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Redusing Losses in the Nigerian 330KV Electric Power Network in Some Areas of South South Geopolitical Zone by Optim Ization

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ABSTRACT

In this paper, the use of particle swarm optimization to reduce line losses is investigated. In this study, theoretical and practical challenges related to particle swarm optimization for minimizing line losses in electrical power networks are discussed. The study made use of STATCOM and other devices for voltage regulation and active power loss reduction. Presenting the concept and advancement of STATCOM application for optimization. Particularly for higher-dimensional search spaces and optimization problems that could be discontinuous, noisy, and time-varying, the behavior of a Particle Swarm Optimization (PSO) is not well known in terms of how it influences real optimization performance. The usage of accelerated particle swarm optimization (APSO), which is standardized and understandable by laypeople, has been adopted to combat these. There are many variations of the fundamental Particle Swarm Optimization (PSO) algorithm because PSO is a very broad field. As a result, the employment of a well-known, precisely defined standard algorithm that offers a useful point of comparison and is utilized throughout the study area to assess new advancements. It is strongly advised to use the most recent standard, PSO 2011 (SPSO 2011).

But in this study, we've completed and executed a line losses analysis of Nigeria's 330KV grid infrastructure. It was possible to identify issues and unstable conditions in the system, apply and test important settings, and get positive outcomes thanks to the detailed line losses data of the system that was displayed.

So, for the transmission of the Nigerian 330KV System to run more safely and effectively in order to develop the future power system, the results of the line losses analysis employing swamp optimization were helpful.

Keywords: Voltage regulation, Network, Active Power loss, Particle swamp optimization (PSO), and Accelerated Particle Swamp, Thyristor-Controlled Series Capacitor TCSC

1. INTRODUCTION

For a country to prosper economically, energy is a necessary requirement. There are other types of energy, but electrical energy is the most significant one. Electrical energy use is crucial to maintaining a contemporary, civilized civilization. An electrical power system network is utilized to obtain this electrical energy; as a result, it is a network of electrical components deployed to provide, transfer, store, and utilise electricity. Due to the significance of electrical energy to the economic and social growth of the society, activities related to the generation, transmission, and distribution of electrical energy must be given the highest priority in any nation's national planning process. In actuality, a nation's population enjoys higher living standards the higher its per capita electrical energy usage. Through extensive networks, electrical energy must be transported from larger power facilities to consumers. Power losses occur during transmission across vast distances. Because of the joule effect in the transformer and power line, the majority of electrical energy losses result in heat loss in the conductor.

As a result, a nation's progress is assessed by the amount of electrical energy it consumes per capita. Electrical networks are the collection of equipment needed to provide electrical electricity from power plants to customers. Overhead transmission lines (OHL), underground or submarine cables, switching equipment (breakers and disconnections), substations (i.e., sub systems equipped with transformers and auto transformers that enable the transfer of power between systems operating at different voltage levels), and reactive power compensation devices (capacitors and reactors) are some of these gadgets. One of the most crucial and vital concerns in power systems is the planning of power plants in order to satisfy the demand for the power network load. The investigation, computation, and reduction of transmission losses in these power networks are of major significance to engineers since transmission lines link producing stations and substations. On the aforementioned factors, numerous research projects have been conducted.

An unstable situation in the system was discovered, operating restrictions and limits were enforced, and a planned corrective action was implemented. The investigation of line losses yielded outstanding results, which will enable the Nigerian 330KV System to be operated more safely and effectively in order to strengthen the country's future power system.

2. OVERVIEW

Over time, a number of strategies for shunt capacitor allocation-based loss reduction in distribution systems have emerged. The backward sweep approach developed by M. Afsari, Singh, and colleagues in 1999 is used to calculate the voltages for radial distribution systems. To reduce power and energy losses and to enhance the voltage profile along the feeder, shunt capacitors are inserted at the proper places in large distribution systems. the method for calculating loss minimization through capacitor placement at nodes where cost savings are the greatest. According to Shiva and Srinivasulu (2001), this is carried out for both single and multiple capacitors. Through the installation of fixed and switched shunt capacitors on primary distribution feeders, a generalized approach is created for optimizing the net momentary savings related to the decrease in power and energy losses (Lee et al., 1981). By decoupling the capacitor and regulator issues and fusing them into a single, comprehensive solution, the volt/var problem in the distribution system can be solved analytically (Grainger et al., 1985). The notion of "normalized equivalent feeder" was used to take into account the feeder's actual size. The technique (Salama et al., 1993) is created for the regulation of reactive power in distribution systems with an end load for fixed load and varying load conditions, and it provides generalized equations for computing the peak power and energy losses reduction as well as the ideal location and rating of capacitor. Heuristic search algorithms have very lately been established as an alternative to conventional analytical optimization techniques. The goal of creating such heuristic algorithms is to reduce the extensive search space while maintaining the conclusion. The ideal or almost ideal result. For large distribution systems, the benefits of heuristic approaches are highly valued since they offer primary feeder shunt capacitors in realistic sizes and locations at a relatively low computational cost. There is a formula to calculate the change in loss that results from moving a group of loads from one feeder to another feeder by shutting off single tie switching and turning on a single sectionalizing switch (Civanlar et al., 1998). Taylor (1990) describes a reconfiguration technique that has the capacity to handle practical operating restrictions.

