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Power Loss Reduction on Transmission Network Using Capacitor Bank (A Case of Akure 132/33 KV Network)

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ABSTRACT: With ageing transmission network in Nigeria, there are trend of power loss along the transmission network which are unsuitable for both the electricity providers and the consumers because of the cost implication of these losses and also the effect of the losses on the stability of the network. The aim of this paper is to simulate a 132/33kV transmission network using NEPLAN software to see the effect of the network with or without capacitor bank placement. The software make use of Newton-Raphson for the load flow analysis. This paper presents a mode of reducing power losses on the transmission network with the use of capacitor bank optimally installed using Akure 132 /33kV network as a case study.

KEYWORDS: *Power Loss, Load Flow, NEPLAN, Capacitor Bank, Newton-Raphson, Transmission Network*

I. INTRODUCTION

Electric power system is one of the most complex system designs that is built and operated not because it is just the most widely used forms of energy in the universe and also an economic transformation determinant factor. For this and many other reasons, it has always becoming more complex with several generators and transformer, hundreds of kilometres of transmission line and huge varying loads [1]. The fact that the loads on the power network varies time and uncontrollable, power flow in some of the transmission lines are within their prescribed limits while others are being loaded above the acceptable limits. This apparently affects load flow analysis on the lines, bringing about change in bus voltage profile, increase power loss and hence decrease of the grid stability which may lead to total or partial system collapse [15].

To avoid losing continuous operation of the system, a steady-state analysis known as power flow study is required to be carried out on a selected section of the power system. This is targeted at determining the voltages, currents, real and reactive power flows in a system under certain conditions. Power flow is the backbone of power system and design which are necessary for planning, operation, economic scheduling and exchange of power between utilities [9].

The fact that delivering of power to the load centres runs through the transmission network system which consists of all equipment from the generating station to the distribution networks is through miles of kilometres, the system faces a number of challenges such as low voltage regulation, low power factor, large amount of line losses, low efficiency and overloading are. It is therefore necessary to improve the working condition of the power distribution systems to reduce losses, improve voltage regulation, improve power factor amongst others. Failure to reduce power losses can result into operating a non-economically viable power system. A number of researchers have worked on means of reducing power losses. Losses can be reduced by introduction of new 33kV substation along the line to avoid long span network, reworking on conductors of the feeders and installation of capacitor bank.

II. BACKGROUND AND RECENT THREADS IN EFFECTS OF CAPACITOR BANK

The effect of shunt capacitor banks in distribution network on voltage, losses, and lines loading. 12.66 kV, 33 IEEE Bus system, was simulated using Mi-Power power system analysis software to verify if effectiveness. It was discovered that the system losses reduced, network voltage increased and line voltage decreased with shunt capacitor bank in the network [7].

Importance of capacitor banks in distribution system which includes improving the power factor of a system, voltage profile, and reliability besides the reducing of the power losses of the system component due to compensation. These benefits depend greatly on how capacitors are placed in the distribution system [8].

A load flow study was carried out on 132KV and 33KV sub- stations to detect effect of group shunt compensation. It was discovered that if reactive power is supplied near the load, the line current will be reduced or minimized, reducing power losses and improving voltage regulation at the load terminals. The leading current drawn by the shunt capacitors compensate the lagging current drawn by the load [4].

It was discovered that the shunt capacitor bank improved the power factor, increased voltage level on the load and reduced current flow through the transmission lines by designing and installing a 12MVAR rating shunt capacitor bank at 33KV bus bar for reactive power compensation on 132/33KV substation [2].

A new algorithm was presented for optimal locations and sizing of static or switched shunt capacitor in order to enhance voltage stability in addition to improving the voltage profile and minimizing losses. This method found the optimal location and determined the size and type of capacitor bank to be placed to enhance the voltage stability besides improving the voltage profile and reducing the system losses [10].

This article shall be establishing the fact that right placement of capacitor bank can as well reduce power line losses which is key to system stability. This which earlier researchers had paid less attention to.

