Comparative Analysis of Transmission Losses in the Nigerian 330kV Old Existing 28-Bus and 41-Bus System

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Abstract

This research work investigates the Nigerian 330kV transmission grid and produces explicit comparative analyses of the technical power losses existing between the old existing 28-bus system and 41-bus system. The input data for the power flow analysis was obtained from the Power Holding Company of Nigeria (PHCN) Generation and Transmission Stations. The network was modeled and the data fed into the MATLAB & Simulink Version 2013 environment, and analysed using Newton-Raphson iterative algorithm. The simulation results revealed that the old existing 28-bus system recorded total power losses of 99.14MW and 392.00Mvar, while the total power losses in the Nigerian 41-bus 330kV power system stood at 34.99MW and 216.24MVar respectively. With the above research analysis, the power system planners and operators in Nigeria can be able to identify and determine needed additional power infrastructure and transmission lines, which will consequently boost industrialization and economic activities in the country.

Keywords - *Power Losses, Busses, Grid, Transmission and Generation.*

I. INTRODUCTION

It has been found out that excessive power losses and low bus voltages militate against the operation of power system in Nigeria. The menace of this problem contributed essentially to the incessant power failures, instability and unreliability of the Nigeria electric power system (Anumaka, (2015); Kumar and Jilami (2015). A large proportion of members of the society, especially those in the industrial, commercial and technological sectors have felt the consequences and debilitating effects of power losses and adverse effect of low bus voltages in the Nigerian power system (Anumaka, (2015); Ayokunle, Awelewa, Mbamaluikem and Isaac (2015). Major investment decisions are also in serious threat. The electro-technical components and equipment are prone to incessant failures and breakdowns. Therefore, it becomes imperative to devise a dependable means of minimizing losses, as well as ensuring that each generator runs at optimum operating point, plan future expansion and provision of safe, affordable, stable and reliable electricity for consumers.

Therefore, the problem of the study emphasized on the creation of dependable models, use of empirical data and relevant techniques that will ensure adequate minimization of losses and improvement of bus voltages in the Nigerian power system.

II. LITERATURE REVIEW

Over the years, the electricity requirements in Nigeria have increased tremendously and its demand has drastically run ahead of supply. Electricity generation, transmission and distribution are insufficient (Anumaka, (2015); Corry, (2007). The transmission losses (technical and non-technical losses) in the Nigerian power system are very high (Ikeme and Obas, 2005). There had been incessant breakdown of generation and transmission stations and periodic closure of some thermal and hydro-power stations due to technical problems, acute shortage of gas and water respectively. Electric power generation could be through one of the following sources of energy: Coal, Oil, natural gas, Solar, Hydro (water turbine), nuclear materials and Wind. Kundar, 1994; Narayan, 2003; Bruce, 2002; Gupta, J.B. (2008); Ikeme and Obas John Ebohon. (2005) Izuegbunam, F.I. Duruibe, S.I. and Ojukwu, G.G. (2011).

Nigeria has considerable natural resources, including arable land, forests and mineral deposits, mainly oil, coal, water, gas bauxite, ore, etc. Although the nation is rich in these aspects, electric power losses and electric crisis has been the order of the day, leading to austere economic situation and drastically decrease in the standard of living [1].

Prior to 1999, the power sector in Nigeria did not witness substantial investment in infrastructural development. At this period, the power sector was in deplorable state, new plants were not built and the existing ones were not properly maintained. In 2001, generation dwindled from the installed capacity of about 5,600MW to an average of about 1.750MW, as compared to a load demand of 6, 000MW. Also, only nineteen out of the seventy-nine installed generating units were in operation (Cory, 2007).

Electricity is a life-wire of every nation, therefore, its availability suppose to be ensured throughout the year. This will facilitates rapid industrialization and boost the economy of the nation. In 1991, the electrical energy management revealed that the Netherlands had non-availability of electricity for 238 minutes per year, while Italy had 293 minutes of non-electricity per year, etc (Okoye, 1998). The developed countries of the world did plan and structure their power systems in rigid manner that will avoid outages, failures and interruptions, as well as ensuring high level of reliability, stability, minimal losses and affordable (Rajesh and Shelly 2017; Rahan, Jibran and Farhan (2017); Jagdale and Rao (2017). In Africa, Ghana was the first and only country to celebrated one year uninterrupted power supply, while Japan had celebrated 50years uninterrupted power supply. However, in 1985 Rilwanu estimated that Nigeria lost about one million naira daily to power outage (Okoye, 1998). In 2005, over two billion, six hundred naira was lost to power losses. In fact, Nigeria has lost tremendous amount of money due to ineffective and inefficient electric power supply (Onohaebi and Kuale, 2007). The lost amount would have been invested in the economy of the country.

In 1979 the Energy Commission of Nigeria (ECN) was established by Act No. 62 of 1979, as amended by Act No. 32 of 1988 and Act No. 19 of 1989, with the statutory mandate for the strategic planning and co-ordination of national policies in the field of energy in all its ramifications. Thus, as a result of this mandate, the ECN is the government organ empowered to carry out overall energy sector planning and policy co-ordination.