3. MATERIALS/METHOD

3.1 Materials

Two software applications namely; Microsoft office and MatLab/PSAT were used in this study, installed in a computer system. While Microsoft word is for the arrangement and typing of the research, PSAT was used for carrying out the model and simulation of the power system network. Also snipping tool application was used for the snapshot of the network data to ensure clarity

3.2 Method .

This study's main goal was to conduct a power flow analysis on Nigeria's 330kV network for the south-southwest region. With the introduction and strategic positioning of the TCSC FACTS, the voltage instability and power losses inherent in the power system network were improved.

3.2.1 Research methodology

The major goal of this study was to analyze power flow in the southern portion of Nigeria's 330kV transmission network and to better the network's power flow by installing TCSC FACTS. The initial step in the process was to obtain the necessary data from the national control center (NCC), which includes detailed information about the power system network of the Nigerian 330kV transmission system with generators and loads. Power system analysis tool (PSAT) was used to choose and model the area of interest, which was the south and south-central stations. Both the system with TCSC FACTS and without FACTS underwent a power flow analysis. To calculate the percentage power flow improvement for both the reduction of power loss and the increase of voltage stability, a comparative analysis of the power system improvement was conducted. The flow diagram in figure 3.1 depicted a summary of the research process.

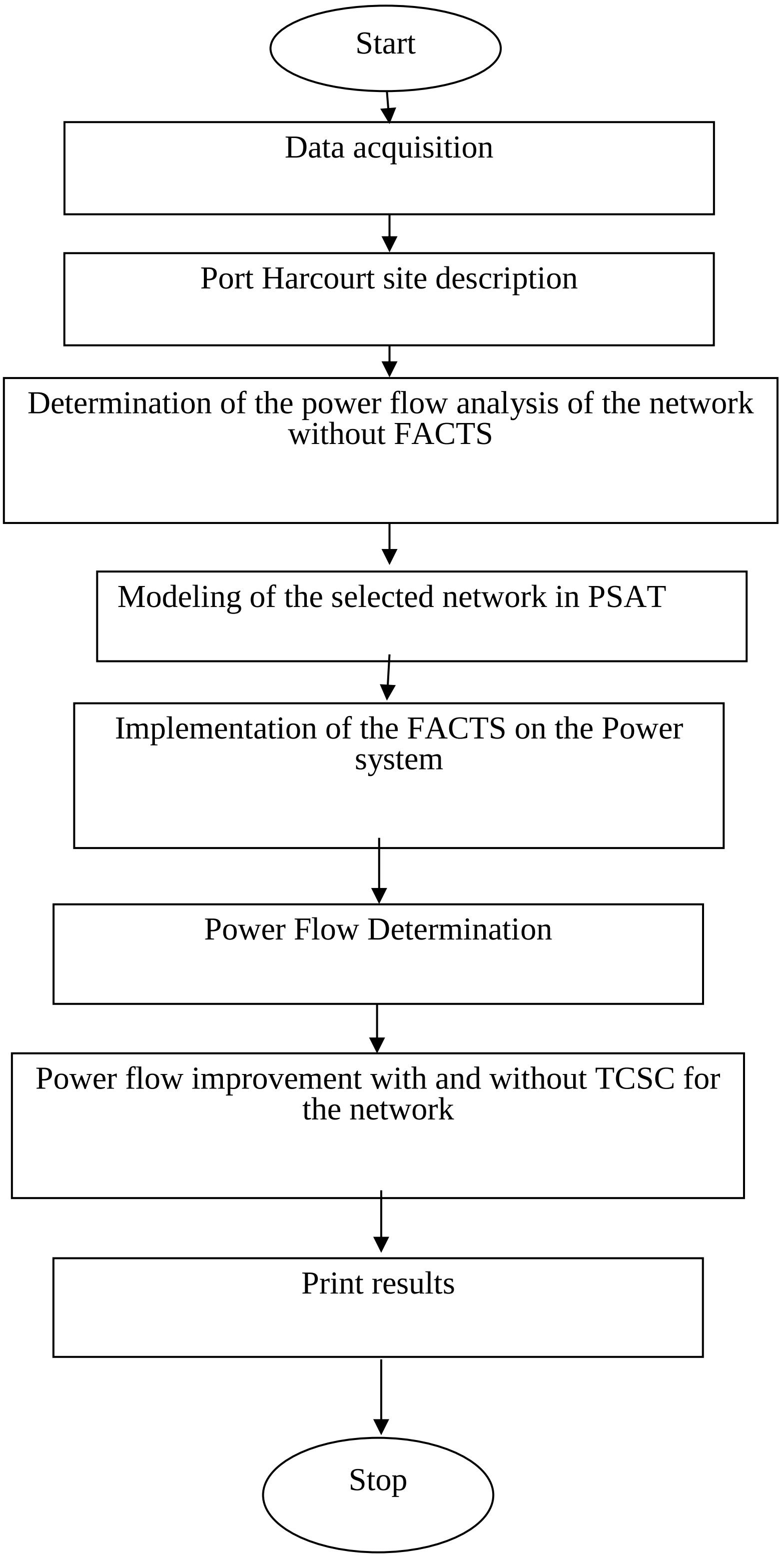


Figure 3.1 Research Procedure

The snapshot of the area of concentration was shown in figure 3.3.

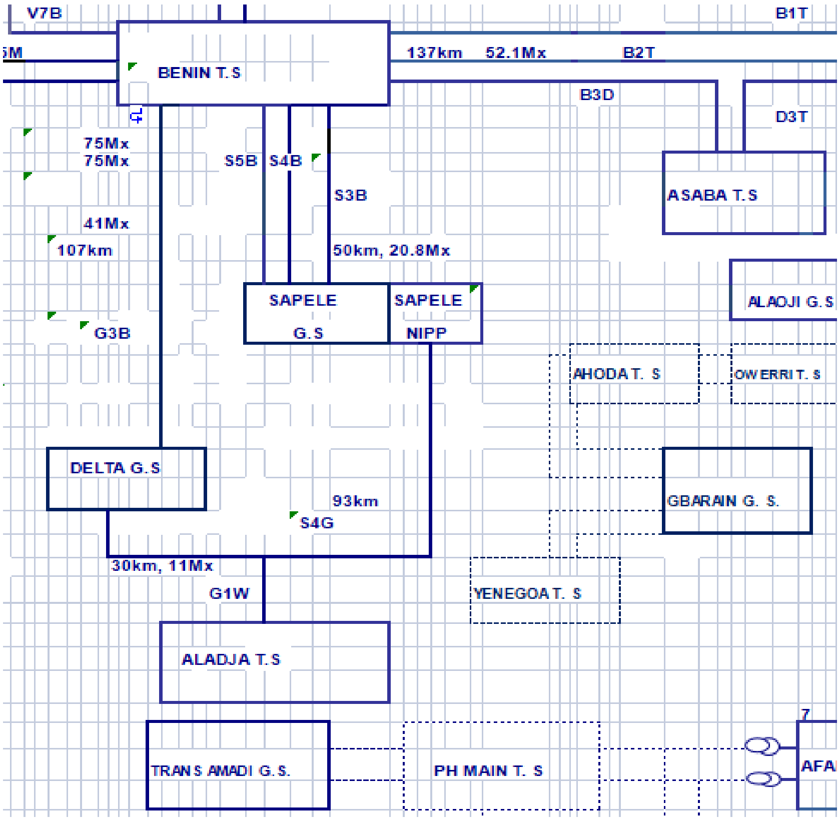
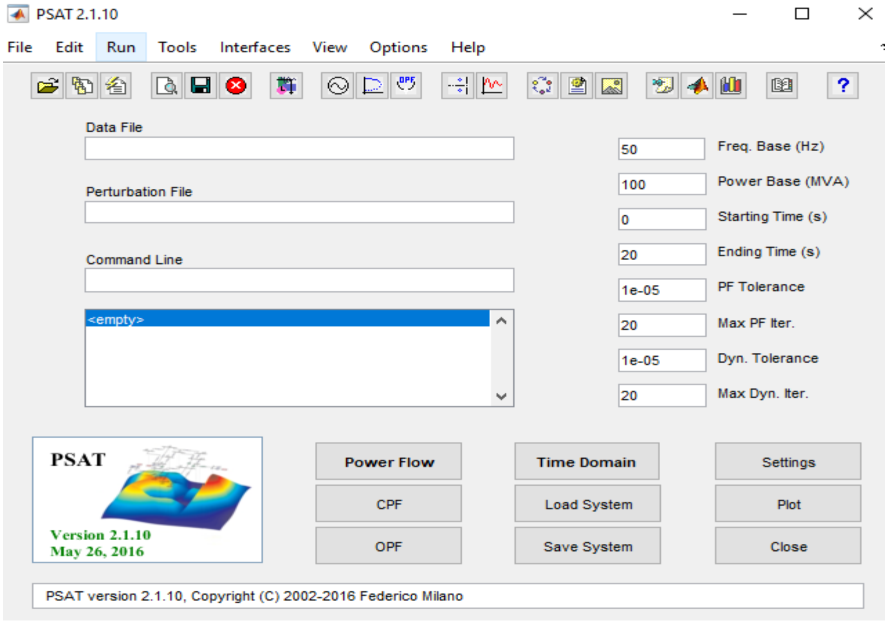


