Analysis of the Proposed Nigerian 330KV Integrated Network using ETAP 12.6 software

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Abstract: The analysis of the impact of integrating the power generated from Generation Company of Nigeria (GENCO), Nigeria Independent Power Project (NIPP) and the Independent Power Producers (IPP) into the existing 330kV transmission network is presented in this work. The analysis is carried out using ETAP 12.6 and MATLAB software for the existing and the proposed 330kV grid network. The result indicates that with the proposed integrated 330kV network, the power losses on each transmission lines reduced by 0.48MWwhich indicates 46% improvement on the existing 330kV transmission network and the voltage profile on each bus of the entire network improves from (0.66 – 1.13) per unit to (0.94 – 1.50) per unit. The result reveals that the integration of the proposed 330kV network, electricity supply in the national grid will be stable, reliable and adequate for sustainable development.

Keywords: 330kV, Networks, Integrated, Power Generation, ETAP 12.6, MATLAB.

I. INTRODUCTION

Electricity plays an indispensable role in the socio-economic and technological development of every nation, but Nigeria is faced with acute electricity challenges, thereby hindering her development in spite of the availability of vast national resources for power generation. Presently the country is faced with the challenges of providing sustainable, stable, adequate, reliable, efficient and economical electricity supply to residential, commercial and industrial consumers. This situation has adversely affected the socio-economic and technological life of the citizenry. Onahaebi (2007) stated in his study of Reduction of the high technical power losses associated with the Nigerian 330KV Transmission Network using Power World Simulator (PWS) that the existing network cannot cope with contingencies leading to very low performance and even blackout at emergencies. He proposed modifications to the 330KV transmission network incorporating additional lines to form more loops with minimal compensation meets the acceptable limit of ±5%. It also reduces the energy losses from 337.5 – 189.9 MWH, representing 45% improvement over the existing network. Omorogiuwa and Ike (2014) in their work reported that Nigeria power system is faced with problems of inadequate power generation and transmission lines, resulting in the overloading and stressing of the network beyond their thermal limit because of the increasing load demand. Shaikh, Jain, Kotnala and Agarwal (2012), reported that the main factor which causes unacceptable voltage profile is the inability of the distribution system to meet the demand for reactive power. Agarwal concluded that for voltage stability, the maximum permissible loading limits must not be exceeded in the operation of the power system. Sambo, Garba, Zarma and Gaji, (2012) in their work stated that adequate power supply is an unavoidable prerequisite to any nation’s development. To provide adequate power to ensure that Nigeria is among the industrialized nations, three critical activities must be effectively achieved, they are: adequate power must be generated, the power generated must effectively be transmitted to all part of the country and finally the power transmitted must be effectively distributed to the consumers. Since development and population growth in any country are highly dynamic, these three activities must also be carefully addressed in a dynamic, creative and logical manner. The epileptic nature of electricity generation in Nigeria associated with the existing 330KV network has become unbearable to most Nigerians, especially in the big cities. It has posed a constant threat to the growth of the country's economy. The existing 330KV network has series of drawback ranging from inadequate generation, weak and fragile transmission lines that are not robust enough to wheel out the generated power in the network. The high load demand on the network makes the network prone to voltage instability which causes voltage limit violation in some of the buses that may lead to voltage collapse in the entire network. The voltage problems associated with this network are caused by long distance power transmission (ie load centres far away from generating stations) and overloading of the transmission line (ie transmission lines carrying load beyond their available transfer capacity). The high load demand on the network result to system insecurity and several voltage collapses on the network, which makes it necessary for power system integration.

In this work, the analysis of the impact of integrating the power generated by Generation Company of Nigeria (GENCO), Nigeria Independent Power Project (NIPP) and the Independent Power Producers (IPP) into the existing 330KV transmission network using the ETAP 12.6 software is presented.

II. MATERIALS AND METHOD

The materials used in the analysis of this work are ETAP 12.6 software, the Existing 330KV grid network, the Proposed 330KV grid network and MATLAB software.

