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Improving Energy Y Efficiency Using Facts Device Technique in Nsukka 33kv Distribution Network

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Abstract- The inconsistence power supply observed in NSUKKA metropolis is as a result of per unit volts not falling within the standard range of 0.95 through 1.05. This is subdued by introducing Improving energy y efficiency using FACTS device Technique in NSUKKA 33kv distribution network. To achieve this it is done in this manner, characterizing the 33KV NSUKKA power distribution network to establish power losses, running a load flow analysis of the NSUKKA power distribution network in order to identify power loss sources and faulty BUSBARS, using SIMULINK to model FACTS device for minimizing Power losses in the NSUKKA 33KV Power Distribution Network, repeating the load flow analysis with the FACTS device and its control circuit integrated into the SIMULINK Model of the NSUKKA 33KV Power Distribution network for minimizing power losses and validating and justifying the use of FACTS device in loss reduction in NSUKKA 33KV power distribution network from the results of 2 and 4 by calculating percentage of improvement in loss reduction. The results obtained are conventional and facts device P.U. volts in bus 3(WILSON) in Improving energy y efficiency in NSUKKA 33kv distribution network. The conventional per unit volts in bus 3 is 0.88 which implies that the power supply therein is unstable because it did not fall within the stable range of 0.95 through 1.05.

Indexed Terms- Energy Efficiency, Facts device technique, Nsukka 33kv, and Distribution Network

I. INTRODUCTION

In the present-day scenario, transmission systems are becoming increasingly stressed, more difficult to operate, and more insecure with unscheduled power flows and greater losses because of growing demand for electricity and restriction on the construction of new lines. However, many high-voltage transmission systems are operating below their thermal ratings due to constraints, such as voltage and stability limits. Now, more advanced technology is used for reliable and operation of transmission and distribution in power system (Paserba,2003). To achieve both reliable and benefit economically, it has become clearer that more efficient utilization and control of the existing transmission system infrastructure is required. Improved utilization of the existing power system is provided through the application of advanced control technologies. Power electronics has developed the flexible AC transmission system (FACTS) devices. FACTS (Paserba,2003), devices are effective and capable of increasing the power transfer capability of a line and support the power system to work with comfortable margins of stability (Candrakar et al,2007). FACTS devices are used in transmission system to control and utilize the flexibility and system performance. To achieve all, the insertion of FACTS devices required in plant in order to control the main parameters namely voltage.

Now, the industry is suddenly faced with the responsibility for many pricing decisions in an environment that can be highly volatile. The deregulation of electric power pricing has created a stimulus for some high quality scientific and economic research and several of these researches focus on power quality improvement, cost, and efficiency to reflect contemporary electricity market dynamics (Pennings and Heijman, 1995) and (Amundsen and Singh, 1999). This deregulation translated into separation of generation, transmission and distribution. Each country has its own liberalization model. The Federal Government of Nigeria has adopted the public-private partnership (PPP) model to privatize the Power Holding Company of Nigeria's (PHCN's) eleven successor distribution companies (Nation Newspaper, 2010). At the ultimate phase, every sector is independent of one another and this would result in improved power system efficiency and price decrease of the kilowatts hour (KWH), particularly for large customers.

- Problem Statement

The instability of power supply in NSUKKA metropolis is as a result of the per unit volts not falling within the range of 0.95 through 1.05. This has equally led to inefficiency in power supply in NSUKKA metropolis this has liquidated some companies or establishments that solely depend on power to run their routine business. This is surmounted by introducing Improving energy y efficiency using FACTS device Technique in NSUKKA 33kv distribution network

- Significance of the Study

In a modern powers system, there are several elements between the generating station and the consumers. Several voltage control equipment is used at various points in the system for the following reasons (Gupta 1995):

The power network is extensive and there is considerable voltage drop in transmission and distribution system the various circuits of the power system have dissimilar load characteristics. For these reasons, it is necessary to provide individual means of voltage control for each circuit or groups of circuit.

In view of the above analysis, the significance of this technical research work includes:

a) Helping government agencies like the Nigerian Electricity Regulatory Commission (NERC) to postulate and implement power policies like statutory limit of voltage variation, optimization and improved power quality.
b) This technical research work has equally shown that power electronic high speed control FACTS-DEVICE is a more efficient method of voltage control than the electromechanically controlled synchronous condenser presently in use at ogui power distribution network control of power system parameters and enhancement of power quality using FACTS devices.