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III. AKURE 132/33KV SUBSTATION SUPPLY SOURCE

The Akure 132/33kV transmission substation is situatedat Akure City in the central part of Ondo State. The station is fed at 132kV voltage from Osogbo 330/132kV Transmission Station (known as Area control centre). Figure 1 shows a network single line of Akure 132/33kV network

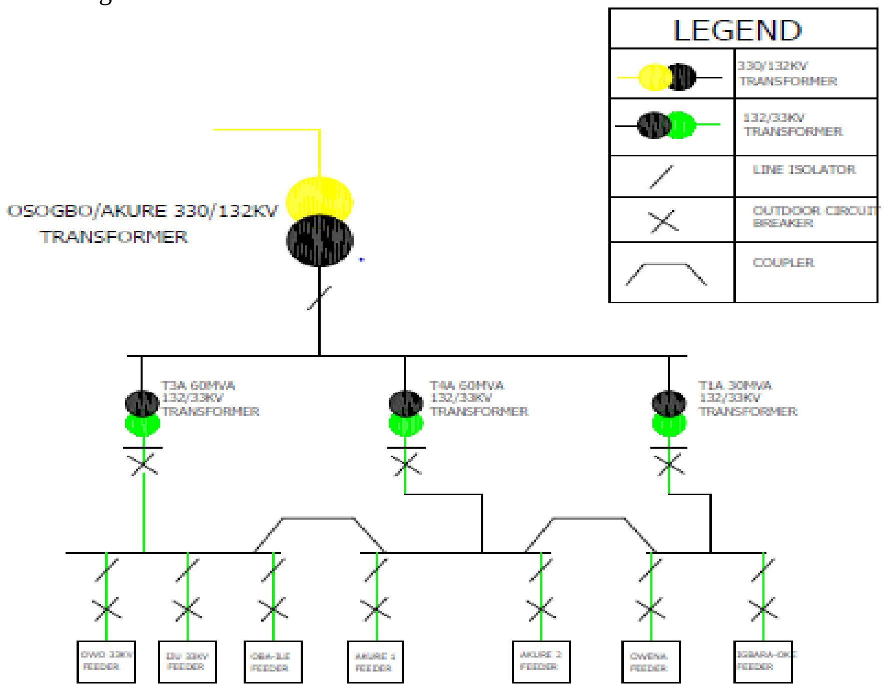

Figure1. Single line diagram of Akure 132/33KV network

IV. MODELING OF AKURE 132/33 KV SUBSTATION

NEPLAN was used for the network modelling because of its superior capability in handing load flow and network stability analysis. NEPLAN has capabilities to perform so many operations in power system network such as: Load flow, Load flow with profiles, optimal separation points, optimal distribution network, optimal capacitor placement, voltage stability, transient stability etc. Figure 2 and 3 show network modelling of Akure 132/33kV network without capacitor bank and with capacitor bank respectively using NEPLAN software

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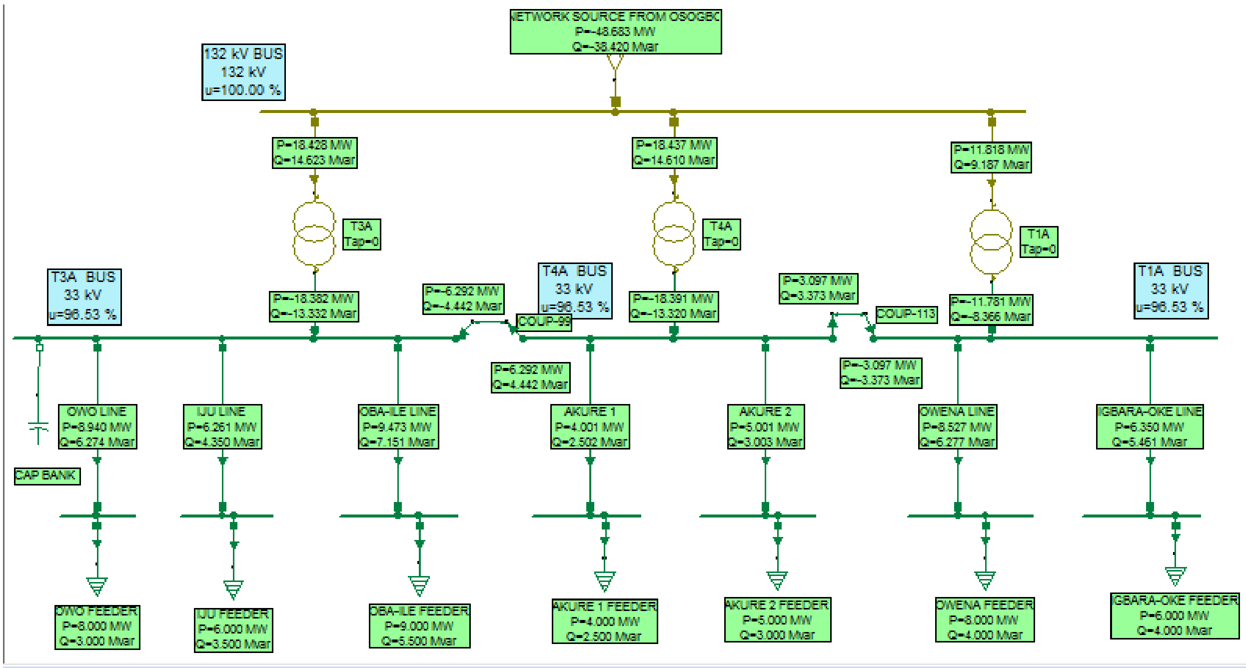


