Power Loss Minimisation on 11kV Distribution Network using Feeder Reconfiguration

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Abstract—The Distribution System can be seen as the networking line that interfaces between the large power generators and transmission lines on one hand and the electricity consumers on the other. The system can exist in different topologies among which, the radial form is popular because of its simplicity and comparative low cost of design. The problem of poor power quality and instability has been a major power systems challenge especially in Nigeria. More reliable and stable power systems among other benefits can be enjoyed when system are optimized. Hence, this paper implements the feeder reconfiguration technique as an optimization procedure to minimize the technical losses on the Ondo Road 11kV Feeder Segment. MATLAB is employed to simulate the optimization process and the results showed that an average of 85.47% active power loss reduction on all phases is obtainable with the proposed technique leading to an estimated financial saving of ₦639,999.75 per hour.

Index Terms—Feeder Reconfiguration, Power System Optimization, Radial Distribution Network, Backward Forward Sweep.

I. INTRODUCTION

Electricity is an essential requirement for all areas of human endeavour. It has almost now been accepted as a basic human need and has been asserted to have the socio-economic development of any country depending on it. Electric power has become a fundamental part of the infrastructure of contemporary society, with most of today’s daily activity based on the assumption that the desired electric power is readily available.

The power systems which provide this electricity are some of the largest and most complex systems in the world. They consist of three primary components: the generation system, the transmission system, and the distribution system. Each component is essential to the process of delivering power from the site where it is generated to the customer who uses it. There exist connecting joints in the system, which are known generically as the transmission lines and the distribution networks. Both the transmission and distribution system have prime task of delivering electrical power to customers at their place of consumption and in usable form. While performing this main task, the electric utility is interested in achieving certain sufficient levels of reliability, efficiency, peak load and costs [1]. The subject of distribution loss minimisation has gained a great deal of attention due to high cost of electrical energy. This is so because, distribution systems can acquire longer life span and have greater reliability by reducing power losses in it[2].

The focus of this report is on the application of a suitable solution of the power flow problem for the determination of technical losses and the feeder reconfiguration – an optimisation technique for distribution systems which aims at minimising technical losses already determined in the system. Typically, every distribution system originates at a substation where the electric power is converted from the high voltage transmission system to a lower voltage for delivery to the customers. This work aims at implementing an optimisation procedure using feeder reconfiguration for minimising technical losses on the Ondo Road 11kV power distribution feeder. The rest of the paper is organised thus: section II gives a description of the Akure Distribution System, section III presents the proposed scheme for performing load flow and feeder reconfiguration, while simulation results and analysis are presented in section IV. Conclusion and recommendation are given in section V.

II. DESCRIPTION OF THE AKURE ELECTRICAL DISTRIBUTION NETWORK

A summarised description of the Structure of the Akure Electrical Distribution Networks is given in Fig. 1. Akure Electrical Power Distribution System consists three 33/11 kV injection stations which are described as follows:

a) Six (6), 11kV feeders which are fed by two (2) 15MVA transformers supplying power to the main city. The feeders are Ijapo, Ondo Road, Oyemekun, Oke-edo, Ilesa road and Isikan.

b) Two (2) 11kV feeders connected to 15MVA transformer serving Oba-ile and Alagbaka.

c) A 7.5MVA transformer dedicated to the Army Cantonment, Akure.

The development of line diagram for Akure was developed on the information obtained from the Utilities- PHCN using the standard symbols[3]. Figure 1 defines the interconnection of the injection stations to the 11kV feeders which transport power to the 11kV/0.415kV substations. The line diagrams for the entire network were developed and are shown in Figure 1 and Figure 2.