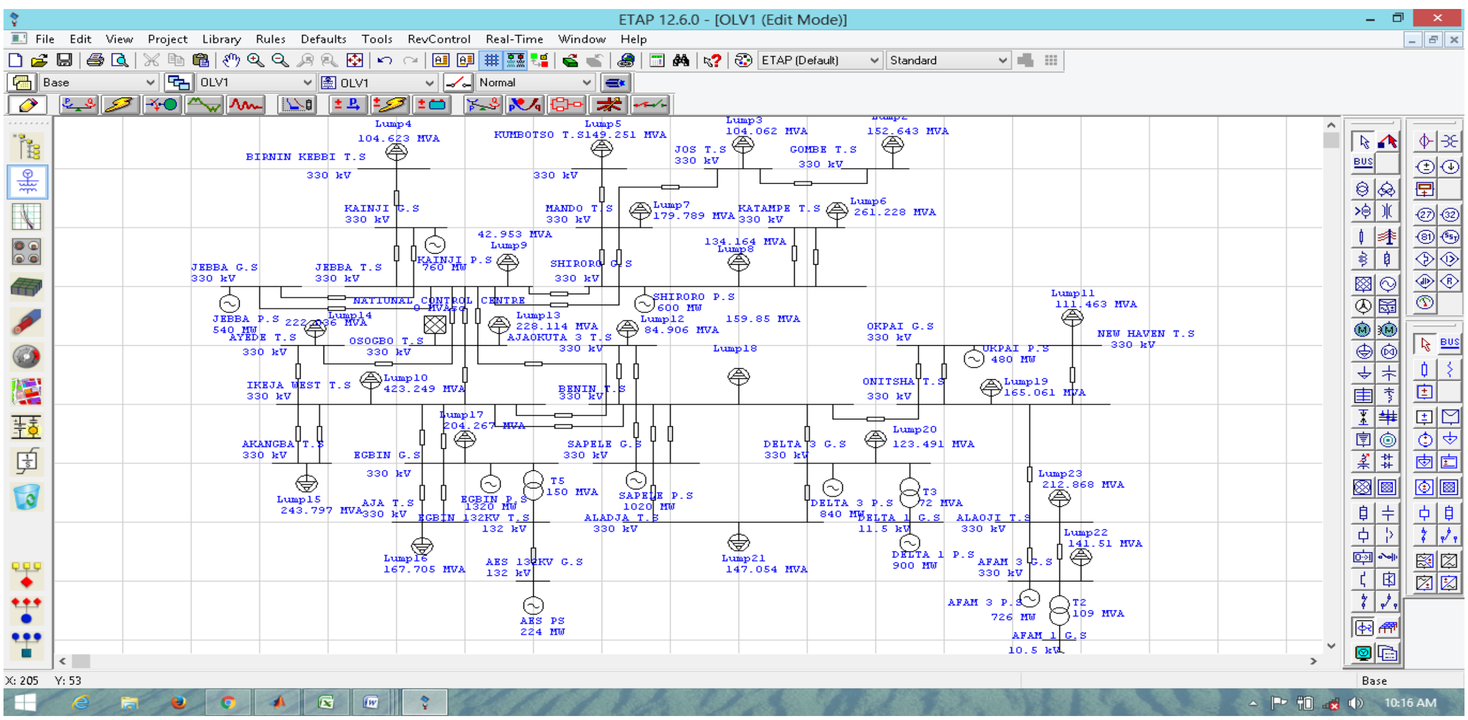

Figure 1: Model of Existing 330KV Network using ETAP 12.6 Software

The research was achieved through modelling and simulation involving the following approaches:

i. Model development of the existing 330KV Network and proposed integrated 330KV Network using ETAP 12.6 as shown in figure 1 and figure 3.

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ii. Simulation (run mode) of the developed existing 330KV Network and proposed integrated 330KV Network model using ETAP 12.6 with Newton Raphson Iteration Algorithm having a precision of 0.0001, as shown in figure 2 and figure 4.

iii. The performance of the existing 330KV Network and proposed integrated 330KV Network model was achieved by analyzing simulation result using MATLAB.