Figure 3.2. Snapshot of the power system location area of concentration

The power system network design commenced from Delta G.S (which was in this case used as the slack bus) to the Transmission station in Aladja then to the generation station in Sapele and to Benin.

3.2.3 PSAT modeling of the Power system Network

The first step to the generation of the model was to launch MatLab application and call up the PSAT environment by typing 'psat' in the command window. The PSAT environment was shown in figure 3.3.



Data File

Perturbation File

Command Line

<empty>

50 Freq. Base (Hz)
100 Power Base (MVA)
0 Starting Time (s)
20 Ending Time (s)
1e-05 PF Tolerance
20 Max PF Iter.
1e-05 Dyn. Tolerance
20 Max Dyn. Iter.

PSAT version 2.1.10, Copyright (C) 2002-2016 Federico Milano

Figure 3.3; Snapshot of the PSAT model environment

The PSAT model environment with the selection of the power system components was shown in figure 3.4.

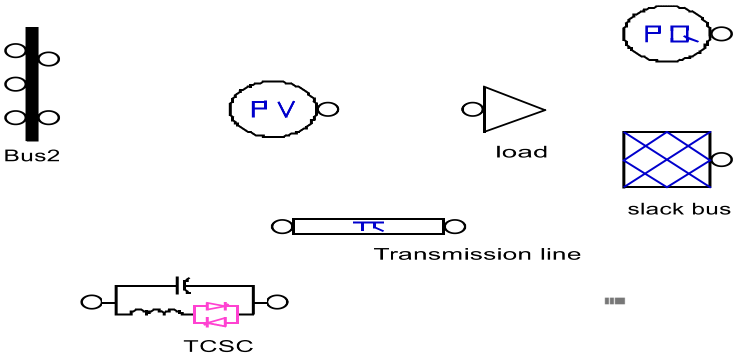


Figure 3.4; power system model components of the power system

The components includes; TCSC, transmission line, slack bus. Load and the generators.

The PSAT model of the power system network was shown in figure 3.5.

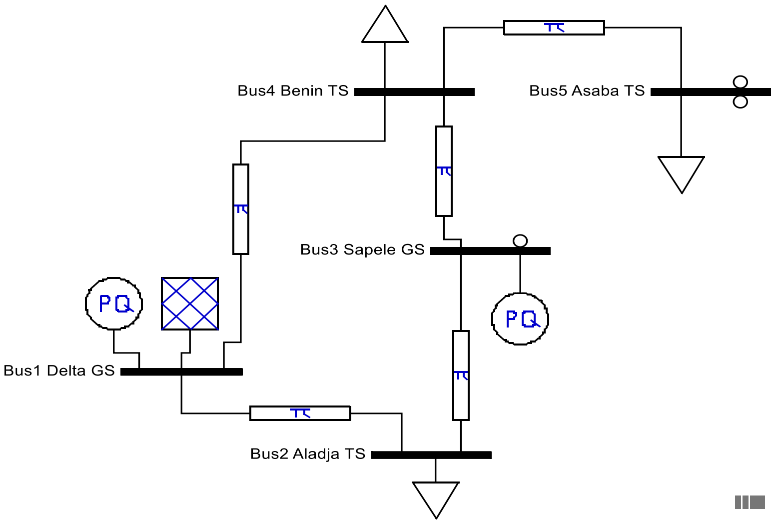


Figure e 3.5; South southern power system network model with PSAT the simulated graph is shown as we proceed

2.3 Frequency Operational Limits of the National Grid System

Up-till entrenchment of the Grid code TCN operation was solely guided by a booklet entitled Operational Procedure for Electric system operators in Grid Code.

