge is to deal and focus upon the present researching methods and areas that would effectively utilize the existing technologies and infrastructure with superior planning.

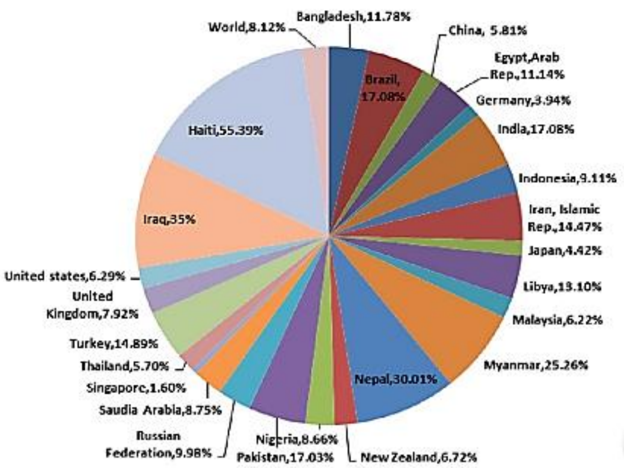

Fig.2: Data Analysis: Transmission and Distribution Losses[12]

A. Load Flow Analysis

The study of power flow popularly known as load flow helps in determining the bus voltages (steady-state), transformer tap settings, active and reactive power flows, voltage set points for generator exciting regulator, circuit loading, losses in system, and system performance in case of emergency condition. It also determines the initial motor start-up based voltage profile [8]. The power systems operate critically under slow transforming conditions that may be analysed using steady-state operation. This type of analysis provides a starting platform to other type of analysis such as under heavily loaded system, the disturbances that cause instability but it may not have any effect in case of lightly loaded conditions. The analysis of power flow is the major core area for the analysis of power systems like additional planning, facilities of generation, and transmission-based expansions. The conditions of overloads and voltages along with allowable tolerances are checked very often. So, for the study of load flow analysis, generally a balanced three-phase operation is usually assumed. The network planning for medium voltage and Load flow calculation usually involves the following steps:

1. To determine the values of element for the components of passive networks.
2. To determine the values and locations of all power (complex) loads.
3. To determine the generation constraints and its specifications.
4. To develop a mathematical model that particularly describes network power flow.
5. To check constraint violations.
6. To compute all the system bus voltages.
7. To determine the transmission lines based reactive and the real power flows in the network.

The calculations of the load flow are generally carried to maintain system stability while it's running operation and determines optimal or possible selection grid component selection like machine regulators automatic control setting, transformers' voltage regulators etc. The inputs to be determined are the currents and/or voltages and/or the reactive/active power at the generator's port or the customer's port. The cables and the over-head line form the significant elements of the network [10, 11]. To carry simple grid-based calculations, few elements of the circuit are used for a specified task. For low line voltages, mostly there is work done by the ohmic resistance and for high line voltages, the longitudinal impedance is to be considered for the operational purpose and for long lines, the capacitive components must be kept in mind [7]. In order to classify the overloading of the equipment and the voltages at the busbar, the given limit values along with network operator are jointly provides as follows:

Table.1. Network equipment description

Network equipment description	Degree of loading
-	%
rated load	< 80
heavy load	≥ 80, < 100
over load	≥ 100

Table.2 Voltage level description

Voltage leveldescription	Voltage more than % nominal voltage
-	%
bus bar voltage is ok	≥ 94, ≤ 106
bus bar voltage is to low	< 94

B. Voltage Stability

It is defined as the power system ability to maintain steady-state system voltage at all the buses in the operating system after the subjection of disturbance from initial condition of operation. It basically carries issues. One is the maximum load ability estimation and the critical power computation leading to voltage collapse. In large typical networks, the load flow analysis is used very commonly [2, 8]. This section carries the analysis of power/load flow with its voltage stability application to understand the concept of voltage stability indices. The voltage stability index helps in computing the bus proximity very sensitive to the mechanism of voltage collapse in distribution systems. The distribution line interchanged power equations active and reactive equations of power is basically used to develop the index for stable process and hence, it only requires solution based on power flow study at its necessary power equations [5]. The mathematical representation of voltage stability index based on distribution line model as shown in fig. is presented as follows:

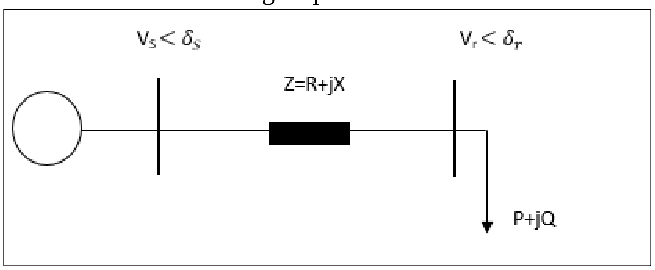

Fig.3: Single Line Diagram: Two bus distribution system

The quadratic equation which is commonly in load flow analysis are used for calculating the sending end line voltages and these can be written in a generalized form given as:

$$V_r^4 + 2V_r^2(PR + QX) - V_s^2V_r^2 + (P^2 + Q^2)|Z|^2 = 0 \text{ .... } (1)$$

From equation (1), the active and the reactive power at the line receiving end can be written as

$$P = -\cos(\emptyset_Z)\,V_r^2 \pm \frac{\sqrt{\cos^2(\emptyset_Z)\,V_r^4 - V_r^4 - |Z|^2Q^2 - 2V_r^2\,QX + V_s^2V_r^2}}{|Z|} \text{ ... ...} 1(a)$$

$$Q = -\sin(\emptyset_Z)\,V_r^2 \pm \frac{\sqrt{\sin^2(\emptyset_Z)\,V_r^4 - V_r^4 - |Z|^2P^2 - 2V_r^2\,PX + V_s^2V_r^2}}{|Z|} \text{ ... ... } 1(b)$$

From equation 1(a) and 1(b), the values of real (P) and reactive powers will exist at receiving end based on the following condition.

$$\cos^2(\emptyset_Z)\,V_r^4 - V_r^4 - |Z|^2Q^2 - 2V_r^2\,QX + V_s^2V_r^2 \geq 0 \text{ ... ... } 3(a)$$

$$\sin^2(\emptyset_Z)\,V_r^4 - V_r^4 - |Z|^2P^2 - 2V_r^2\,PX + V_s^2V_r^2 \geq 0 \text{ ... ... } 3(b)$$

Performing the summation at each side of equation 3(a) and 3(b)

$$2V_s^2V_r^2 - 2V_r^2(PR + QX) - |Z|^2(P^2 + Q^2) \geq 0 \text{ ... ... } (4)$$

Thus with the help of equation (4), it is observed that there is some reduction/decrease with increased line impedance and power transferred and thus it can be used for maintaining the bus stability index for the case of distribution network system is given as:

$$SI\,(r) = 2V_s^2V_r^2 - V_r^4 - 2V_r^2(PR + QX) - |Z|^2(P^2 + Q^2) \text{ ... ... } (5)$$

The equation (5) is used to find the voltage stability index in radial distribution systems for each of the receiving bus end. Thus after load flow study operation, all the nodal voltage and the branch currents are known which helps in easy calculation of real (P) and the reactive (Q) powers. The position of the node where the stability index value stays minimum is considered to be most sensitive to voltage collapse mechanism.

C. Distribution System: Power Loss Minimization

The one major advantage of distribution system is the process of power loss reduction in the system line. In normal, the power loss based on real power generates more attention for the connected utilities as it is helpful in reducing the transmitted energy efficiency to the consumers. The reactive loss of power is not of greater importance as it is required to be maintained at a specific amount for adequate level of voltage [9, 10]. Hence, the reactive power (Q) enable transfer of the real power (P) through transmission and distribution lines to the consumers. The loss reduction in the system by strategical planning of DG along its network is considered to be very useful if decision analyzer is strictly committed to lower the system losses and to improve the performance of the network i.e. on losses and reliability level, maintenance of low level reasonable investments. This kind of methodology is very impressive in case recovered revenue by the DISCOs (distribution companies) that not only depend upon the value of assets but also depend upon the performance of the network [11].