Adequate power supply is a sine-qua-non to any nation's development, and electricity generation, transmission and distribution are capital-intensive activities requiring huge resources of both funds and human capital. The demand for electricity in Nigeria is squarely for industrial, commercial and residential purposes. It is worthy to note that electricity consumption by the domestic sector has dominated other sectors since 1978, while the industrial sector's demand has witnessed continuous downward trend (PHCN, 2005). The fall in the industrial sector's demand for electricity can be attributed to inadequate power supply which has forced manufacturers to resort to privately generated electricity for powering their production processes.

The Nigerian power system has became so fragile that it is now characterized by epileptic power supply and incessant outages, leading to disruption of livelihood of the citizenry and damage of electro-technical components and equipment. The level of disruption depends on the consumers of electricity. Inadequate performance of the Nigerian electric power system has mitigated industrialization, standard of living, commercialization, economic meltdown and academic research work

Sequel to expansion of the Nigeria 330kV from 9 power stations, 32 transmission lines, 28-bus system to 16 generating power stations, 45 transmission lines and 41-bus power system, there is need to re-evaluate its power evacuation capabilities and assessment of the impact of adding more power infrastructure to the new grid, which this research work tends to harness

Therefore, it becomes imperative to devise dependable models for the Nigeria 330kV grid that will insure adequate minimization of power losses and improvement of bus voltage profiles as well as conducting power flow study of the Nigeria 330kV power system (Surendra and Prateek (2017), which this research work attempted to explore.

III. OBJECTIVE OF THE STUDY

This study has the following objectives:

- To review the present status of the Nigerian 330kV transmission network and conduct the power flow study.
- To examine the power losses and power flows in the 28-bus system and 41- bus Nigerian330kV network.
- To determine the bus system and transmission line that recorded the highest transmission losses and the effects on the network and consumers.
- To provide dependable models and techniques for minimization of losses and improvement of bus voltages in the Nigerian 330kV transmission grid.

IV. METHODOLOGY

In this research, the performance analysis of the Nigrian 330kV is investigated using Matlab/Simulink models. The simulation models are built systematically by means of function blocks which are graphics and user friendly. The data was fed into the Matlab & Simulink Version 13.0 environment and analyzed using Newton-Raphson iterative algorithm.

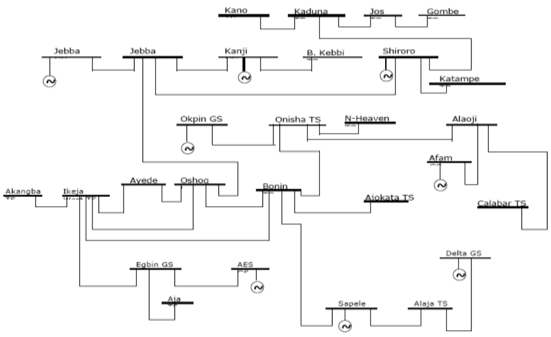

Figure 1- One Line Diagram of 28 - bus system

Source: [1]

A. The Procedure: Adopted for this Study involves:

- Literature review of power losses and methods of minimization in power systems.
- Overview of the Nigeria power system with emphasis on generation, 330kV transmission lines. These include the schematic diagrams of the entire network, line impedances and the associated lengths.
- Data Collection based on PHCN Logbooks, Reports, and visitation to transmitting stations and interaction with PHCN staff. These data include:
- Generation plants locations, power ratings and their outputs.
- Transmission lines and transformers ratings in the 330kV, Capacity utilization of 330/132kV system transformers for the Nigeria power network
- Monthly peak loads in the Nigeria Electric Power Network
- Presentation of data using Microsoft Access Microsoft Excel, by generating 'Queries' to obtain the maximum and average values for the various stations/lines involved in the case study.
- Power flow analysis using Newton-Raphson method in Matlab/Simulink environment to determine voltages and power angles, real and reactive power at various buses and the power losses on the lines.
- Simulation of the results using graphic user interface method in Matlab/Simulink environment (Version 13.0) to ascertain the various flow configurations among various possibilities and effects on the networks.
- Analysis of the simulated results to determine the best size and the most favourable devices for loss minimization for improving the power factor, real and reactive flow power control, bus voltages and hence improve the power quality of the electrical network.
- Examination of the effects of losses on the network and the resulting minimization and control approaches to assess the usefulness of this research and hence contribution to knowledge.
- Develop a model to improve the performance of the Nigerian 330kV Transmission Network.

B. Choice Of Software And Analytical Tools

Matlab Simulink: This power software was chosen as the simulation tool for this research work because of the ease of manipulation of matrix structures and inputs. It has in-built routine such as inverse function, abs function, etc and graphing facilities to plot convergence of load flow.

Newton-Raphson Method: The N-R method was adopted because of its unique quadratic convergence characteristic. It possesses very fast convergence speed compared with G.S method. The convergence criteria are specified to ensure convergence for real and reactive power mismatches, and ensure accuracy. Generally, N-R method convergence is set at 0.00MW and MVar. The use of one line diagram was sequel to the fact that it represent typical meshed network where a load bus is supplied from alternative generators.