III. METHODOLOGY

The optimisation of a distribution power system consists of the solution of a distribution power flow and a loss reduction problem. The power flow problem involved is one of finding the operating point of a distribution network at steady state under given conditions of load and cogeneration. This involves, first of all, finding all of the bus
voltages. From these voltages, it is possible to directly compute currents, power flows, and system technical losses. The loss reduction problem involves the development of a loss reduction formula validate the optimisation procedure. A variety of methods exist by which distribution system can be optimised. These include the optimal placement of capacitors[4-7], feeder reconfiguration[2, 5, 8], phase balancing[1], placement of volt–var regulators, and placement of Distributed Generators (DG)[9]. The loss minimisation technique proposed in this paper is called Network/Feeder Reconfiguration which involves the closing of a normally open tie line and closing of a normally closed sectionalising switches. The change in real power losses after feeder reconfiguration is computed from two power flow solutions which are performed before and after the procedure.

A. Determination of Technical Losses Using BFS Power Flow Algorithm

The radial distribution system is one in which only a unique path exists between the substation and the final consumer. It is this structure that makes it possible to implement the algorithm - the Backward/Forward Sweep (BFS) Power Flow Algorithm for the case study distribution system[10-12]. This algorithm is based on updating voltages
and currents (power flows) along paths from the source to the end buses and back to the source bus, hence is known as the Backward/Forward Sweep (BFS) Algorithm.

1) Backward sweep

The purpose of the backward sweep is to update the branch currents in each section using the voltage at each node in the previous iteration[10]. Backward sweep starts at the principal (end) node of the system and proceeds along the forward path to the source node.

\[
I_{abc}^{k-1} = I_{abc}^{kLoad} + \sum_{m \in M} I_{abc}^{m} + \sum_{m \in M} Y_{shm} \cdot V_{k}^{abc(n-1)}
\]

where \( I_{abc}^{kLoad} \) is the node injected current by Load at the k-th bus in the (n-1)th iteration given by \( I_{abc}^{kLoad} = s_{kLoad} \cdot I_{abc}^{k(n-1)} \); \( I_{abc}^{k} \) is the branch current of the (k-1)th branch leading to the k-th node in the n-th iteration; \( I_{abc}^{m} \) is the branch current of the m-th branch in the n-th iteration where \( m \in M \) representing the set of lines sections connected to the (k-1)th branch; \( Y_{shm} \) is the half branch shunt admittance of the m-th branch; and \( V_{k}^{abc(n-1)} \) is the node voltage at the k-th node in the (n-1)th iteration.

2) Forward sweep

The purpose of the forward sweep is to calculate the voltages at each node starting from the source node. The source node voltage is set as 1.000 pu as stated earlier in the constraint and the other nodes are obtained from Eq. 2:

\[
V_{k}^{abc} = V_{k}^{abc(n)} + Z_{e_{k-1}} \cdot (Y_{sh_{k-1}} \cdot V_{k}^{abc(n)} - I_{k}^{abc(n)})
\]

where, \( Z_{e_{k-1}} \) and \( Y_{sh_{k-1}} \) are the branch impedance and the half shunt admittance of the (k-1)th branch leading to the k-th node respectively. These calculations are carried out until the voltage at each bus is within specified convergence criterion values. At this point, when all voltages at each bus and current flowing through all the line segments are known, the real and reactive power loss can then be determined with Eq. 3 and 4:

\[
SLoss_{k-1}^{abc} = (V_{k}^{abc} - V_{k-1}^{abc}) \cdot (I_{k-1}^{abc})^*;
\]

\[
PLoss_{k}^{abc} = Re\left\{ (I_{k}^{abc})^2 \cdot r_k \right\};
\]

\[
QLoss_{k}^{abc} = Im\left\{ (I_{k}^{abc})^2 \cdot x_k \right\}
\]

Total\( PLoss_{k}^{abc} = \sum_{k} PLoss_{k}^{abc} = \sum_{k} Re\left\{ (I_{k}^{abc})^2 \cdot r_k \right\} \]

where \( SLoss_{k-1}^{abc} \) is the complex power loss at the (k-1)th branch leading to the kth node; \( PLoss_{k}^{abc} \) is the real (active) power loss at the k-th branch; \( QLoss_{k}^{abc} \) is reactive power loss at the k-th branch; and \( TotalPLoss_{k}^{abc} \) is the total real or active power loss.