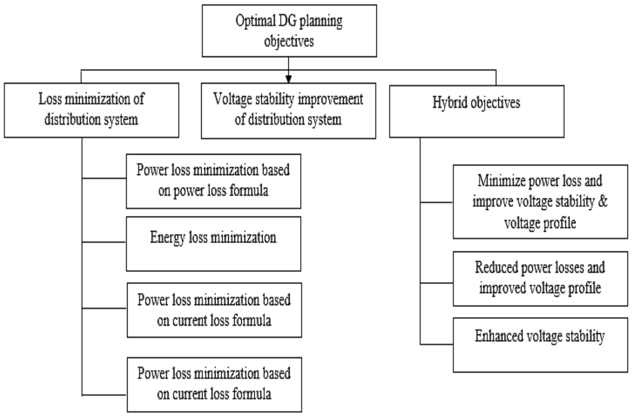

Fig.4: Optimal DG planning objectives

(a) Losses in Distribution System: The major role of electrical-based distribution system is to provide electricity to its particular customers with the process of completing the mechanism with minimum point of voltage. From bases, the electrical power distribution is complemented at its end level with losses of power at all the times. In distribution systems, the losses of power arise due to Joule's effect affecting economy straightly [12]. Such type of major losses effect the supply utility efficacy in total. There are two types of power distribution losses.

- Technical Losses: The losses that occur technically usually occur natural in form (due to internal action to power system) and consist as the process of power dissipation in electrical power system)
- Non-Technical Losses: These occur basically by external actions such as electricity theft, errors, record-keeping, and customer's non-payment for electricity.

(b) **Loss Reduction Techniques**

Various types of reduction techniques are described in the section below:

*1. Network Reconfiguration:*It is technique or procedure of switches operating to modify the topology of the circuit such that the charges and operational overloads get more concise while sustenance of the stated constraints.

2. Distribution Transformers Sizing and Locating: In aspect of clients, the DTs are not located centrally i.e. the main reason for the farthest consumers to have low voltage whereas the high level of voltage gets retained at other transformer. This has contributed to distribution system maximum losses [9]. Here, the DTs must be placed near to load center and the large transformers must be replaced by small rating transformers which serves small consumers in order to maintain optimum level voltage.

*3. Automatic Voltage Booster:*Popularly known asAVB which at point of site increases the voltage in different steps in turn developing the voltage profile and reduce the sectional losses outside its point of location towards its receiving side. The voltage boost done by AVB is approximately 10% in equal steps. So, the minimization of loss is directly proportional to enhancement process of voltage.

*4. Reactive Power Compensation:*It describes the energy management to boost ac energy systemenactment. This kind of technique provides a large area of both the difficulties related to consumer and the system, specifically related to subjects of power superiority as some of the QoS (quality of service) can be easily resolved with reactive power requisite control. In distribution system, there is use of inductive load requiring large reactive power. The shunt based capacitor at its site helps in providing compensation for reactive power i.e. not dependent on load whereas the use of series capacitor contributes to negative reactance [9]. This means that series-based compensation alters the factors or the conductors of distribution system whereas the shunt-based compensation variates the corresponding load impedance.

5. High Efficiency of Transformers: The highly efficient transformers helps in reduction of losses with the use of amorphous core transformers having high magnetic vulnerability, with electrical resistance (maximum) and less coactivity.

*6. High Voltage Distribution System:*This technique is most effective and efficient in minimizing the technical losses and refining the power quality in distribution system. In this technique, transformation of previous Low Voltage Distribution System to High Voltage Distribution System is done. This technique aims at extending high voltage lines as nearer to the load as possible and replacing large transformers with various small rating transformers. By using high this method, we can reduce the losses as current is low in high voltage systems.

7. Aerial Bunched Cables (ABC): The aerial bunched cables (ABC) provides the best choice in urban areas due to flexible for switching lane. It offers reliability and safety, reduces final system budget and power losses by lowering the repairs, operational cost, and setting up. This kind of technique is used for rural type distribution.