Line Utilization Factor (LUF): It is the measure of utilization of a particular line or overall system. It gives an idea about how much percentage of the line is used for the power flow. If the value of utilization is less, it means that less power has been transferred and the system will be less congested and vice-versa.

$$LUF_{ij} = MVA_{ij}/MAV_{ij}^{MAX} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3.1)$$

Where,

LUF_{ij} is the line utilization factor (LUF) of the line connected to bus – i and bus –j. MVA_{ij}^{MAX} is the mega volt ampere (MVA) rating of the line between bus-i and bus j. MVA_{ij} is the actual MVA rating of the line between bus-i and bus –j.

Table.1 - Bus Identification of 28- Bus System.

Bus No	Bus Name	Bus No	Bus Name
1	Shiroro GS	15	Gombe TS
2	Jebba TS	16	Ikeja West TS
3	AES GS	17	Jebba GS
4	Afam GS	18	Jos TS
5	Aja TS	19	Kaduna TS
6	Ajaokuta TS	20	Kanji GS
7	Akangba TS	21	Kano TS
8	Aladja TS	22	Abuja TS
9	Alaoji TS	23	N.Haven TS
10	Ayede TS	24	Okpai GS
11	B-Kebbi TS	25	Onitsha TS
12	Benin TS	26	Oshogbo TS
13	Calabar TS	27	Sapele GS
14	Delta GS	28	Egbin GS

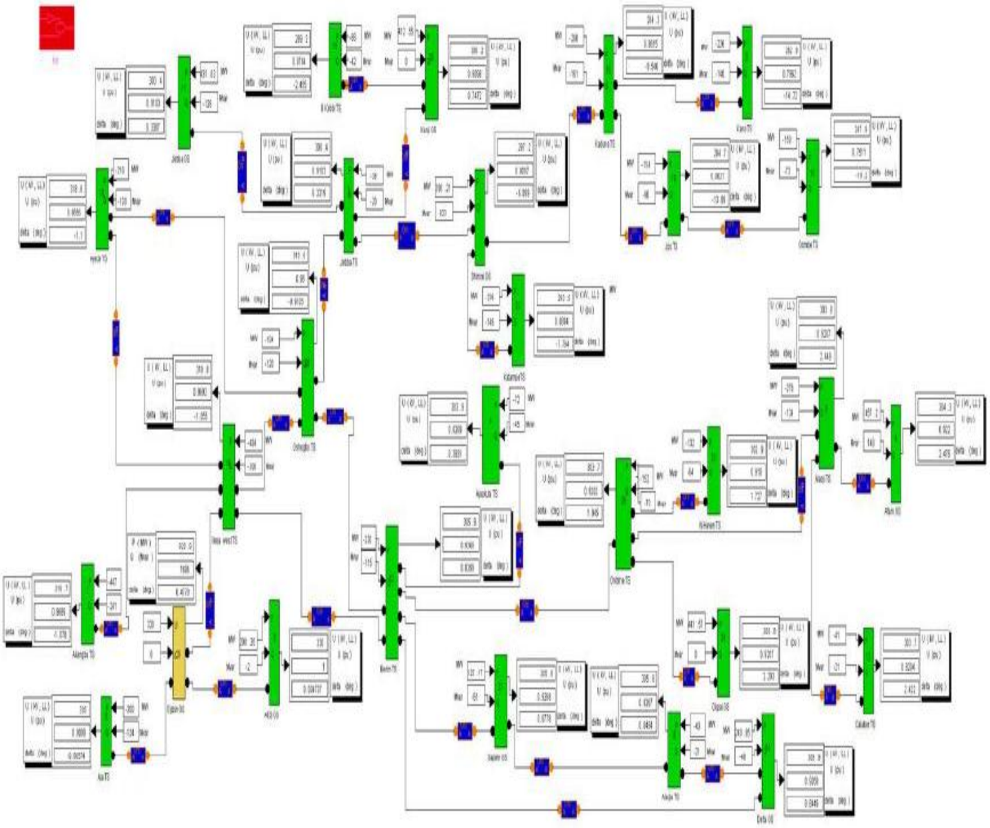

Figure 2 - Simulink model of the 28- bus 330kV transmission network.

Table. 2 - Simulated Result of Voltage Profile and Phase Angles of 2 8-bus System