- Scope of the Study

The scope of this research work covers the reduction of power losses in NSUKKA distribution network only. It does not extend to restructuring of the distribution networks.

- Justification of the Study

Electricity is modern society's most convenient and useful form of energy. Without it, the present social and physical infrastructure would not all be feasible. The increasing per capita consumption of electricity throughout the world reflects a growing standard of living of the people (Gyugyi, 2009). The greater the per capita consumption of electrical energy in a country, the higher is the standard of living of its people. To reflect this global *trend, the Electric Power Research Institute (EPRI) in the US launched the Flexible Alternating* Current Transmission System (FACTS) initiative in the later 1980's with two main objectives: To increase the power transfer capability of electric power system and to conveniently keep voltage constant over designated routes.

II. MATERIALS AND METHODS

- Materials Used.

a. MATLAB 2015a
b. Laptop 4gb RAM, 64 Bit operating system

- Design Method

This work is built upon the principle of steady-state operation and modeling of FACT controller describes the power flow theory. Newton-Raphson model was developed because of their strong convergence characteristics have proved the most successful and have been embraced by power industry. This work employed an elegant method for accommodating models of controllable equipment namely STATCOM Flexible Alternating Current Transmission System controller into the Newton-Raphson power flow algorithms. The algorithm was simulated using MATLAB 2015a Two different power flow programs of EECD Distribution Network are written in MATLAB environment, MATLAB program to calculate positive sequence power flows using the conventional Newton-Raphson method and MATLAB program to incorporate the static compensator (STATCOM) FACTS controller within the Newton-

Raphson power flow algorithm. Data was collected to test-run the model from EECD Enugu. The model was compared with network that has FACT DEVICE and NO FACT DEVICE.

III. TO CHARACTERIZE THE 33KV NSUKKA POWER DISTRIBUTION NETWORK TO ESTABLISH POWER LOSSES.

Power loss is the outage of power from the power system which occurs unexpectedly. However, the loss in power transmission lines could be as a result of the voltage level, distance of transmission, the level of current and so on etc.

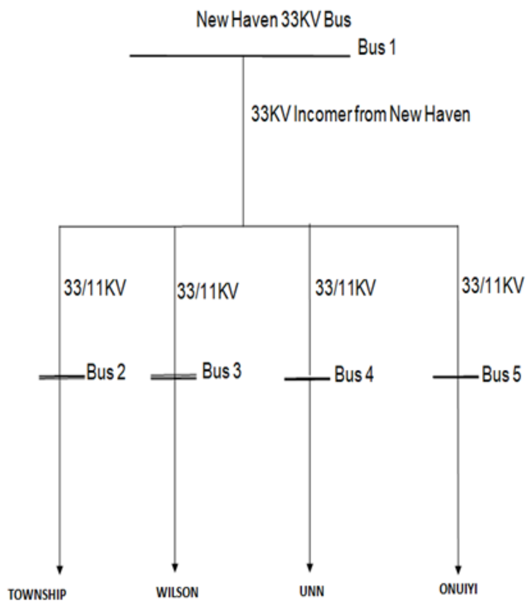

Fig 1: Single Line Diagam of the Nsukka 33 KV Power Distribution Network

The Nsukka 33KV distribution network consists of five buses, four feeders, four transformers and five transmission lines. it receives its incoming 33KV supply from the New Haven 330/132/33KV transmission network. The 33KV voltage is then stepped down to 11KV using four 5MVA, 33/11KV transformers and feeds Township, Wilson, UNN and Onuiyi on 11KV as shown in fig 1 above.

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Table 1 collected data of NSUKKA distribution network

S/n	Feeders	P_{Actual}(MW)
1	Township	3.98
2	Wilson	1.04
3	UNN	2.67
4	Onuiyi	0.97

Table 2 empirical data for 33KV distribution network in NSUKKA metropolis.

Bus No	Bus code	[V] P.U	Ang Degree	Load MW	Load MVar	Gen MW	Gen Mvar	Gen Min	MVar Max	Injected MVar
1	1	0.86	0	0	0	0	0	0	0	0
2	0	0.91	0	0	0	0	0	0	0	0
3	0	0.81	0	150	120	0	0	0	0	0
4	0	1.0	0	0	0	0	0	0	0	0
5	0	1.0	0	120	60	0	0	0	0	0
6	0	0.6	0	140	90	0	0	0	0	0
7	0	1.0	0	0	0	0	0	0	0	0
8	0	1.0	0	110	90	0	0	0	0	0
9	0	1.0	0	80	50	0	0	0	0	0
10	2	1.025	0	0	0	200	0	0	180	0
11	2	1.05	0	0	0	160	0	0	120	0