D. Distribution System: Voltage Profile Improvement

In a power system, the operator of the system needs to maintain the level of voltage for each of the consumer bus within specified limit. In distribution system, for ensuring a satisfied profile voltage, distinct standards have been developed to provide recommendations or stipulations [8]. In distribution system, the recommendations by American National Standards Institute (ANSI) {standard C84.1} has specified the voltage variation range lying within -13% to 7%. In practice, various electrical companies, try to control voltage variation within ±6%. The most improved technology adopted was the use of distributed generation (DG) in the distribution systems. The units of DG improve the profile of voltage by transforming the patterns of power flow. The size and location of DGs plays a key role in maintenance of voltage profile. However, in case of medium voltages tie/sectionalizing switches are provided in such a way that the configuration of the network may get altered in order to requirements of operation. The configurational transformation transforms/alters the path of power flow resulting in transformed altered node voltages, degree of unbalances, line currents, and also alters the node voltages distortion level in the presence of harmonics. As the power flow path impedance gets changed because of reconfiguration process, the nodal voltage present in case of voltage sag has the liability to be changed. The problem of tripping of sensitive loads may occur due to process of voltage sag, it is evident that the enhanced voltage sag has the ability to lower the system loss under the condition of voltage sag. The change of nodal voltage harmonic content is resulted by the change in mutually induced voltage and power flow path effective impedance due to transformation in current distribution line. Thus, the task of network reconfiguration can be formulated as:

1. Minimizing the network power losses.
2. Maximizing the network voltage sag in case of switching or fault.
3. Minimizing nodal voltage harmonic distortion.
4. Minimizing the system-based unbalances.

E. Distribution System: Network Configuration

The distribution based network configuration involves the following points:

*(a) Branch exchanges for loss minimization:*The minimized-power loss configuration is basically obtained where there occurs optimum flow pattern with the process of exchanging branch operations. The open tie switch at its normal operation is usually closed for loop formation. The power flow pattern on optimum basis is identified by solving KVL and KCL loop equations, where

KVL is written as resistive voltage drops summation in the loop where it is equal to be zero. This kind of pattern for power flow corresponds to minimized power flow loss.

(b) Branch exchanges for minimized voltage unbalances: For reduction of voltage unbalances, the process starts with its initial radial configuration. Further the network load flow is performed and the voltage nodal unbalance occurs in the operation. The identification of maximum voltage unbalance occurs at its node and the selection of tie-line takes place where the closing of tie-switch results in loop formation including the node identification. The voltages modified at its node in the loop are evaluated and the power flows are determined through the loop branches. The line having minimum power flow is chosen to be in open form such that nodal voltages are disturbed minimally. This kind of procedure helps in reduction of voltage unbalance due to loop formation, the redistribution of current flow takes place. The maximum branch flows, alternative paths availability get reduced which results in branch voltage drops reduction. It helps in improved quality of node unbalances and node voltages. If the branch with minimum flow is opened in its network, the loop flow pattern is least disturbed and the resulting network is modified or updated.

(c) Branch exchanges for compounded problem: The compounded form of reconfiguration problem seek to simultaneously satisfy all the tasks. Thus the procedure of minimizing single task is avoided. The priority is allotted to the task that depends upon its values and its importance in the network prevailed configuration. The loss of power is a critical issue as it carries money wastage repeatedly, so it is called as the highest priority. The main effort is the attempt for system losses reduction. For indices case of power quality, an attempt is generally made for reducing some of the critical violations [7, 11]. Initially, a radial type of configuration, the load flow, harmonic flows are solved and the losses of the system, unbalances of voltage, harmonic distortion are observed or determined. Further voltage sag is performed along with the evaluation of power quality indices and further these are compared with limiting values. In violation case, the severe case is identified and the tie branch is chosen such that a loop gets formed which includes loop problematic node. Thus the updated loop quantities are formed are determined and a chosen branch is opened for the process.

F. Operational Constraints

The multi-objective function (MOF) is reduced/minimized to certain operating constraints in order to fulfill the requirements for the distribution network operation.