2.3.1 Frequency Limits Under The Operational Procedure:

Statutory Limits:	50Hz ± 1% (49.5Hz to 50.5Hz)
Operational Limits:	50Hz ± 0.4% (49.8Hz to 50.2Hz)

2.3.2 Grid Code's Frequency Limits

Normal Conditions: 50Hz ± 0.5% (49.75Hz to 50.25Hz)

Emergency Conditions: 50Hz ± 2.5% (48.75Hz t 51.25Hz)

It should be noted however that frequency is determinant to quality of power supply. The electrical behaviours and performance of all electrical equipment in the National Grid and consumers are affected by frequency changes.

All efforts must hence be made to keep frequency from dropping to 49.0Hz, as much as possible. Failure to prevent this inevitably leads to cascade collapse of all power stations.

2.3.3 EFFECT OF ADVERSE SYSTEM FREQUENCY ON CONSUMER PLANTS

Majority of consumer equipment in Nigeria may tolerate transient frequency flicker, as well as even endure long tolerance limit frequencies (i.e. 49.5Hz or 50.5Hz), it must be borne in mind that process control industries, laboratories, synchronous clocks and computer centers etc, require stricter adherence to the 50Hz frequency of supply.

3.4 Load Despatch.

Load dispatch aims to generate demanded energy, transmit and distributes it with minimum cost. It dispatches the load among generators by decreasing fuel cost, Transmission Cost and Distribution cost.

3.4.1 Functions of Load Despatch Grid Operators.

Carry out real time Operations for Grid control and dispatch of electricity within the National Grid through secure and economic operation of the National grid in accordance with the Grid Code. A load Monitoring Dispatcher responsibilities includes receiving emergency and non emergency calls, monitoring the load flows, keeping records, addressing problems in the grid and dispatching appropriate team members.

3.4.2 Mode of Communication for Despatch Operators

The Load Despatch communication may be through telephone, remote telemetering and signalling and SCADA System between the Generation Grid Operators and Transmission Grid Operators and between the Transmission Grid Operators and the DisCos Grid Control Operators,

4 .1 DATA PRESENTATION AND ANALYSIS

The table above shows the daily load allocation from National Control Centre in Portharcout. The table shows the load allocation to all the DisCos connected to the National Grid. All the DisCos are to maintain the load allocated to them.

Table 4.1 shows BENIN ELECTRICITY DISTRIBUTION

BENIN ELECTRICITY DISTRIBUTION COMPANY								
Transmission Interface S/S	**Transformer Norm**	**Power Transformer Rating (MVA)**	**Associated Feeder**	**Priority Not To Shed**	**Average Load**	**Required load**	**%age**	ALLOCATION
AMUKPE 132/33KV 1X30MVA & 1X60MVA	T1	30/40	ADEJE	2	6.1	**65.1**	**8%**	**7.7**
			INDUSTRIAL	2	13			
	T2	60	MOSOGAR	2	14			
			SAPELE (SAPELE)	3	17			
			ABRAKA	2	15			
EFFURUN 132/33KV 3X60MVA	T21	60	ENERHEN	3	16	**99**	**12%**	**22.3**
			EFFURUN	1	15			
			SAPELE (EFFURUN)	2	15			
			PTI	1	6			
	T23	60	WARRI	2	14			
			REFINERY 1	1	16			
			REFINERY 2	3	17			
DELTA 132/33KV 1X60MVA & 1X60MVA	T1	60	OTOVWODO/PATANI	3	23	**106.1**	**12%**	**23.9**
			AGBARHO/EKU	3	23			
			UGHELLI/SHELL	1	13			
	T3	60	BETA GLASS	1	8			
			ALADJA	2	28			