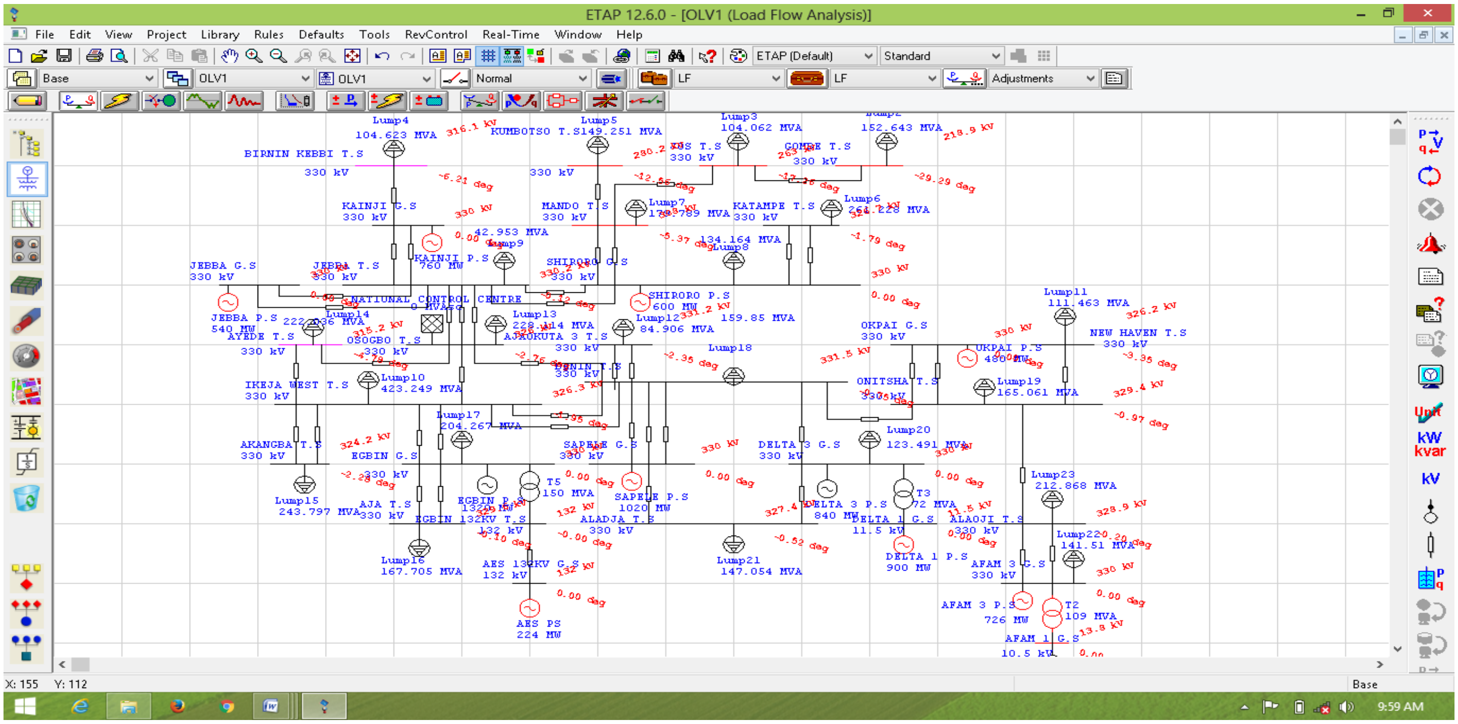

Figure 2: Simulation (Run Mode) of Existing 330KV Network using ETAP 12.6 Software