B. Development of Loss Reduction Procedure

Feeder reconfiguration determines the switching operations which yields minimum loss. A switching option is carried out between a tie and sectionalising switch. The switching option can also be referred to as branch exchange, because a normally opened branch (tie line) is exchanged with a normally closed branch by a switching operation. The best branch exchange to be implemented is chosen at each successive operation that gives maximum loss reduction without any violation of constraints.

A radial distribution network can be represented by several loops. One tie line can only make one loop and therefore, the number of loop equals the number of tie lines[2]. In the proposed technique, a loss reduction formula is derived that will estimate the loss reduction in the network from a switching operation in the loop. A loop in a radial network is created by a tie-line as shown in Figure 4. There is a voltage difference across the normally open tie switch in the tie line. The higher voltage drop side is called the lower voltage side and the lower voltage drop side is called the higher voltage side of the loop[2]. The lower and higher voltage sides in the figure are denoted as \( l \) and \( h \) respectively.

To explain the procedure suggested in this work Figure 4 will be considered as a very basic system. Assume that \( l \) and \( h \) are laterals from a common feeder. The loads are considered to be concentrated at the nodes. It is assumed that after a load flow solution that bus \( l \) is found to be the lower voltage side of the loop and conversely bus \( h \) is found to be the higher voltage side. Since these nodes can be connected via a tie link a switching action should be...
considered to find out whether or not it yields a reduction in power loss. The losses associated to the elements of loop for the initial configuration are called $P_1$ and is obtained by Eq. 5:

$$P_1 = I_{11}^2 R_{01/2} + I_{11}^2 R_{12/11} + I_{12}^2 R_{11/12} + I_{h}^2 R_{h/h1} + I_{h}^2 R_{h/h0}$$

(5)

In order to transfer the load of bus $l$ from lateral $l$ to lateral $h$, the switching action to be done involves the closing of the line between $l$ and $h$ and opening the line between $l$ and $l$ and the new losses within the path are called $P_2$ and are calculated by adding the current of node $l$ to every loop element associated to the lateral $h$ and subtracting it from every loop element of the lateral $l$. On the other hand the tie line has to be considered. The expression for $P_2$ is given by:

$$P_2 = (I_{12} - I_l)^2 R_{01/2} + (I_h - I_l)^2 R_{12/11} + (I_h + \alpha I_l)^2 R_{h/h1} + (I_h + \alpha I_l)^2 R_{h/h0}$$

(6)

where $\alpha$ is the corrective voltage factor (CVF) representing the ratio of old to new voltage of the node $l$. The CVF is used to reduce the current at this node as its voltage improves when the reconfiguration takes place. CVF is recommended to be used only to calculate the losses reduction when the first load is transferred. This is due to the fact that when more than one load is transferred at a time by the time, the exact voltage improvement is not certain until a full load flow is conducted.

However, the calculation of loss reduction in remote lines of lateral $l$ when transferring more than one load at a time by opening subsequent switches are done in a similar manner but care has to be exercised to use the correct current component. This means that for the line located between the new opening point under consideration and the tie link, the current must be taken from the values corresponding to the initial network minus the currents of the loads located downstream. For the lines of lateral $h$, the procedure is same as afore.

$$P_2 = (I_{12} - I_h)^2 R_{01/2} + (I_h + I_{12})^2 R_{h/h1} + (I_h + I_{12})^2 R_{h/h0} + (I_h - I_h)^2 R_{h/h1} + I_h^2 R_{h/h0}$$

(7)

It is important to state clearly here that these last three Equations only account for losses within the path affected by the reconfiguration and do not give the total loss for the system. Therefore, only the difference between $P_1$ and $P_2$ must be taken to access whether or not the branch exchange is worthwhile.