			ISOKO/KWALE	3	11.1			
AFIESERE 132kV	T1	30	AFIESERE TOWN	0	0	**0**		
BENIN 132/33KV 3X60MVA 1x80MVA	T21	40	SWITCHING STATION	1	22.5	**117.95**	**14%**	**55.6**
			GUINNESS	1	10			
	T22	80	STEEL COMPANY 1	1	0			
			STEEL COMPANY 2	1	0			
	T23	60	NEKPENEKPEN	2	22			
			KOKO	1	16.45			
	T24	60	GRA	1	23			
			ETETE	1	24			
IHOVBOR 132/33KV 2X60MVA	T1	60	EGBA	2	21	**69**	**8%**	**23.6**
			OLUKU	2	15			
	T2	60	IHOVBOR	2	16			
			UNIBEN	1	17			
OKADA 132/33KV 2X40MVA	T2	40	OKADA	2	11	**17**	**2%**	**3.8**
			EXPRESS	1	6			
OGHARA 132/33KV 2X30MVA	T2	30	OGHARA TEACHING HOSPITAL	1	3	**14.1**	**2%**	**3.2**
			OGHARA TOWN	3	11.1			
IRRUA 132/33KV 1X60MVA & 1X30MVA	T1	60	AGENEBODE	2	1	**36.5**	**4%**	**3.2**
			UZEBBA	3	8			
			EHOR	2	12.3			
	T2	30	UBIAJA	3	8			
			AGBOR IRRUA	3	7.2			
ETSAKO 132/33KV	T1	40	AGHOR	2	15.2	**29.9**	**3%**	**12.7**
			AGBEDE	2	14.7			
AKURE 132/33KV 1X60MVA & 2X30MVA	T1A	30	OWENA	2	10.5	**69.5**	**8%**	**15.7**
	T3A	60	AKURE	1	15			
			IJU	1	8			
			OWO	2	11			
	T4A	60	ELIZADE	1	2			
			FUTA	1	2			
			IGBARA OKE	3	8			
			OBAILE	1	13			
ONDO 132/33KV 2X30MVA	T2	30	OKITIPUPA	2	17.12	**32.12**	**4%**	**7.2**
	T1	30	ONDO	1	15			
ADO 132/33KV 2X30/40MVA	T1	30/40	IKERE	2	9.4	**40.8**	**5%**	**12.2**
	T2	30/40	ADO	1	13.8			
			AFE-BABALOLA	1	2			
			IWOROKO/IKOLE	2	9.2			
	T3	66	ILAWE/ARAMOKO	2	6.4			
Asaba 132/33KV	TR1	60MVA	GSM	1	17.3	**98.3**	**11%**	**34.2**
			ISELE-UKU	2	15			
			OGWASHI-UKU	2	8.4			
	TR2	60MVA	HEAD BRIDGE	1	17.9			
			TOWNSHIP	1	18.7			
			EASTERN METAL	1	21			
OKPELLA 1X15MVA	TR1	15 MVA	CEMENT FACTORY	1	6.8	**6.8**	**1%**	**1.5**
OKPELLA 1X15MVA	TR1	60MVA	OKPELLA TOWN	2	8.4	**16.3**	**2%**	**3.7**
			AUCHI IKPESHI	2	7.9			
OMUARAN 132/33KV	T2	30MVA	OTUN	1	0	**18**	**2%**	**4.1**
	TR1	60MVA	AGBOR 6	2	19.6	**19.6**	**2%**	**4.4**

AGBOR 132/33KV	TR2	60MVA	SPARE FDR					
TOTAL					838.07	**856.07**	**100%**	**239**

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4.2 Results of the power flow analysis without FACTS

The voltage profile for each of the stations was shown in table 4.1.

Table 4.1; Voltage profile of the power system network without FACTS

Bus	Voltage (pu)
Bus1 Delta GS	0.8244
Bus2 Aladja TS	0.721420435
Bus3 Sapele GS	0.818955065
Bus4 Benin TS	0.745248822
Bus5 Asaba TS	0.659960761

The barchart representing the outcome in table 4.1 was shown in figure 4.1.