Table 3: load distribution in the network after running the load flow

S/n	Feeders	(V)P.U.	P_{Actual}(MW)	P_{Load}(MW)	%Loss
1	Township	0.869	3.98	3.81	4.3
2	Wilson	0.880	1.04	0.965	7.2
3	UNN	0.966	2.67	2.67	0
4	Onuiyi	0.959	0.97	0.97	0

The formular for the percentage loss in a power system can be calculated using the formular:

$$\%PowerLoss = \left(\frac{ActualPower - LoadPower}{ActualPower}\right) \times 100 \quad (1)$$

% Power loss at Township

$$\%PowerLoss = \left(\frac{3.98 - 3.81}{3.98}\right) \times 100\% = 4.3\%$$

% Power loss at Wilson

$$\%PowerLoss = \left(\frac{1.04 - 0.965}{1.04}\right) \times 100\% = 7.2\%$$

% Power loss at UNN $\left(\frac{2.67 - 2.67}{2.67}\right) \times 100\% = 0\%$

% Power loss at Onuiyi = 0%

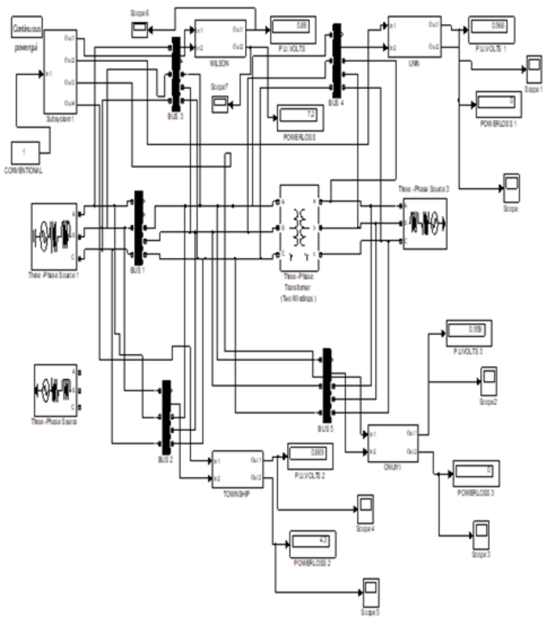

Fig 2 Conventional SIMULINK model for improving energy y efficiency in NSUKKA 33kv distribution network.

Fig 2 shows conventional SIMULINK model for improving energy y efficiency in NSUKKA 33kv distribution network. The results obtained are as shown in figures 5 through figure 8.

To use SIMULINK to model FACTS device for minimizing Power losses in the NSUKKA 33KV Power Distribution Network

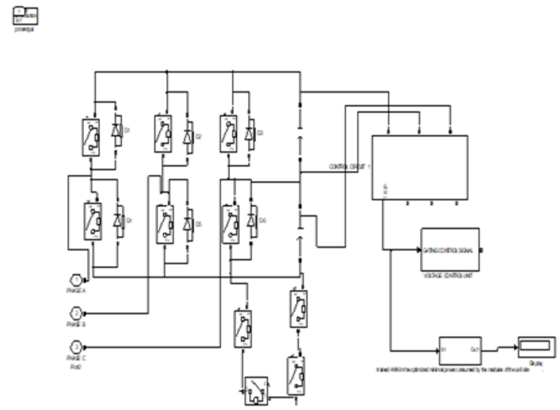

Fig 3 FACTS device SIMULINK model for minimizing Power losses in the NSUKKA 33KV Power Distribution Network

To repeat the load flow analysis with the FACTS device and its control circuit integrated into the SIMULINK Model of the NSUKKA 33KV Power Distribution network for minimizing power losses

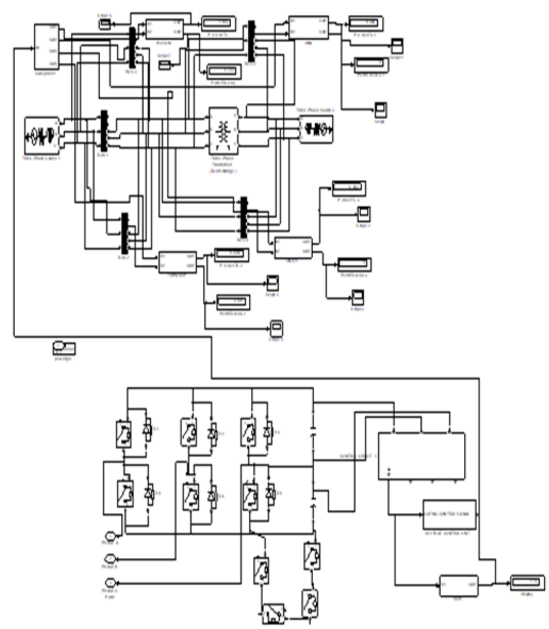

Fig 4 repeated load flow analysis with the FACTS device and its control circuit integrated into the SIMULINK Model of the NSUKKA 33KV Power Distribution network for minimizing power losses