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...Start Analysis....
Iteration 1- Max. Mism. (Area/Zone/Network) at Equation: 93 = 4.600000e-001
Iteration 2- Max. Mism. (OWO LINE,ID=151) at Equation: 6 = 1.584096e-002
Iteration 3- Max. Mism. (OWO LINE,ID=151) at Equation: 6 = 2.370960e-003
Iteration 4- Max. Mism. (OWO LINE,ID=151) at Equation: 6 = 8.657524e-005
Load Flow converged after 4 iterations.
Network MW   losses = 2.682741
Network Mvar losses = 12.919727
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Fig 2: Modelling of Akure 132/33kV network without Capacitor Bank

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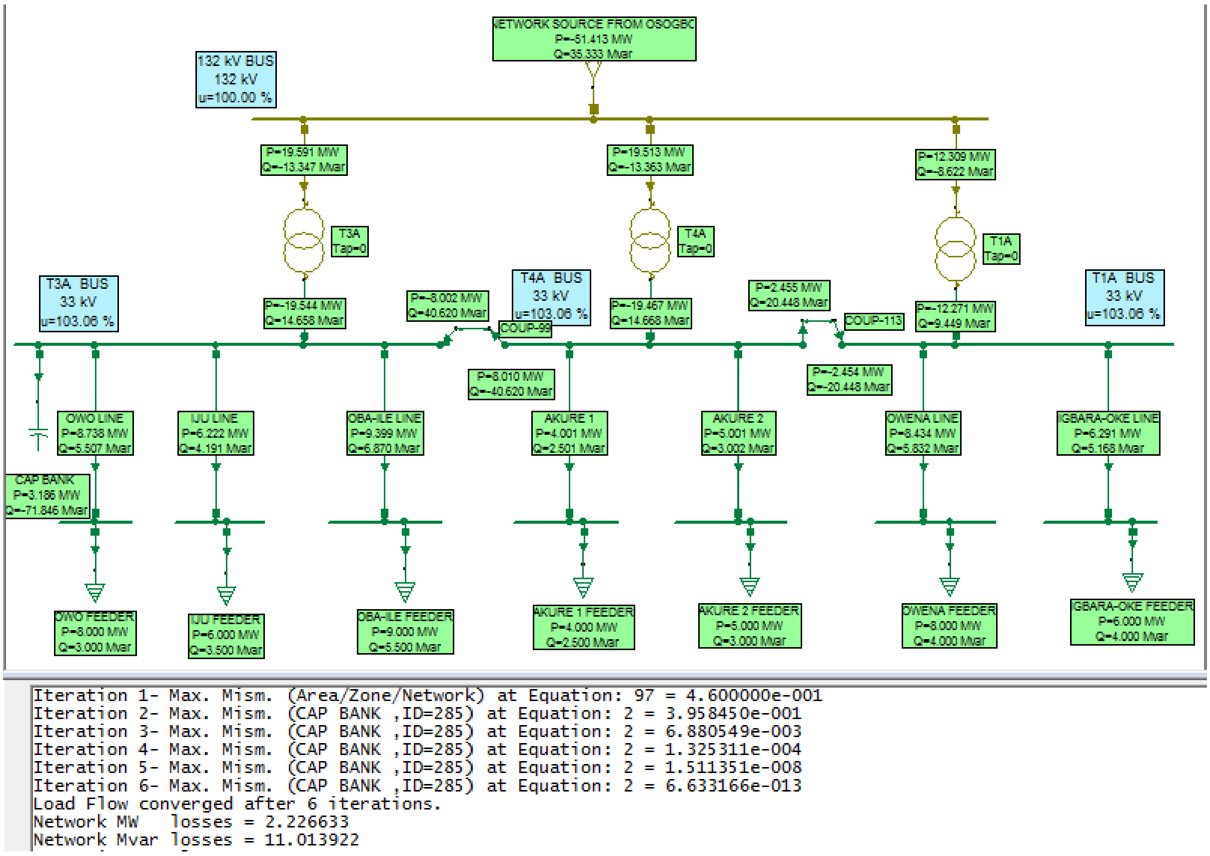