C. Overall Algorithm Implemented Using MATLAB®

Overall solution algorithm for the proposed technique for minimising losses is laid out as follows in Table 1:

| Step | Description |
|------|-------------|
| 1. Upload system data |
| ii. Program initialisation | a. Update and convert of data to suitable program format. |
| b. Read system structure. |
| ii. Execution of BFS Power flow solution | a. Determine Node Voltages and Branch Currents |
| b. Estimate system losses |
| v. Implementation of feeder reconfiguration | a. Obtain the loops in the system |
| b. Estimate initial loop losses |
| c. Perform branch – exchange |
| d. Estimate final loop losses |
| e. Compute change in loop loss |
| i. If loop loss change is negative |
| 1. Retain old system data |
| 2. Try the next tie line |
| ii. Otherwise |
| 1. Execute branch exchange |
| 2. Generate new data with the implemented branch exchange |
| v. Repeat step iv until all tie lines have been used in the switching options. |
| iii. Repeat step iii. |
| iv. Print Results |
| ii. Compare Results of before and after reconfiguration |

End

IV. RESULTS AND ANALYSIS

A. Data Acquisition and Analysis

The system data required for the simulation of the proposed solution is the line segment and bus/load data. The line segment data describes the system topology. The bus/load data gives information on how the system is loaded in terms of the power demand and use at each node in the system. However, for the distribution system under study the line and load data were not readily available but were develop from transformer inventory and by counting of pole span between any two adjacent distribution transformers. The network was simplified by taken each distributions transformers as load points.

TABLE I: OVERALL SOLUTION ALGORITHM FOR THE PROCEDURE

1) Elements of the system data

The elements contained in the line segment data include the following:

i. Sending node (From Bus): - is the node from which a branch emanates.

ii. Receiving node (To Bus): - is the node at which a branch is terminated.

iii. Branch/Line status: - gives information of the branch status, ‘1’ to denote that the branch is active or ‘IN SERVICE’ and ‘0’ denotes that the branch is ‘OUT OF SERVICE’

iv. Length of line: - gives information on the distance between the sending node and the receiving node, i.e. the length of the line connecting the sending and receiving nodes

v. Line resistance per kilometres ($\Omega$/km): - is a characteristics of the conductor that is dependent on the conductor type and size and is expressed as $R/l = \rho/A$ ($\Omega$/m), where $R$ is the resistance of the conductor (in ohms); $l$ is the length of the conductor (in m); $A$ is the cross-sectional area of the conductor (in $m^2$) and $\rho$ is the resistivity of the conductor (in Ohm-m) which is dependent on the type of material.

vi. Line reactance per kilometres ($\Omega$/km): - is a characteristics of the conductor that is dependent on the conductor type and size and frequency of operation and is expressed as
\[ X_L / l = \omega L / l \quad (\Omega / m) \], where \( X_L \) is the inductive reactance of the conductor (in ohms); \( l \) is the length of the conductor (in m); \( \omega \) is the angular frequency of operation, \( \omega = 2\pi \) (in rad/s) and \( L \) is the inductance of the conductor (in Henry).

The elements contained in the load data are the active power demand, \( P_d \) and reactive power demand \( Q_d \) in kW and kVar respectively.