(a) Load Balance Constraints

The load regulations of each bus should be satisfied as follows:

$$P_{gni}-P_{dni}-V_{ni}\sum_{j=1}^{N}V_{nj}Y_{nj}\cos(\delta_{ni}-\delta_{nj}-\theta_{nj}) = 0 \ldots\ldots\ldots\ldots 1.30\ (a)$$

$$Q_{gni}-Q_{dni}-V_{ni}\sum_{j=1}^{N}V_{nj}Y_{nj}\sin(\delta_{ni}-\delta_{nj}-\theta_{nj}) = 0 \ldots\ldots\ldots\ldots\ldots\ (b)$$

Where,

$n_i = 1,2,\ldots,n_n$

(b) Power Generation Limit

This involves the lower and the upper generation limits of real and reactive sources at a given bus i

$$P_{gi}^{min} \leq P_{gi} \leq P_{gi}^{max}, i = 1,2,\ldots\ldots, N_g \ldots\ldots\ldots\ldots 1.31\ (a)$$

$$Q_{gi}^{min} \leq Q \leq Q_{gi}^{max}, i = 1,2,\ldots\ldots, N_g \ldots\ldots\ldots\ldots\ldots\ldots (b)$$

Where,

P_{gi}^{min} *and* P_{gi}^{max} = Generation limits based on real powers

P_{gi}^{min} *and* P_{gi}^{max} = Generation limits based on reactive powers *(c) Voltage Limit*

This limit involves the lower and the upper limits of the magnitude i.e. V_i^{min} *and* V_i^{max} at bus-i. In reality the voltage of the generator includes the voltage of the bus/load in addition to line impedance and the line-based power flow. The voltage should be kept within standards maintained as:

$$V_i^{min} \leq V_i \leq V_i^{max}, i = 1,2, \dots \dots .., N_b \quad \dots \dots \dots \dots (1.32)$$

Where,

V_i^{min} *and* V_i^{max}= min and max voltage limits

II. RELATED WORK

Q. S. Chua, et.al [1] considered the real time system implementation methods of monitoring that was able to provide power system based time warning before the occurrence of voltage collapse. In this work, different types of line voltage stability indices (LVSI) have been differentiated to overcome the effectuality which determines the power system weakest lines. The LVSI have been accessed using IEEE 14-Bus and IEEE 9-Bus system for practicability validation. This paper work also contributed real-time voltage stability monitoring implementation using Artificial Neural Network (ANN). The results demonstrated the indices evaluation using ANN methodology for predicting the system based voltage collapse. K.R. Devabalaji, et.al [2] proposed the work with the main objective to reduce the power loss in total along with maintenance and satisfaction of all the constraints. The implementation of LSF i.e. Loss Sensitivity Factor was done to pre-determine the capacitor optimal location. An effective use of BAT algorithm (biologically-inspired) has been done to pinpoint the capacitor banks optimal location. The method proposed was tested on IEEE 34-bus distribution system to observe the effectiveness and performance of the proposed technique. Chaw Su Hlaing, et.al [3] presented an approach based on voltage stability index utilizing an analogy of combined sensitivity factor to optimally place and size a DG multi-type using 48-bus Belin distribution test system with the objective of power losses reduction and the improvement of voltage profile with the placement of type 2 DG than the type 1 based DG placement i.e. DG generation using both real and reactive powers. It reaches a point where the increment in DG number results in improving voltage profiles and minimizing the power losses of the system. Pyone Lai Swe, et.al [4] considered for types of DGs in their proposed work. With its types, one DG was installed at location to reduce the total losses i.e. the real and the reactive power losses occurred during the operation. The main objective was to evaluate the size and to observe or identify the Dg optimum corresponding location to reduce the real and reactive losses and to improve the primary distribution voltage profile. With this type of method, it was able to obtain maximum reduction of losses for optimally placed DGs in the network.The DG based optimized sizing was calculated an exact type of loss formula along with an efficient approach to determine the DG optimized placement. The performance of the proposed method was demonstrated in Belin Substation in Myanmar on a 36-bus radial type distribution system which was validated with different sizes of the DGs in the network. Yorukoglu, Sinan, FuadNasibov, et.al [5] conducted a study of distinct distribution system losses, Turkish electricity distribution network based privatization process, and percentage of current losses. In SYSTEM distribution network topology, possible alternations decreased the losses (non-technical) using analytical methods and the best form of strategy against losses was determined for distinct customer characteristics and network topologies with the help of AHP method. Salah Kamel, et.al [6] this paper investigated the DSTATCOM impact over the performance of Upper Egypt electrical realistic network. The analysis was done using NEPLAN commercial software and the network was selected using 20 buses with 22/0.4 kV distribution transformers (20) and two of the voltage (medium) distribution points. The network was studied with and without forms of D-STATCOM showing the impact over the performance of the network regarding voltage magnitude control, total reduction active power losses, and the stability of the voltage. Sultana, U., et.al [7] conducted a comprehensive study for optimized DG placement by considering minimized power/energy losses, voltage profile improvement, and voltage stability enhancement. The researchers made an attempt to provide a summary of existing methods and presented a deep analysis helping the energy planners to decide what type of objectives and factors of planning were required for optimum allocation of DG. YalishoGirmaLoaena [8] provided a deep study on the issues related to power system like distribution system based on energy loss and its reduction techniques, reactive power flow along with its compensation, indicators of voltage quality such as regulation of voltage and voltage unbalance. In order to achieve the tasks, the existing form of distribution system based on study site has been designed using a Power Factory Software named DIgSILENT and the process of simulation was performed under balancing and unbalancing operating conditions. The measurement using Clamp-on meter was done to find the line to line voltages and the load demand.