Fig 3: Modelling of Akure 132/33kV network with Capacitor Bank

V. RESULTS AND DISCUSSION

The optimal location of the capacitor bank minimizes real and reactive power losses on the power system. This was obtained using conventional Newton-Raphson iterative method of load flow in NEPLAN software which converges after six iterations. The results obtained with and without capacitor bank are presented below with effect on both real and reactive power loss.

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Table 1: Load Flow Results for the Buses without Capacitor Bank

	Name of Buses	P Load Loss MW	Q Load Loss MVar	Voltage Level's State	Remarks
1	Owo	0.940	3.274	Low Voltage	Critical
2	Iju	0.261	0.850	Low Voltage	Sustainable
3	Oba-Ile	0.473	1.651	Low Voltage	Sustainable
4	Akure 1	0.001	0.002	Normal	Good
5	Akure 2	0.001	0.003	Normal	Good
6	Owena	0.527	2.277	Low Voltage	Critical
7	IgbaraOke	0.350	1.461	Low Voltage	Critical
	Total	**2.682**	**12.919**		

Table 2: Load Flow Results for the Buses with Capacitor Bank

	Name of Buses	P Load Loss MW	Q Load Loss MVar	Voltage Level's State	Remarks
1	Owo	0.738	2.507	Low Voltage	Sustainable
2	Iju	0.222	0.691	Normal	Good
3	Oba-Ile	0.399	1.370	Normal	Good
4	Akure 1	0.001	0.001	Normal	Good
5	Akure 2	0.001	0.002	Normal	Good
6	Owena	0.434	1.832	Low Voltage	Sustainable
7	IgbaraOke	0.291	1.168	Normal	Good
	Total	**2.217**	**11.014**		

A. Comparison of Real Power Loss

The real power loss of the case study without capacitor and with capacitor banks are compared as shown in Figures 4 and 5. The losses on each lines when the capacitor bank was introduced were reduced compare to without capacitor bank as presented in figure 4. There is no significant difference in the case of Akure lines 1 and 2 because the lines were close to the load centres hence they are armoured cables laid underground. Figure 5 show the overall effect of the capacitor bank on active and reactive power on the entire network under consideration.

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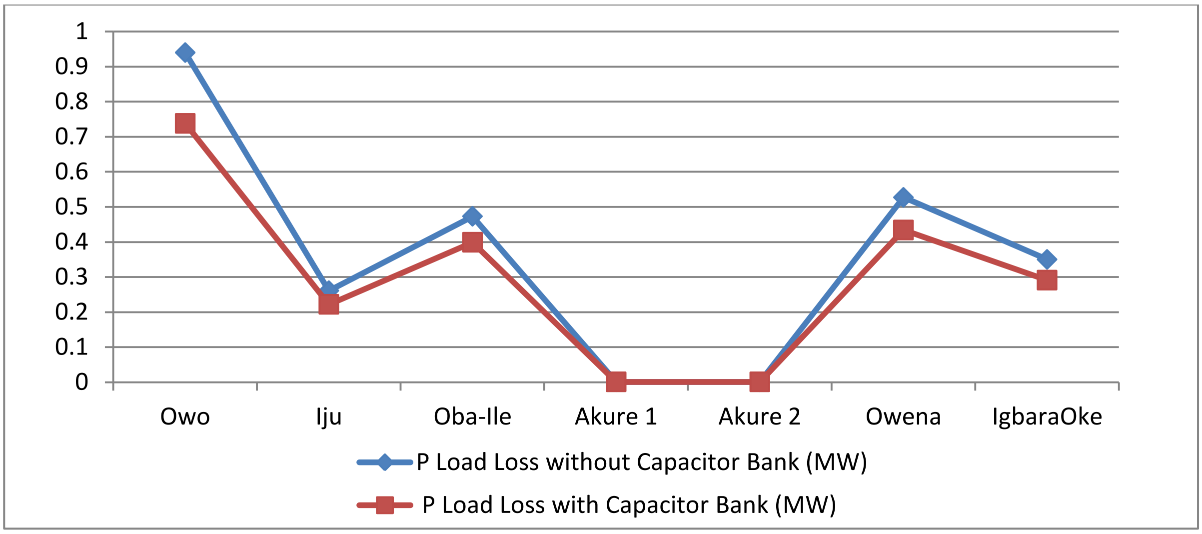