Fig 4 shows repeated load flow analysis with the FACTS device and its control circuit integrated into the SIMULINK Model of the NSUKKA 33KV Power Distribution network for minimizing power losses. The results obtained after extensive simulation are as shown in figures 5 through figure 8.

IV. RESULTS AND DISCUSSIONS

Table 4 comparing conventional and facts device P.U. volts in bus 3(WILSON) in Improving energy y efficiency in NSUKKA 33kv distribution network

Time(s)	Conventional P.U. volts in Bus 3(WILSON) in Improving energy y efficiency in NSUKKA 33kv distribution network.(volts)	FACTS device P.U VOLTS(WILSON) in Improving energy y efficiency in NSUKKA 33kv distribution network.(volts)
1	0.88	1.003
2	0.88	1.003
3	0.88	1.003
4	0.88	1.003
10	0.88	1.003

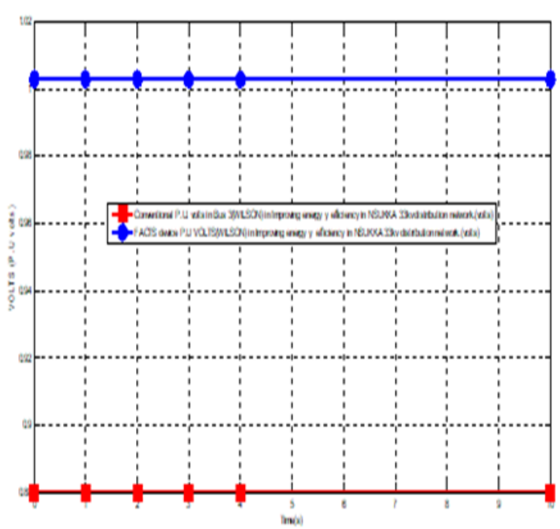

Fig 5 comparing conventional and facts device P.U. volts in bus 3(WILSON) in Improving energy y ef``12ficiency in NSUKKA 33kv distribution network.

Fig 5 shows comparing conventional and facts device P.U. volts in bus 3(WILSON) in Improving energy y efficiency in NSUKKA 33kv distribution network. Fig 4.1 shows that the conventional per unit volts in bus 3 is 0.88 which implies that the power supply therein is unstable because it did not fall within the stable range of 0.95 through 1.05. On the other hand, when Facts device is incorporated in the system it boost the per unit volts to 1.003 thereby enhancing energy efficiency in bus 3.

Table 5 comparing conventional and facts device power loss in bus 3(WILSON) in Improving energy y efficiency in NSUKKA 33kv distribution network

Time(s)	Conventional power loss in Bus 3(WILSON) in Improving energy y efficiency in NSUKKA 33kv distribution network.(%)	FACTS device power loss in bus 3 (WILSON) in Improving energy y efficiency in NSUKKA 33kv distribution network.(%)
1	7.2	6.743
2	7.2	6.743
3	7.2	6.743
4	7.2	6.743
10	7.2	6.743

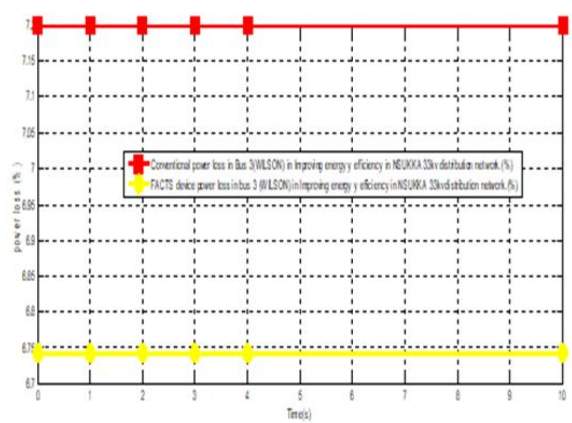

Fig 6 comparing conventional and facts device power loss in bus 3 (WILSON) in Improving energy y efficiency in NSUKKA 33kv distribution network

Fig 6 shows comparing conventional and facts device power loss in bus 3 (WILSON) in Improving energy y efficiency in NSUKKA 33kv distribution network. In bus 3 the conventional percentage of power loss in NSUKKA 33kv distribution network is7.2% thereby reducing the energy efficiency of the distribution network at Wilson in NSUKKA metropolis. Meanwhile, when Facts device is imbibed in the system it reduced the power loss in bus 3 to 6.743% thereby improving the energy efficiency in bus 3 to 0.46%.