Patel, J. S., R. R. Patel, et.al [9] conducted a novel approach utilizing generated power with the help of distributed generation in case of primary distribution network such that the DG incorporation installed with capacity reduce the losses occurring in the overall system. The method of DG location and sizing using Genetic Algorithm was presented. A very simple load flow technique for accuracy was described and technique proposed was implied over two of the systems. One is the 2. 69 Bus Distribution System and the other is the IEEE 34 Bus distribution System using a software MATLAB tool. A. V. Sudhakara Reddy, et.al [10] proposed an algorithm popularly known as a Grey Wolf Optimization (GWO) algorithm to overcome the issues related to feeder reconfiguration with the help of fitness function corresponding to power distribution systems based optimized switch combination to overcome the issues related to reconfiguration including the real power loss reduction.

III. ALGORITHM

The following section describes the algorithm used below:

Grey Wolf Optimizer (GWO): It is a meta-heuristic algorithm which simulates the leadership hierarchy and hunting behavior of wolves. The fitness of the wolves measured in the form of alpha, beta and delta. Grey wolves have the ability of memorizing the prey position and encircling them. The alpha as a leader performs in the hunt. For simulating the behavior of grey wolves hunting in the mathematical model, it is assumed that the alpha (α) is the best solution, the second optimal solution is beta (β) and the third optimal solution is delta (δ). Omega (ω) is assumed to be the candidate solutions. Alpha, beta and delta guides the hunting while position is updated by the omega wolves by these three best solutions considerations.

Encircling prey: Prey encircled by the grey wolves during their hunt. Encircling behavior in the mathematical model, below equations is utilized [37].

$$\vec{A}(T+1) = \overrightarrow{A_P}(T) - \vec{X}.\vec{Z}$$

Table.1 Inferences Drawn

Author's Name	**Year**	**Algorithm Used/ Technology Used**	**Outcomes**
Q. S. Chua, et.al.	2015	Line Voltage Stability Indices (LVSI)	This paper work also contributed real-time voltage stability monitoring implementation using Artificial Neural Network (ANN). The results demonstrated the indices evaluation using ANN methodology for predicting the system based voltage collapse.
K.R. Devabalaji, et.al.	2015	Power Loss Minimization in Radial Distribution System.	Proposed work with the main objective to reduce the power loss in total along with maintenance and satisfaction of all the constraints. The implementation of LSF i.e. Loss Sensitivity Factor was done to pre-determine the capacitor optimal location. An effective use of BAT algorithm (biologically-inspired) has been done to pinpoint the capacitor banks optimal location.