Figure 4. Comparison of Real Power Losses on the Lines

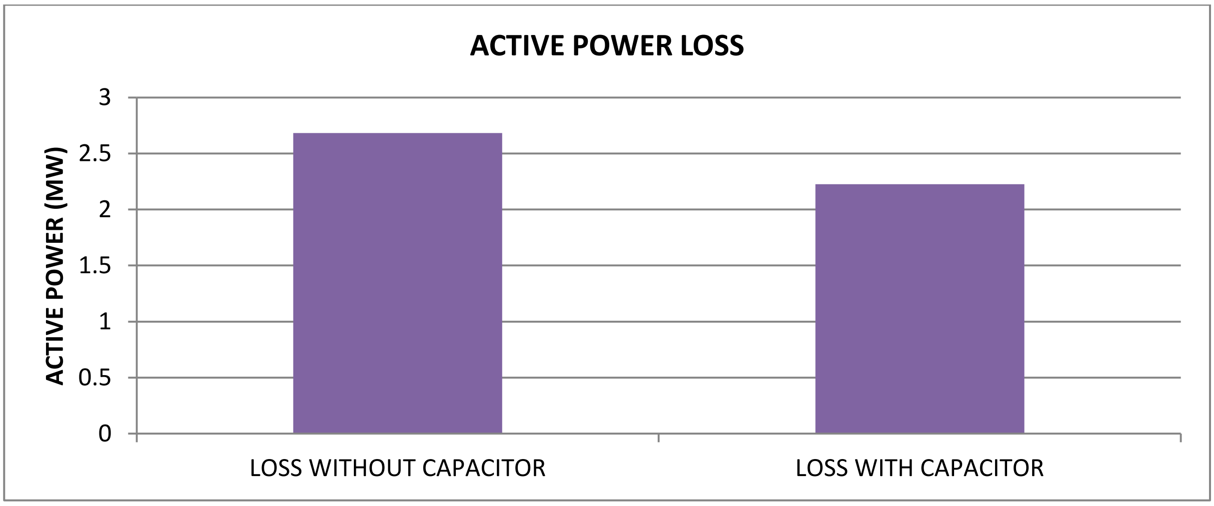

Figure 5: Cumulative Effect on Active Power Loss

The real power loss was saved by 0.465MW when shunt capacitor bank is optimally installed. Loss without capacitor bank is 2.682MW which was reduced to 2.217MW with capacitor bank.

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B. Comparison of Reactive Power Loss

The reactive power is also reduced when the capacitor bank is installed optimally. Figure 6 shows the relationship between the Var loss on the line with and without optimally place capacitor bank. A reduction of 1.905MVar was achieved. That is from 12.919MVar without capacitor bank to 11.014MVar with capacitor bank as shown in figure 7.