Bus No	Bus Name	Voltage (p.u)	Voltage (kV)	Phase angle (δ)
1	Shiroro GS	0.8949	295.30	-6.8442
2	Jebba TS	0.9051	298.68	0.4757
3	AES GS	1.0000	330.00	0.00
4	Afam GS	0.9009	297.29	3.45
5	Aja TS	0.9999	329.97	-0.0057
6	Ajaokuta TS	0.8998	296.94	1.27
7	Akangba TS	0.9685	319.59	-1.0796
8	Aladja TS	0.9057	298.88	1.7399
9	Alaoji TS	0.8996	296.86	3.4194
10	Ayede TS	0.9646	318.31	-1.0849
11	B-Kebbi TS	0.8710	287.42	-2.3447
12	Benin TS	0.9059	298.94	1.7341
13	Calabar TS	0.8993	296.76	3.39
14	Delta GS	0.9059	298.93	1.74
15	Gombe TS	0.7436	245.40	-19.36
16	Ikeja West TS	0.9687	319.68	-1.0580
17	Jebba GS	0.9052	298.71	0.48
18	Jos TS	0.7952	262.42	-13.9449
19	Kaduna TS	0.8553	282.24	-9.5277
20	Kanji GS	0.9047	298.54	0.90
21	Kano TS	0.7894	260.50	-14.79
22	Abuja TS	0.8835	291.56	-7.75
23	N.Haven TS	0.8968	295.94	2.66
24	Okpai GS	0.8996	296.86	3.16
25	Onitsha TS	0.8991	296.70	2.8909
26	Oshogbo TS	0.9458	312.12	-0.7774
27	Sapele GS	0.9056	298.85	1.7737
28	Egbin GS	1.0000	330.00	0.0000

Table 3 - Simulated Power Results of 28 - Bus 330kV Grid

Lines	From [MW]	From [Mvar]	From [MVA]	To [MW]	To [Mvar]	MW Loss	Mvar Loss	Line Rating [MVA]	LUF [%]
Ohl 10-26	-63.59	483.28	487.4479641	72.74	-473.50	9.15	9.78	760	64.13789
Ohl 2-20	-320.54	51.12	324.5940452	323.7579	-48.72	3.21	2.40	760	42.70974
Ohl 11-20	-84.00	-42.00	93.91485505	88.79	48.72	4.79	6.72	760	12.35722
Ohl 1-19	767.62	614.80	983.4676076	-756.3750	-552.61	11.24	62.18	760	129.4036
Ohl 19-21	229.93	173.49	288.0367561	-222.5000	-140.00	7.43	33.49	760	37.89957
Ohl 19-18	270.45	218.13	347.4478834	-266.33	-182.84	4.12	35.29	760	45.71683
Ohl 25-23	132.08	64.69	147.0707911	-132.0000	-64.00	0.08	0.69	760	19.35142
Ohl 18-15	152.33	92.84	178.3880649	-150.0000	-73.00	2.33	19.84	760	23.47211
Ohl 12-14	-237.56	81.00	250.995479	240.5675	-80.98	3.00	0.02	760	33.02572
Ohl 26-12	-185.37	241.08	304.1056967	187.4878	-222.90	2.12	18.18	760	40.01391
Ohl 16-12	-116.52	245.77	271.9895208	129.3711	-223.79	12.85	21.98	1000	27.19895
Ohl 12-27	-76.54	49.12	90.94727745	82.5489	-49.05	6.01	0.07	760	11.96675
Ohl 27-8	42.62	-11.95	44.26426392	-38.6179	11.97	4.00	0.03	760	5.824245
Ohl 8-14	-0.38	-32.97	32.97693178	0.3825	32.98	0.00	0.01	760	4.33907
Ohl 12-25	-295.87	155.67	334.3182749	296.7058	-148.54	0.84	7.13	760	43.98925
Ohl 25-24	-441.33	2.08	441.3320533	441.5700	0.00	0.24	2.08	760	58.07001
Ohl 16-10	138.71	615.98	631.4029733	-138.4052	-613.28	0.31	2.70	760	83.07934
Ohl 25-9	-139.46	8.77	139.7341886	139.6088	-7.49	0.15	1.28	760	18.38608
Ohl 12-6	72.11	45.89	85.47649156	-72.0000	-45.00	0.11	0.89	760	11.24691
Ohl 26-2	-92.10	233.58	251.0790356	92.9989	-221.54	0.90	12.04	760	33.03672
Ohl 9-4	-452.61	-147.54	476.0531045	457.2000	148.00	4.59	0.46	760	62.63857
Ohl 9-13	41.00	21.03	46.08073016	-36.0000	-21.00	5.00	0.03	760	6.063254
Ohl 28-3	-208.20	2.02	208.2077656	208.2000	-2.00	0.00	0.02	760	27.39576
Ohl 1-22	236.66	151.64	281.0696298	-232.5430	-146.00	4.11	5.64	760	36.98285
Ohl 7-16	-447.00	-241.00	507.8287113	447.0273	241.23	0.03	0.23	1000	50.78287
Ohl 2-17	-431.78	128.04	450.3601576	431.8300	-128.00	0.05	0.04	760	59.25792
Ohl 2-1	623.32	22.38	623.7218836	-612.0630	56.57	11.26	78.95	760	82.06867
Ohl 16-26	-10.37	124.15	124.5781195	10.7196	-121.16	0.35	2.99	760	16.39186
Ohl 5-28	-200.00	-124.00	235.3210573	200.0035	124.03	0.00	0.03	760	30.9633
Ohl 28-16	933.70	1593.95	1847.290495	-932.8431	-1527.12	0.85	66.83	760	243.0645
					Total	99.14	392.00		

C. Simulation Result Of Nigerian 28-Bus System

The Nigerian old existing 28-Bus network consists of nine (9) generating stations and nineteen (19) transmission lines. Fig. 1 shows the one-line diagram of the old existing 28-bus network of the Nigerian 330kV grid.