The Ondo Road 11kV Feeder serves the inhabitants around Ondo Road Area. The entire feeder spans about 39.25km in its route length. The feeder was split into two because of its size and for load shedding reasons. The two parts are the Ajipowo and Oke-Aro segments served alternately and separated by an isolator. This case study focuses on the Ajipowo segment of the feeder. The case study network consists of a total of about 27, 11/0.415kV substations. The Line diagram for the network is given in Figure 2. A simplified form of the network is also shown in Figure 5. The type of the conductor used in the distribution network is the All Aluminium Conductors (AAC) with cross-sectional area of 150mm\(^2\). The length of the conductor from point to point was determined by counting the number of the pole spans between each substation. A pole–span is 45m (0.045km). The Resistance and Inductive Reactance (at 50Hz) of the AAC were obtained from manufacturer’s Technical Datasheet as 0.265 Ohm per km and 0.128Ohm per km. The Capacitance of the Aluminium Conductor is obtained from manufacturer’s data sheet as 0.338µF/km. Therefore,

\[
R = 0.045 \times 0.265 \times N; \\
X_L = 0.045 \times 0.128 \times N; \\
X_C = 0.045 \times (1/ (100\pi \times 3 \times 10^{-7})) \times N
\]  

where, \( N \) = Number of pole span counted. The line impedance is given as \( Z = R + j(X_L - (1/X_C)) \). The line segment data developed from the above computation is tabulated in Table 2.

The bus / load for the system is developed from the PHCN’s transformer inventory. This loading information is obtained through the use of clamp meters used to obtain the current on each phase on the secondary of the 11/0.415kV transformer and these measurements are done during hours of peak load. The phase currents obtained are added together with the neutral current and divided by three (3) obtained the average. The average is then compared with the rated current of the 11/0.415kV transformer.

Table 4 shows the number of 11/0.415kV and their ratings. The complete information on the loading of each transformer is tabulated in Table 1. A power factor (p.f.) of 0.8 is used to compute and obtain bus load data from the percentage loading information as the per phase complex power demand, \( S_d \) (in kVA) = \( I_d \times V_{L-L, rated} \times \sqrt{3} \); per phase real power demand, \( P_d \) (in kW) = \( S_d \cdot \text{p.f} \); and per phase reactive power demand, \( Q_d \) (in kVar) = \( \sqrt{S_d^2 - P_d^2} = S_d \cdot \sqrt{1 - \text{p.f}^2} \).

The load data obtained from the above computation for the case study is shown in the overall combined line and load data given in Table 2.

![Fig. 5. Simplified Line Diagram of the Ondo Road 11kV Feeder.](image-url)
TABLE II: PHCN INVENTORY OF DISTRIBUTION TRANSFORMERS ON THE ONDO ROAD 11kV TAKEN AS AT JUNE 2013