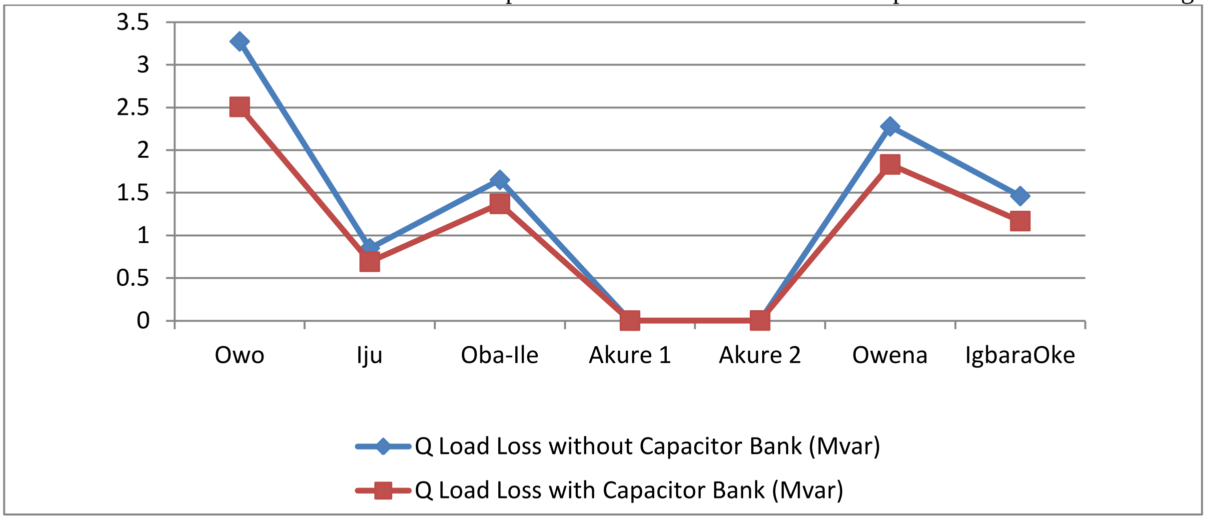

Figure 6Comparison of Reactive Power Losses on the Lines

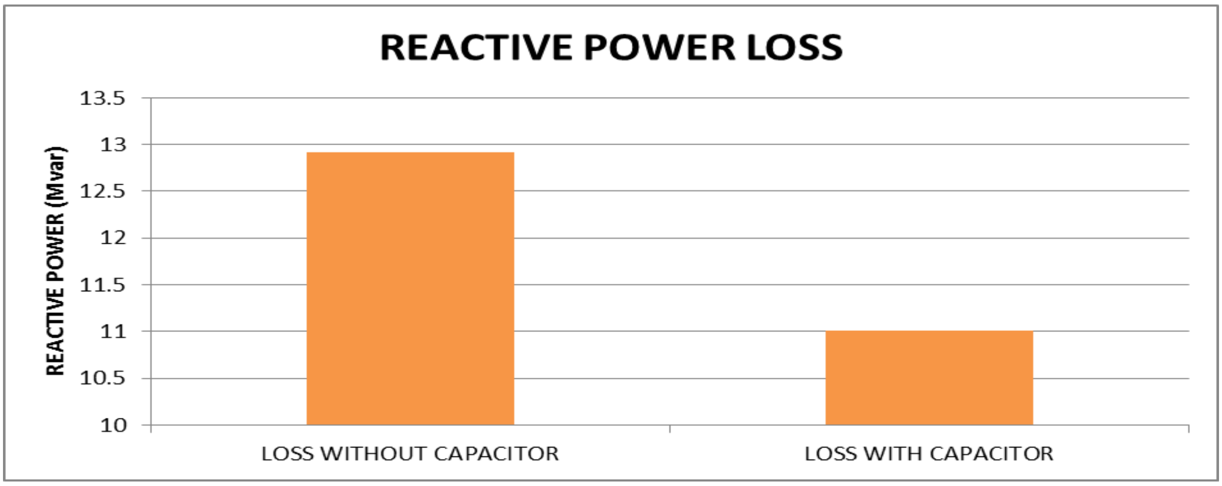

Figure 7 Comparison of Reactive Power Loss

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VI. CONCLUSION

This work has been able to establish effects of an optimally placed capacitor bank on transmission power network with Akure 132/33KV network as a case study. For the fact that power transmission losses were reduced with capacitor bank rightly placed, it is not out of place that installation of capacitor bank affects overall system performance positively. Reduction in power losses ensure the stability of the power system. Also while the cost of installing capacitor bank is compared to the cost of generating and transmitting the amount of power to be wasted as losses, it sound economically reasonable to install capacitor bank to avoid the wastage.

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