The first result was obtained from the investigation and simulation of the old existing 28-bus Nigerian 330kV grid. The simulated result indicated that the total power losses stood at 99.14MW and 392.14Mvar respectively (Table 3), and 24 buses recorded voltages below statutory limit of 313.3kV as shown in table 2. The one line diagram model of the of the 28-bus system and 41-bus system are shown in fig. 3 and fig. 3 respectively. Table 1 and table 4 identified the buses in 28-bus system and 41-bus system respectively.

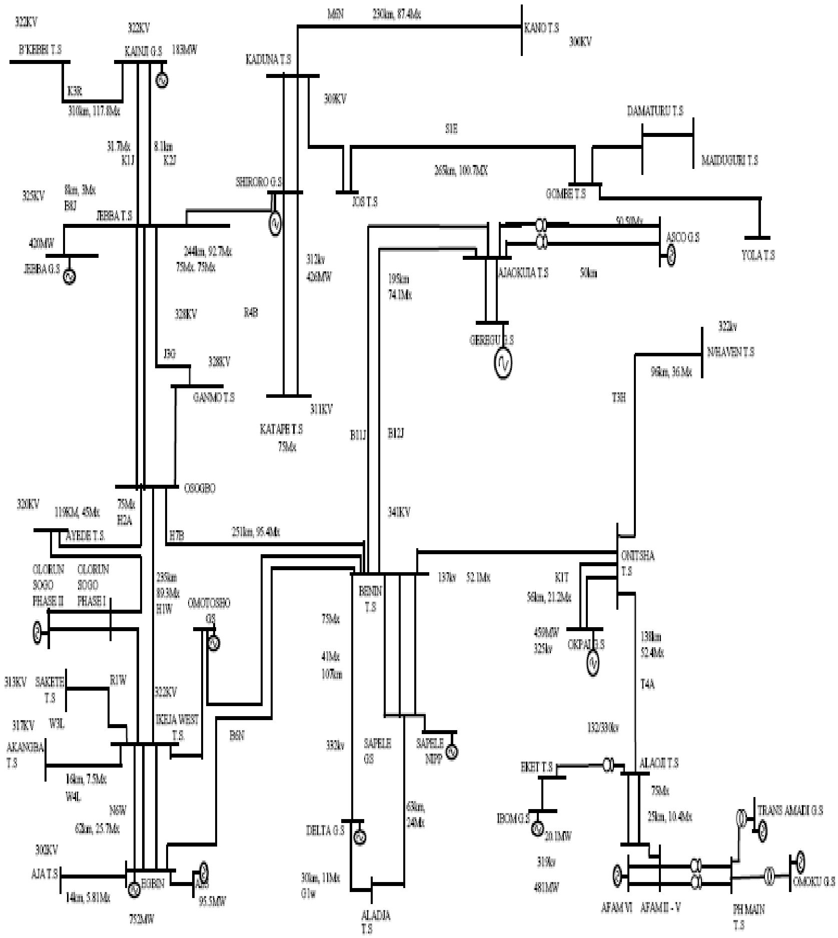

Figure 3 - Single line diagram of the existing 330kV 41-bus grid.
Source: [1]

Table 4 - Bus Identification of 41- Bus System

Bus No	**Bus Name**	**Bus No**	**Bus Name**	**Bus No**	**Bus Name**	**Bus No**	**Bus Name**
1	Shiroro GS	**12**	Ayede TS	**23**	Jebba GS	**34**	Onitsha TS
2	Jebba TS	**13**	B. Kebbi TS	**24**	Jos TS	**35**	Oshogbo TS
3	Omotosho GS	**14**	Benin TS	**25**	Kaduna TS	**36**	PH Main TS
4	AES GS	**15**	Damaturu TS	**26**	Kanji GS	**37**	Sakete TS
5	ASCO GS	**16**	Delta GS	**27**	Kano TS	**38**	Sapele GS
6	Afam GS	**17**	Eket TS	**28**	Katampe TS	**39**	Trans Amadi
7	Aja TS	**18**	Ganmo TS	**29**	Maiduguri TS	**40**	Yola TS
8	Ajaokuta TS	**19**	Geregu GS	**30**	N. Haven TS	**41**	Egbin GS
9	Akangba TS	**20**	Gombe TS	**31**	Okpai GS		
10	Aladja TS	**21**	Ibom GS	**32**	Olorunso go GS		
11	Alaoji TS	**22**	Ikeja West TS	**33**	Omoku GS		