| S/N | Name                | Capacity (kVA) | Power Rating (kVA) | Secondary Current (A) | Red | Yellow | Blue | Neutral | Total | % Loading |
|-----|---------------------|----------------|------------------|-----------------------|-----|--------|------|---------|-------|----------|
| 1   | Injection S/S       | -             | -                | -                     | -   | -      | -    | -       | -     | -        |
| 2   | Fanibi 1            | 300           | 417.36           | 300                   | 330 | 320    | 40   | 330     | 791   | 0.791    |
| 3   | Aloba               | 300           | 417.36           | 205                   | 289 | 340    | 26   | 287     | 687   | 0.687    |
| 4   | Guomco              | 300           | 417.36           | 220                   | 280 | 220    | 31   | 250     | 600   | 0.600    |
| 5   | Aloba Extension     | 300           | 417.36           | 340                   | 363 | 357    | 46   | 369     | 883   | 0.883    |
| 6   | Ondo M/Park         | 500           | 695.60           | 580                   | 610 | 591    | 25   | 602     | 865   | 0.865    |
| 7   | Osele Poly          | 500           | 695.60           | 510                   | 517 | 557    | 40   | 541     | 778   | 0.778    |
| 8   | Army Cantonment      | 300           | 417.36           | 320                   | 390 | 330    | 20  | 353     | 847   | 0.847    |
| 9   | Onward Electric      | 200           | 278.24           | 127                   | 186 | 174    | 10   | 166     | 595   | 0.595    |
| 10  | Ola-Egba            | 200           | 278.24           | 200                   | 205 | 185    | 28   | 206     | 740   | 0.740    |
| 11  | LEyo               | 300           | 417.36           | 256                   | 290 | 240    | 19   | 268     | 643   | 0.643    |
| 12  | Ofulunya            | 200           | 278.24           | 230                   | 250 | 270    | 36   | 262     | 942   | 0.942    |
| 13  | Jowica              | 300           | 417.36           | 340                   | 336 | 290    | 25   | 330     | 791   | 0.791    |
| 14  | Temadire            | 300           | 417.36           | 205                   | 345 | 320    | 56   | 309     | 740   | 0.740    |
| 15  | Bencafe             | 500           | 695.60           | 420                   | 500 | 492    | 16   | 476     | 684   | 0.684    |
| 16  | Fembo               | 200           | 278.24           | 176                   | 186 | 155    | 32   | 183     | 658   | 0.658    |
| 17  | Stephen S/Mill       | 300           | 417.36           | 215                   | 291 | 245    | 46   | 266     | 637   | 0.637    |
| 18  | Fanibi 2            | 300           | 417.36           | 300                   | 320 | 337    | 53   | 337     | 807   | 0.807    |
| 19  | MTN                 | 100           | 139.12           | 102                   | 116 | 67     | 15   | 100     | 719   | 0.719    |
| 20  | Empress Hotel       | 300           | 417.36           | 298                   | 250 | 309    | 13   | 290     | 695   | 0.695    |
| 21  | Aloba1d             | 300           | 417.36           | 294                   | 340 | 356    | 44   | 345     | 826   | 0.826    |
| 22  | Adegbemile          | 300           | 417.36           | 510                   | 443 | 457    | 36   | 482     | 693   | 0.693    |
| 23  | Ajipow              | 500           | 695.60           | 510                   | 443 | 457    | 36   | 482     | 693   | 0.693    |
| 24  | Agric. Poultry       | 300           | 417.36           | 298                   | 250 | 309    | 13   | 290     | 695   | 0.695    |
| 25  | Onward/Plastic      | 500           | 695.60           | 480                   | 370 | 420    | 22   | 404     | 584   | 0.584    |
| 26  | DeLady Life         | 500           | 695.60           | 356                   | 478 | 462    | 61   | 452     | 650   | 0.650    |
| 27  | Aston               | 200           | 278.24           | 200                   | 210 | 259    | 26   | 232     | 833   | 0.833    |
| 28  | Ogunussi            | 200           | 278.24           | 270                   | 210 | 256    | 18   | 251     | 903   | 0.903    |
| 29  | Omotosho            | 300           | 417.36           | 310                   | 280 | 310    | 36   | 312     | 748   | 0.748    |
| 30  | MTN                 | 100           | 139.12           | 127                   | 105 | 121    | 18   | 124     | 889   | 0.889    |

B. Results Obtained and Analysis

From the simplified line diagram for the network given in Figure 5, the Ondo Road Feeder can be seen as 30-node radial distribution system with 6 laterals and 3 tie lines. The base values for the system are taken as 11kV and 10MVA.
The total system load per phase for the base configuration is 1599.28kW, 1842.14kW, 1844.82kW and 1189.78kVar, 1093.06kVar, 1094.65kVar on the Red, Yellow, and Blue Phases respectively. The total initial active power losses per phase in the system were 32.47kW, 15.48kW, 18.52kW summing up to yield a total active power loss of 66.47kW. The minimum voltage before reconfiguration occurred at the 17th bus (Stephen S/Mill) and are 0.9740pu (10.71kV) and 0.9803pu (10.78kV) on the Red Yellow and Blue phases respectively. After reconfiguration the voltages in the same bus were improved to 0.9940pu, (10.91kV), 0.9968pu (10.95kV) and 0.9962pu (10.94kV).

The results obtained are summarised and tabulated in Tables 4 – 5 and shown in Figures 6. The total final active losses per phase in the system are 5.55kW, 1.92kW, and 2.61kW.