Table 6 comparing conventional and facts device P.U. volts in bus 2 (Township)) in Improving energy y efficiency in NSUKKA 33KV distribution network

Time(s)	Conventional P.U. volts in Bus 2 (Township) in Improving energy y efficiency in NSUKKA 33kv distribution network.(volts)	FACTS device P.U VOLTS in bus 2 (Township) in Improving energy y efficiency in 33kv distribution network.(volts)
1	0.869	0.9907
2	0.869	0.9907
3	0.869	0.9907
4	0.869	0.9907
10	0.869	0.9907

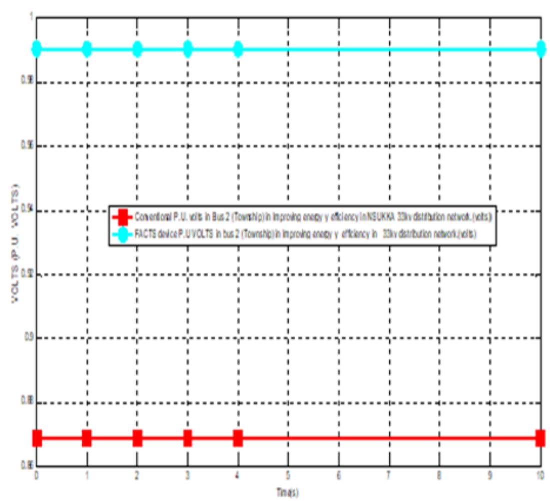

Fig 7 comparing conventional and facts device P.U. volts in bus 2 (Township)) in Improving energy efficiency in NSUKKA 33kv distribution network

Fig 7 comparing conventional and facts device P.U. volts in bus 2 (Township)) in Improving energy efficiency in NSUKKA 33kv distribution network. In fig 4.3 the conventional per unit volts of bus 2 in NSUKKA metropolis is 0.869 which is definitely out of range of 0.95 through 1.05 per unit volts that determines voltage stability. With this result it depicts that there is intermittent power supply in bus 2. On the other hand, when Facts device is incorporated in the system it stabilizes the voltage to 0.9907 per unit volts thereby improving energy efficiency in bus 2.

Table 7 comparing conventional and facts device power loss in bus 2 (Township) in Improving energy efficiency in NSUKKA 33kv distribution network

Time(s)	Conventional power loss in Bus 2(TOWNSHIP) in Improving energy y efficiency in NSUKKA 33kv distribution network. (%)	FACTS device power loss in bus 2 (TOWNSHIP) in Improving energy y efficiency in NSUKKA 33kv distribution network. (%)
1	4.3	4.027
2	4.3	4.027
3	4.3	4.027
4	4.3	4.027
10	4.3	4.027

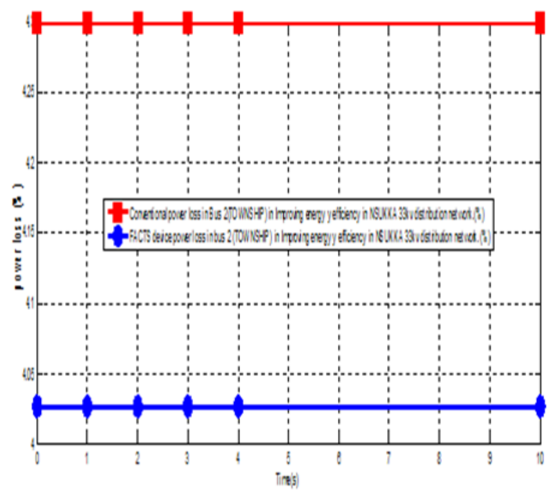

Fig 8. Comparing conventional and facts device power loss in bus 2(Township) in Improving energy efficiency in NSUKKA 33kv distribution network

Fig 8. Shows comparing conventional and facts device power loss in bus 2(Township) in Improving energy efficiency in NSUKKA 33kv distribution network. In fig 8. The conventional power loss in bus 2 in NSUKKA distribution network is 4.3% while that when Facts device is incorporated in the system is 4.027%. With these results obtained, it shows that the energy efficiency improvement is 0.273% when Facts device is incorporated in the system.