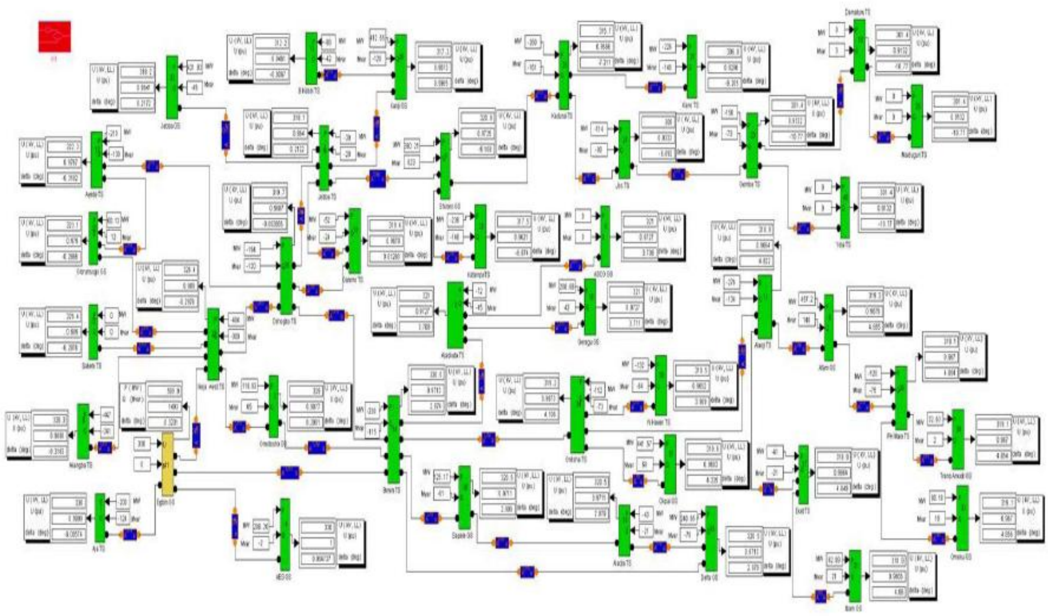

Figure. 4 - Simulink Model of 41-Bus System

D. The 41-bus nigerian 330kv grid and simulation

As a result of ever increasing demand for electricity, the old existing 28-bus network was expanded to 41-bus system. Figure 3 shows the one-line diagram of the present 330Kv 41bus system. The present existing 41-bus 330kV transmission grid was investigated, modeled and simulated (figure 4). The simulated result reveals improvement in the voltage profile, and reduction of the total power losses to 34.99MW and 216.4Mvar (table 6).

Table 5 - Simulated Results of Voltage Profiles of 41-Bus System.

Bus No	Bus Name	Voltage (p.u)	Voltage (kV)	Phase angle (δ)	Percentage Error(%)
1	Shiroro GS	0.9725	320.93	-6.1076	2.748485
2	Jebba TS	0.9640	318.12	0.2122	3.6
3	Omotosho GS	0.9877	325.95	0.2901	1.227273
4	AES GS	1.0000	330.00	0.00	0
5	ASCO GS	0.9727	320.98	3.71	2.733333
6	Afam GS	0.9675	319.27	4.8547	3.251515
7	Aja TS	0.9999	329.97	-0.0057	0.009091
8	Ajaokuta TS	0.9727	320.98	3.7076	2.733333
9	Akangba TS	0.9888	326.30	-0.3183	1.121212
10	Aladja TS	0.9711	320.48	2.8792	2.884848
11	Alaoji TS	0.9664	318.90	4.8222	3.363636
12	Ayede TS	0.9767	322.31	-0.3192	2.330303
13	B. Kebbi TS	0.9461	312.22	-0.8067	5.387879
14	Benin TS	0.9713	320.54	2.8741	2.866667
15	Damaturu TS	0.9132	301.36	-10.7665	8.678788
16	Delta GS	0.9713	320.53	2.88	2.869697
17	Eket TS	0.9664	318.92	4.8495	3.357576
18	Ganmo TS	0.9679	319.42	0.01	3.206061
19	Geregu GS	0.9727	320.99	3.71	2.730303
20	Gombe TS	0.9132	301.36	-10.7665	8.678788
21	Ibom GS	0.9665	318.94	4.86	3.351515
22	Ikeja West TS	0.9890	326.38	-0.2976	1.09697
23	Jebba GS	0.9641	318.15	0.22	3.590909
24	Jos TS	0.9333	307.98	-8.8920	6.672727
25	Kaduna TS	0.9566	315.69	-7.2110	4.336364
26	Kanji GS	0.9613	317.21	0.60	3.875758
27	Kano TS	0.9296	306.78	-9.20	7.036364
28	Katampe TS	0.9621	317.50	-6.87	3.787879
29	Maiduguri TS	0.9132	301.36	-10.77	8.678788
30	N. Haven TS	0.9652	318.50	3.91	3.484848
31	Okpai GS	0.9683	319.55	4.33	3.166667
32	Olorunso go GS	0.9790	323.08	-0.2966	2.09697
33	Omoku GS	0.9670	319.12	4.86	3.29697
34	Onitsha TS	0.9673	319.20	4.1057	3.272727
35	Oshogbo TS	0.9687	319.67	-0.0031	3.130303
36	PH Main TS	0.9670	319.12	4.8542	3.29697
37	Sakete TS	0.9890	326.38	-0.2976	1.09697
38	Sapele GS	0.9711	320.45	2.9086	2.893939
39	Trans Amadi	0.9670	319.12	4.85	3.29697
40	Yola TS	0.9132	301.36	-10.77	8.678788
41	Egbin GS	1.0000	330.00	0.0000	0