Chaw Su Hlaing, et.al	2015	Belin distribution test system	Presented an approach based on voltage stability index utilizing an analogy of combined sensitivity factor to optimally place and size a DG multi-type using 48-bus Belin distribution test system. It reaches a point where the increment in DG number results in improving voltage profiles and minimizing the power losses of the system.
Patel, J. S., R. R. Patel, et.al.	2016	Genetic Algorithm based DG location	A very simple load flow technique for accuracy was described and technique proposed was implied over two of the systems. One is the 2. 69 Bus Distribution System and the other is the IEEE 34 Bus distribution System using a software MATLAB tool.
A. V. Sudhakara Reddy, et.al	2017	Grey Wolf Optimization (GWO) algorithm	Proposed an algorithmto overcome the issues related to feeder reconfiguration with the help of fitness function corresponding to power distribution systems based optimized switch combination to overcome the issues related to reconfiguration including the real power loss reduction.

$$\vec{Z} = \left|\vec{Y}.\overrightarrow{A_P}(T) - \vec{A}(T)\right|$$

Where,

$\vec{Z}$ and $\vec{X}$ are vectors that are calulated by above given equation.

T←iterative number

$\vec{A}$←grey wolf position

$\overrightarrow{A_P}$←prey position

$$\vec{X} = 2x.\vec{r_1} - x$$
$$\vec{Y} = 2\vec{r_2}$$

Where

$\vec{r_1}$and$\vec{r_2}$←random vector range[0,1]

The x value decrease from 2 to 0 over the iteration course.

$\vec{□}$←random value with range [0,1] and is used for providing random weights for defining prey attractiveness.

Hunting: For grey wolves hunting behavior simulation, assuming □, □, and □ have better knowledge about possible prey location. The three best solutions are firstly considered and then □ (other search agents) are forced for their position update in accordance to their best search agent position. Updating the wolve's positions as follows [37]:

$$\vec{□}(□ + 1) = \frac{\overrightarrow{□_1} + \overrightarrow{□_2} + \overrightarrow{□_3}}{3}$$

Where $\overrightarrow{□_1}, \overrightarrow{□_2}$, □□□ $\overrightarrow{□_3}$ are determined,

$$\overrightarrow{□_1} = \left|\overrightarrow{□_□} - \overrightarrow{□_1}.□_□\right|$$
$$\overrightarrow{□_2} = \left|\overrightarrow{□_□} - \overrightarrow{□_2}.□_□\right|$$
$$\overrightarrow{□_3} = \left|\overrightarrow{□_□} - \overrightarrow{□_3}.□_□\right|$$

Where $\overrightarrow{□_□}, \overrightarrow{□_□}$, □□□ $\overrightarrow{□_□}$← first three best solution at a given iterative T

$□_□$, $□_□$, and $□_□$ are determined,

$$\overrightarrow{□_□} \leftarrow \left|\overrightarrow{□_1}.\overrightarrow{□_□} - \vec{□}\right|$$

$$\overrightarrow{\square_{\square}} \leftarrow \left|\overrightarrow{\square_{2}}\cdot\overrightarrow{\square_{\square}} - \overrightarrow{\square}\right|$$
$$\overrightarrow{\square_{\square}} \leftarrow \left|\overrightarrow{\square_{3}}\cdot\overrightarrow{\square_{\square}} - \overrightarrow{\square}\right|$$

The first level wolver are called are alpha wolves which are dominant in nature and all other wolves follow their orders. Alpha are the best decision makers having the best fitness value in the whole pack and are also the leaders of the pack

1) The second level wolves are the beta wolves and also called as subordinate wolves which help in decision making in alpha and also the other members of the pack.
2) The third level wolves are the delta wolves which work after the beta wolves. Delta wolves are considered when the beta wolves are not working properly. These wolves are also called as scouts.
3) The fourth and the last level of the hierarchy are related to the omega wolves. Omega wolves have low fitness value and are considering at the last. Omega wolves are also known as scapegoats.

IV. CONCLUSION

For power system secure and safe operation, all the states that are of secured form must be identified at its initial state in order to provide correct measures overcoming the voltage collapse threat to the operating condition. The large development on economical basis has increased the distribution networks based load demand. The production capacity of distributed generation lies from few kW to 10 kW for the generation of electricity near the consumer area. These can be used for different purpose such as fuel cells, micro turbines, wind farms, and solar cells etc. If such kind of power plants is linked or connected to the network, then the network shows various impressive effects such as improved voltage profile, increase the reliability, and loss reduction.

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