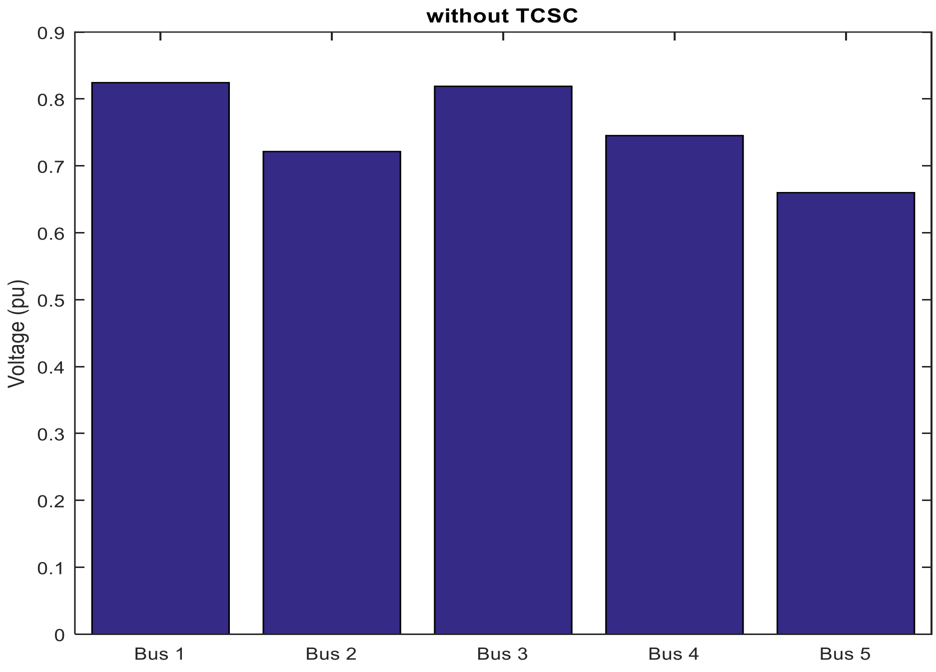

Figure 4.1; Voltage profile of the power system network without FACTS

The active and reactive power losses of the power system without FACTS was shown in table 4.2.

Table 4.2; Power Losses of the power system network

Line	From Bus	To Bus	P loss	Q loss
1	1	2	0.0104	0.1027
2	3	2	0.0152	0.0676
3	4	3	0.0104	0.1034
4	4	1	0.0267	0.2659
5	4	5	0.0141	0.1403

The real power of the power system network without FACTS was shown in figure 4.2.

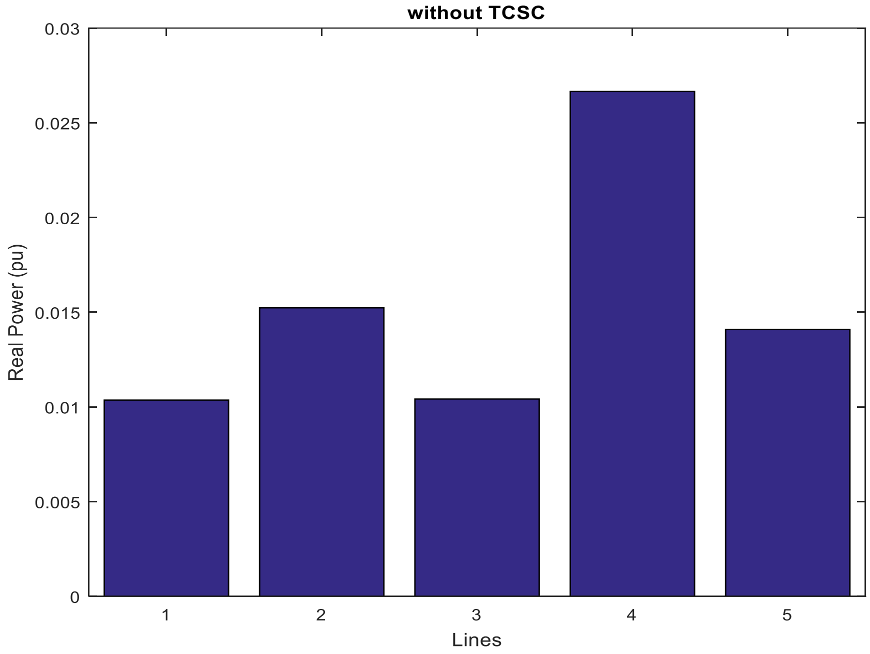

Figure 4.2; Real power loss for the system without FACTS

From figure 4.2, it was observed that the maximum loss occurred at line 4.

The Reactive power losses of the power system network without FACTS was shown in figure 4.3.