Table 6 - Simulated Results of Power Profile 330kV on41-Bus System

Lines	From [MW]	From [Mvar]	From [MVA]	To [MW]	To [Mvar]	MW Loss	Mvar Loss	Line Rating [MVA]	LUF [%]
Ohl 41-14	-20.80	251.95	252.806	32.45	-243.40	11.65	8.54	1000	25.2806
Ohl 12-35	-111.24	218.15	244.8713	111.5231	-215.75	0.28	2.40	760	32.21991
Ohl 2-26	-323.98	175.52	368.4668	324.21	-172.85	0.24	2.67	760	48.48247
Ohl 13-26	-88.00	-42.00	97.50897	88.3356	44.85	0.34	2.85	760	12.83013
Ohl 2-18	87.71	-130.19	156.9794	-87.6168	131.02	0.10	0.84	760	20.65519
Ohl 1-25	756.27	517.65	916.4581	-753.60	-494.79	2.66	22.86	760	120.5866
Ohl 25-27	227.42	152.07	273.5773	-226.0000	-140.00	1.42	12.07	760	35.99701
Ohl 25-24	266.19	181.71	322.2972	-264.7714	-169.58	1.42	12.13	760	42.40753
Ohl 34-30	132.07	64.59	147.0196	-132.0000	-64.00	0.07	0.59	760	19.34468
Ohl 24-20	150.77	79.58	170.4834	-150.0000	-73.00	0.77	6.58	760	22.43202
Ohl 14-16	-240.56	110.60	264.7689	240.5658	-110.58	0.00	0.02	760	34.83801
Ohl 35-14	-265.85	23.26	266.8622	267.4036	-9.91	1.56	13.35	760	35.11344
Ohl 3-14	-298.99	166.06	342.006	301.0833	-149.88	2.10	16.18	1000	34.2006
Ohl 14-38	-82.54	49.51	96.25521	82.5511	-49.45	0.01	0.06	760	12.66516
Ohl 38-10	42.62	-11.55	44.15565	-42.6161	11.57	0.00	0.02	760	5.809954
Ohl 10-16	-0.38	-32.57	32.57284	0.3842	32.58	0.00	0.01	760	4.2859
Ohl 14-34	-371.39	123.08	391.2571	372.3927	-114.59	1.00	8.49	760	51.4812
Ohl 34-31	-441.36	-66.16	446.2868	441.5700	68.00	0.21	1.84	760	58.72195
Ohl 32-12	98.86	349.02	362.7468	-98.7585	-348.15	0.10	0.87	760	47.72984
Ohl 34-11	-215.11	43.16	219.3935	215.4260	-40.43	0.32	2.73	760	28.86757
Ohl 22-3	-417.40	105.48	430.5217	417.9167	-101.06	0.52	4.42	760	56.64759
Ohl 14-8	-136.44	4.99	136.5322	136.6885	-3.01	0.25	1.98	760	17.96476
Ohl 35-2	-18.44	28.01	33.5331	18.4580	-27.80	0.02	0.20	760	4.412249
Ohl 8-19	-208.69	-41.99	212.8703	208.6900	42.00	0.00	0.01	760	28.00925
Ohl 8-5	0.00	0.00	0	0.0000	0.00	0.00	0.00	760	0
Ohl 11-6	-449.54	-93.61	459.1831	450.0067	93.97	0.47	0.36	760	60.41883
Ohl 6-36	7.19	54.03	54.5047	-7.1903	-54.00	0.00	0.03	760	7.171671
Ohl 36-33	-80.18	-19.00	82.39961	80.1800	19.00	0.00	0.00	760	10.84205
Ohl 36-39	-32.63	-2.00	32.69123	32.6300	2.00	0.00	0.00	760	4.301477
Ohl 20-15	0.00	0.00	1.05E-11	0.0000	0.00	0.00	0.00	760	1.38E-12
Ohl 15-29	0.00	0.00	0	0.0000	0.00	0.00	0.00	760	0
Ohl 20-40	0.00	0.00	0	0.0000	0.00	0.00	0.00	760	0
Ohl 11-17	-41.89	0.04	41.88572	41.89	-0.02	0.00	0.02	760	5.511279
Ohl 41-4	-208.20	2.02	208.2078	208.2000	-2.00	0.00	0.02	760	27.39576
Ohl 17-21	-82.89	-20.98	85.50272	82.8900	21.00	0.00	0.02	760	11.25036
Ohl 1-28	236.55	150.75	280.5073	-236.0000	-146.00	0.55	4.75	760	36.90885
Ohl 35-18	-35.60	155.15	159.1869	35.6168	-155.02	0.02	0.13	760	20.94565
Ohl 9-22	-447.00	-241.00	507.8287	447.0262	241.22	0.03	0.22	760	66.81957
Ohl 2-23	-431.79	49.03	434.5603	431.8300	-49.00	0.04	0.03	1000	43.45603
Ohl 2-1	610.59	-86.57	616.6939	-602.6107	154.60	7.98	68.04	760	81.14394
Ohl 22-35	-14.09	113.07	113.9399	14.3679	-110.67	0.28	2.40	760	14.99209
Ohl 7-41	-200.00	-124.00	235.3211	200.0035	124.03	0.00	0.03	760	30.9633
Ohl 37-22	0.00	0.00	1.8E-10	0.0000	0.00	0.00	0.00	760	2.37E-11
Ohl 41-22	538.86	1115.24	1238.603	-538.6652	-1100.22	0.19	15.02	760	162.974
Ohl 32-22	-38.73	-337.02	339.2343	39.1286	340.46	0.40	3.44	760	44.63609
					Total	34.99	216.24		