CONCLUSION AND RECOMMENDATIONS

- Conclusion

The intermittent power supply observed in NSUKKA metropolis has arisen as a result of per unit volts not falling within the range of 0.95 through 1.05. This has caused low energy efficiency in NSUKKA metropolis. This is overcome by introducing Improving energy y efficiency using FACTS device Technique in NSUKKA 33kv distribution network .To achieve this it is done in this manner, characterizing the 33KV NSUKKA power distribution network to establish power losses, running a load flow analysis of the NSUKKA power distribution network in order to identify power loss sources and faulty BUSBARS, using SIMULINK to model FACTS device for minimizing Power losses in the NSUKKA 33KV Power Distribution Network, repeating the load flow analysis with the FACTS device and its control circuit integrated into the SIMULINK Model of the NSUKKA 33KV Power Distribution network for minimizing power losses and validating and justifying the use of FACTS device in loss reduction in NSUKKA 33KV power distribution network from the results of 2 and 4 by calculating percentage of improvement in loss reduction. The results obtained are conventional and facts device P.U. volts in bus 3(WILSON) in Improving energy y efficiency in NSUKKA 33kv distribution network. The conventional per unit volts in bus 3 is 0.88 which implies that the power supply therein is unstable because it did not fall within the stable range of 0.95 through 1.05. On the other hand, when Facts device is incorporated in the system it boost the per unit volts to 1.003 thereby enhancing energy efficiency in bus 3, conventional and facts device power loss in bus 3 (WILSON) in Improving energy y efficiency in NSUKKA 33kv distribution network. In bus 3 the conventional percentage of power loss in NSUKKA 33kv distribution network is7.2% thereby reducing the energy efficiency of the distribution network at Wilson in NSUKKA metropolis. Meanwhile, when Facts device is imbibed in the system it reduced the power loss in bus 3 to 6.743% thereby improving the energy efficiency in bus 3 to 0.46%, the conventional per unit volts of bus 2 in NSUKKA metropolis is 0.869 which is definitely out of range of 0.95 through 1.05 per unit volts that determines voltage stability. With this result it depicts that there is intermittent power supply in bus 2. On the other hand, when Facts device is incorporated in the system it stabilize the voltage to 0.9907 per unit volts thereby improving energy efficiency and the conventional power loss in bus 2 in NSUKKA distribution network is 4.3% while that when Facts device is incorporated in the system is 4.027%. With these results obtained, it shows that the energy efficiency improvement is 0.273% when Facts device is incorporated in the system.

- Recommendations

In this work, the objective was to determine the steady-state operating condition of Radial distribution network. The steady-state was determined by finding out, for a given set of loading conditions, the flow of active and reactive powers throughout the network and the voltage magnitude and phase angles at all buses of the network. Buses where voltage magnitudes are outside acceptable limit, STATCOM was deployed to regulate such voltage magnitudes and increase the active power flow in the network. However, with ever increase in the load sizes and operational complexities brought about by a widespread interconnection of power system, the operating philosophy had to be revised, and the concepts based on economic consideration like optimal power flow should be adopted. It is most likely that this thesis, although feasible, would not yield the most economic operating schedule. The OPF solution, in contrast, would optimize the power flow network equation subject to physical and operational constraints. Any solution point that satisfies all the constraints would then yield an economic feasible solution.

The optimal power flow suggested above is usually solved by converting the constrained optimization problem into an un-constrained optimization problem using Newton's method. This is achieved by constructing an augmented Lagrangian function. In view of the rigorous mathematical analysis involved in conventional optimization algorithms, combinatorial optimization problems are better solved using artificial intelligence. Sequel to this, it is suggested that expert systems such as Genetic algorithm and Fuzzy logic should be applied to simultaneously determine the best node/bus to connect the FACTS DEVICE, the type of

FACTS DEVICE and the rating of the FACTS device in order to achieve the most economic feasible solution.

- Contribution to Knowledge

This work contributes to knowledge in the area of the following:

1. The development of newton Raphson model which will incorporate with the STATCOM FACT-DEVICE in order to improve energy efficiency of power distribution networks
2. The simulation of the model use in the improvement energy efficiency of power distribution networks

V. ACKNOWLEDGEMENT

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