### TABLE IV: RATINGS OF 110/415kV TRANSFORMERS ON THE ONSDO ROAD 11kV FEEDER

| Transformer Rating(kVA) | Number | Maximum Secondary Current(A) |
|-------------------------|--------|-------------------------------|
| 100                     | 1      | 139.12                        |
| 100                     | 2      | 278.24                        |
| 300                     | 3      | 417.36                        |
| 300                     | 4      | 695.60                        |
| Total                   | 27     |                               |

The total cost per hour of power saved is calculated as follows:

\[
\text{Total Cost per hour of Power Saved} = \sum_{i=1}^{n} \left( \text{Active Power Saved}_i \times \text{Cost per hour of Energy Saved} \right)
\]

where \( \text{Active Power Saved}_i \) is the active power saved at bus \( i \), and \( \text{Cost per hour of Energy Saved} \) is 305,599.63 Naira.

### TABLE V: NODE CHARACTERISTICS BEFORE AND AFTER RECONFIGURATION FOR THE ONSDO ROAD 11kV, 30-Node System

#### TABLE IV: SUMMARY OF RESULTS

| Description | Before Reconfiguration | After Reconfiguration |
|-------------|-----------------------|-----------------------|
| Open Lines  | (21, 27), (23, 11), (17, 30) | (7, 26), (9, 10), (15, 16) |
| Minimum Voltage | 0.9740 | 0.9803 |
| Percentage Voltage Improvement | 0.9818 | 0.9918 |
| Total Active Power Demand (kW) | 1599.28 | 1842.14 |
| Total Reactive Power Demand (kVar) | 1189.78 | 1093.06 |
| Total Active Power Loss (kW) | 32.47 | 15.48 |
| Percentage Power Loss Reduction (%) | 82.92 | 81.57 |
| Energy Savings (kWh) | 26.93 | 13.55 |
| Cost per hour of Energy Saved (N) | - | - |
| Total Cost per hour of Power Saved | - | - |

Fig. 6. Graph Showing Voltage Profile before and after Reconfiguration

Fig. 7. Percentage Voltage Improvement After Reconfiguration

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V. CONCLUSION AND RECOMMENDATION

A. Conclusion

The objectives of this work were to implement a formulation for the distribution power flow and develop an efficient solution algorithm for the loss minimisation problem. These solutions developed can be used in distribution system automation environment for real world power systems. These objectives were partially achieved through the implementations of the Backward/Forward Sweep Algorithm for power flow and Feeder Reconfiguration for loss reduction. The power flow solution offered optimal performance as low computational requirements. Results from simulation showed that number of iterations required for convergence was not a function of system size. However, the system performance was seen from the result of the power flow that the system is operating in accordance to IEEE stipulation on the voltage of operation. The system’s voltage of operation on all three phases was above 0.95pu which the stipulated minimum voltage of operation. The proposed optimisation technique implemented however also did yield substantial results and proved effective because an average of 85.47% loss reduction and a maximum voltage improvement of 1.7% were achieved for the case study system.

B. Recommendation

After considering effects of active power losses in distribution system on any nation’s economy and cost of electricity, it is recommended that such feeder reconfiguration, capacitor placement among the many optimisation techniques be performed on the system. However, the implementation of any of these optimisation techniques requires certain studies to be carried on the system under consideration. The studies are carried out to ascertain the level of losses and other system operation parameters. These studies require certain information on the system which must be readily available from the utility and up to date. Following the trends in power system technologies worldwide and recent research and development of Smart Grid Technologies, it can be inferred that hardware application of the optimisation technique implemented in this project can be achieved. Hence, further research should be carried out on how through the use of remote sensing and control unit our indigenous can be optimised remotely. Incorporation of Smart Grid Technology into our power may pose a challenging initial cost implication but the benefits are more on the long run.

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