V. DISCUSSION

The power flow analysis revealed that the condition of the old existing 28-bus 330kV Nigerian transmission network was very unsatisfactory due to high violation of statutory voltage limits and high power losses. The simulated results indicated that many buses recorded high power losses. The total power losses recorded in the system were very high. Real and reactive power losses in the system stood at

99.14 MW and 392.00 Mvar respectively. High level of power losses in the network can be attributed to both technical and non-technical factors.

The Nigerian power system is endowed with radial and long transmission lines, which has impeded the evacuation of generated power (Izuegbunam, Duruibe andOjukwu, 2011; Obadote, 2009; Onohaebi and Kuale,2007). This nature of power system accumulates high voltage drop along the transmission lines, with resultant surge in temperature and drastic reduction of voltage in the system. The radial nature of the grid can be found at the northern part of the grid, the link between the north and the south (Obi and Offor, 2012).

Moreover, it was found out that the Nigerian power system has only one major ring loop circuit. The existing major ring loop circuit involves Benin-Ikeja West-Ayede-Oshogbo and Benin. Absence of ring loops accounts for weak, unreliable and inability of the power system to evacuate generated power.

The simulated results also indicated that some transmission lines have high level of line utilization factor (LUF). The percentage LUF in some lines was high. The Egbin – Ikeja West transmission line recorded the highest LUF of 243.0645%, followed by Shiroro –Kaduna transmission line that had 129.4036% LUF.

The extreme low bus voltages can be attributed to longitudinal and radial transmission lines. Some transmission lines also recorded high losses. Table 3 and 6 indicated the simulated results of the power flow and losses of 28-bus 330kV network and the 41-bus 330kV network respectively.

The Ikeja-West to Benin transmission line recorded the highest transmission loss value of 12.85 MW and 21.98 Mvar. Other remission lines that recorded high losses include Jebba-Shiroro (11.26 MW, 78.95 Mvar), Ayede – Oshoigbo (9.15MW, 9.78Mvar), Kaduna – Kano (7.43MW,. 33.49Mvar) and Benin – Sapele (6.01 MW, 0.07Mvar).

The adverse situation of the Nigerian power system resulted annual energy loss of 337.5 GWH in 2005, which amounted to over three billion naira, (Onohaebi and Kuale, 2007).

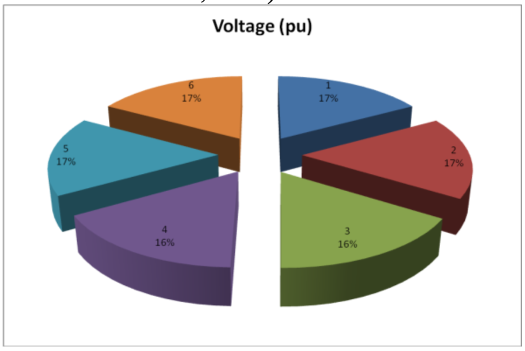

Figure 5 - Pie graphic representations of high profile voltage buses.

The simulation results obtained indicated the present condition of the Nigerian 41-bus 330kV and revealed that the total active and reactive losses in the system have drastically reduced to 34.99MW and 216 MVar respectively. This can be attributed to introduction of additional lines, generators and other power infrastructures to the existing network.

The results also indicated overloaded transmission lines. Egbin to Ikeja West transmission line recorded the highest percentage LUF of 162.974%, followed by Shiroro-Kaduna transmission line that recorded LUF of 120.5866%. Figure 5 and figure 6 illustrates the pie graph representation of high and low voltage buses in the present Nigerian 41-bus 330kV network.

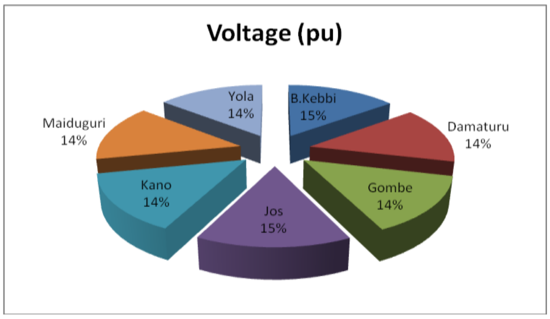

Figure 6- Pie graphic representation of low voltage buses.

VI. CONCLUSION

This research found out that the 28-bus system has been tackled with high power losses. The installation of power infrastructure, addition of transmission lines and strategic placement of buses reduced the high power losses. This research revealed that the total power losses drastically reduced from 99.14MW and 392.00Mvar to 34.99MW and 216.24MVar respectively.

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