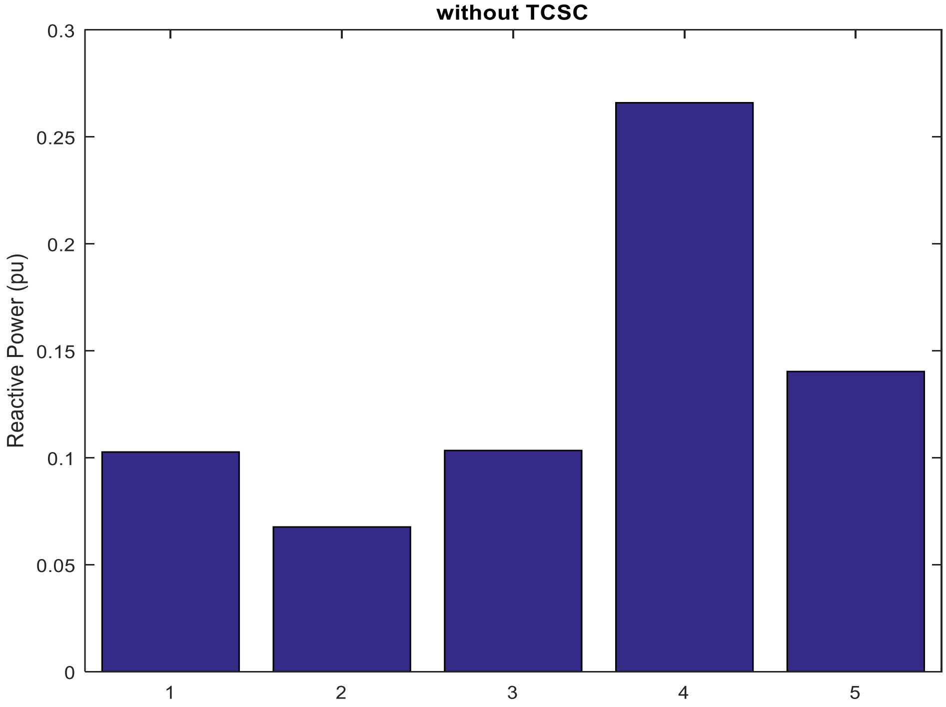

Figure 4.3; Reactive power loss of the power system

The reactive power loss of the power system network was displayed in figure 4.3. it was observed that maximum reactive power loss occurred at line 4.

4.3 Results of the Comparative Analysis

The comparative analysis of the voltage profile of the power system was shown in figure 4.4.

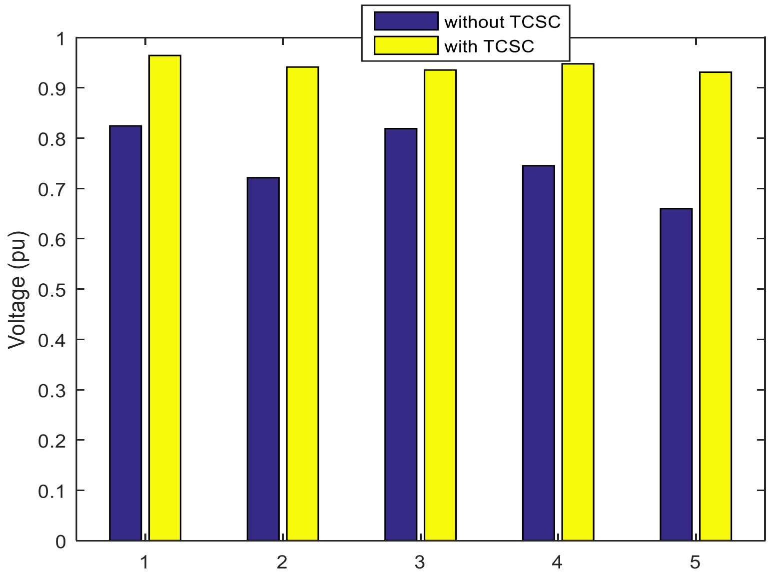

Figure 4.4; Power system with and without TCSC

The comparative analysis of the voltage profile of the power system network for with and without TCSC was shown in figure 4.4and it was observed the FACTS improved the voltages to the expected voltage ratings.

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The National Grid power system is very large intergrading about 120 generators, 19 power stations, 48 Nos. 330kv lines spread all over 1,000,000sq.km. of Nigeria landscape, successful frequency control depends on the co-operation of area control and power station staff in supplying information and taking prompt action as when necessary.

Frequency control in National Grid aims at 50HZ +1%. The mode of control depends on the state – Normal, Alert, Emergency or Restorative.

Frequency control itself starts with daily 24 hour active demand forecast which relies on historical records of generation and demand for accuracy. An economic generation schedule is drawn up to meet this demand forecast.

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