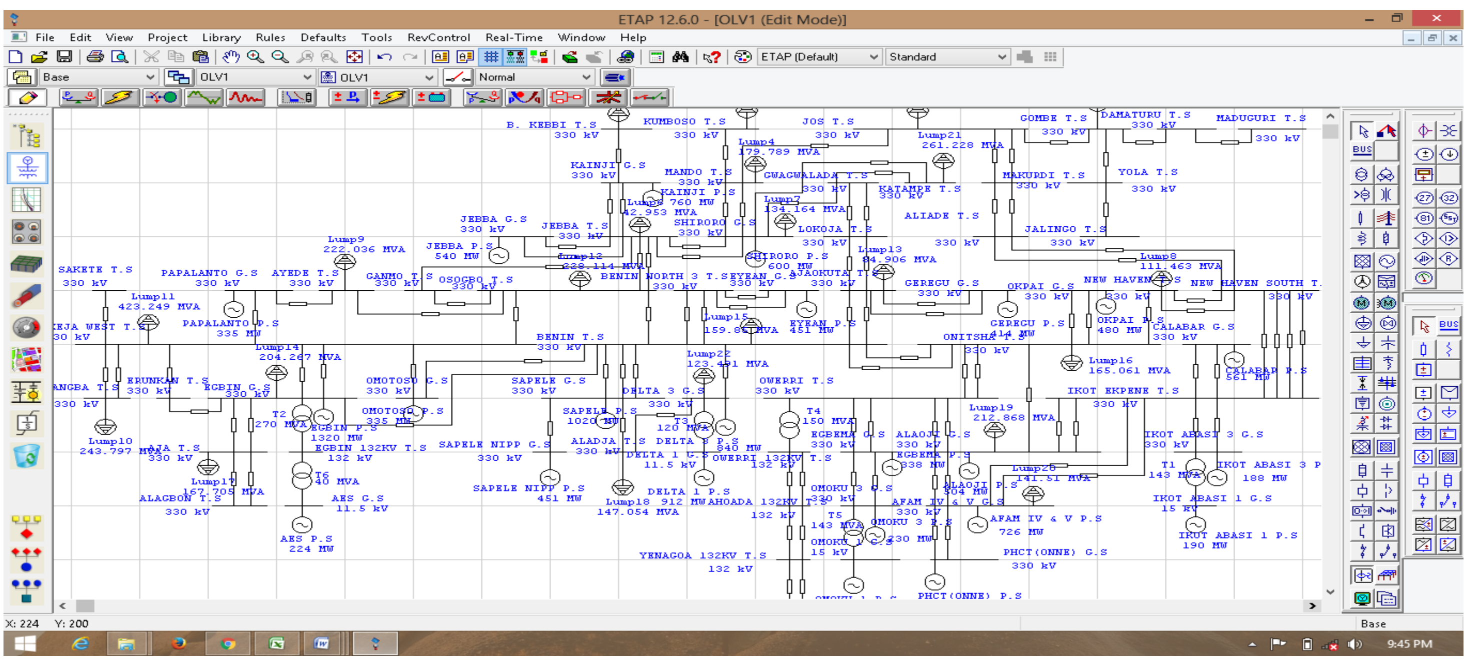

Figure 3: Model of Proposed Integrated 330KV Network using ETAP 12.6 Software

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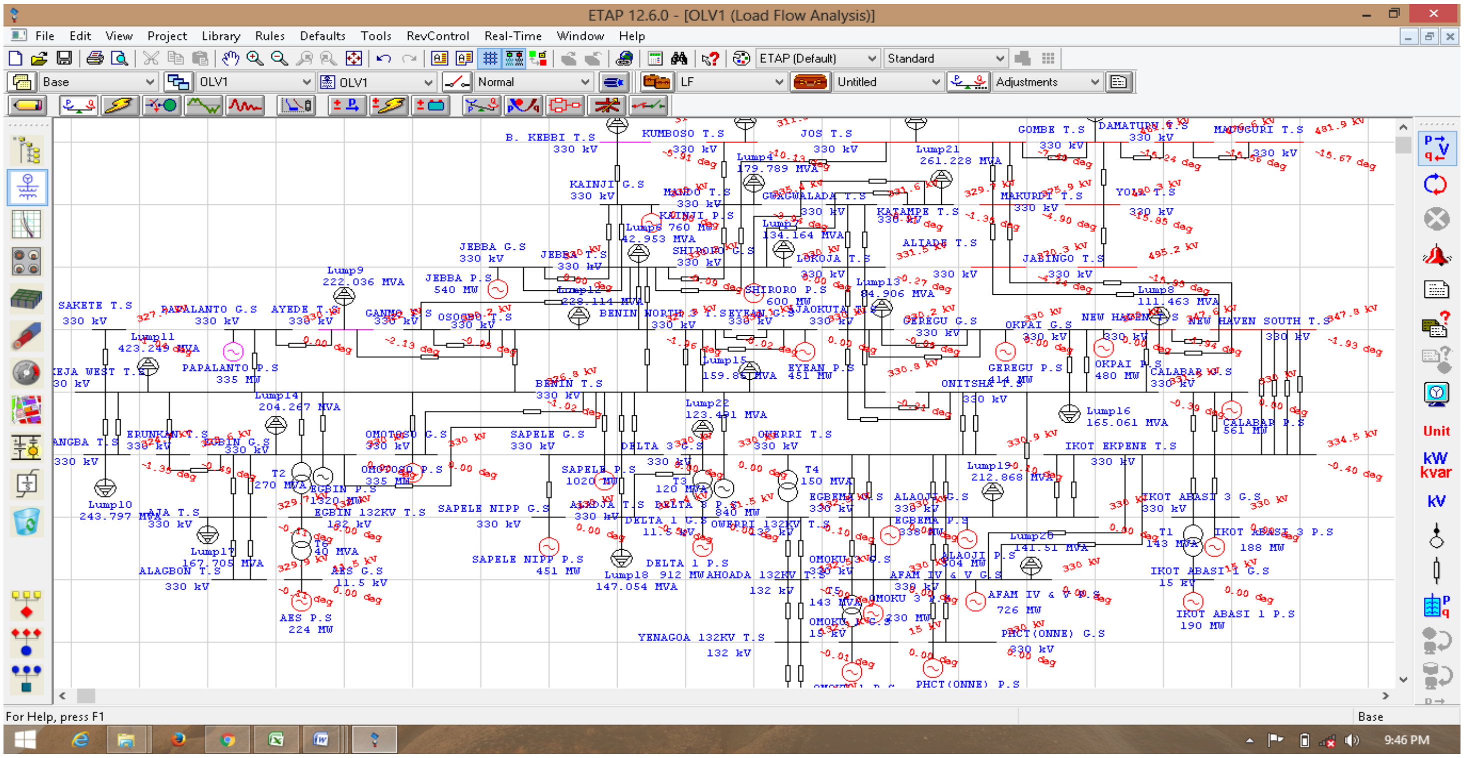

Figure 4: Simulation (Run mode) of Proposed Integrated 330KV Network using ETAP 12.6 Software

III. RESULT AND DISCUSSION

The result obtained from the simulation indicate that the real and reactive power losses in the existing 330KV network are 49.72MW and -1525.49 MVar respectively, with the following transmission stations having their operating voltages below the acceptable voltage limit of ±5%; Gombe T.S 218.91KV, Jos T.S 263.05KV, Kumbotso T.S 280.25KV and Mando T.S 308KV as shown in table 1.

Table 1: Performance of Existing 330KV Network with ETAP 12.6

Bus No	Bus ID	Nominal kV	Voltage	Voltage PU	% Voltage Drop	Remark
1	AFAM 3 G.S	330	330	1	0	Acceptable Voltage limit
2	AJA T.S	330	329.59	0.99	0.12	Acceptable Voltage limit
3	AJAOKUTA 3 T.S	330	331.16	1	-0.35	Acceptable Voltage limit
4	AKANGBA T.S	330	324.17	0.98	1.77	Acceptable Voltage limit
5	ALADJA T.S	330	327.44	0.99	0.78	Acceptable Voltage limit
6	ALAOJI T.S	330	328.89	0.99	0.34	Acceptable Voltage limit
7	AYEDE T.S	330	315.21	0.96	4.48	Acceptable Voltage limit
8	BENIN T.S	330	331.46	1	-0.44	Acceptable Voltage limit
9	BIRNIN KEBBI T.S	330	316.14	0.96	4.2	Acceptable Voltage limit

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10	DELTA 3 G.S	330	330	1	0	Acceptable Voltage limit
11	EGBIN G.S	330	330	1	0	Acceptable Voltage limit
12	GOMBE T.S	330	218.91	0.66	33.67	Below acceptable Volt. Limit
13	IKEJA WEST T.S	330	326.31	0.99	1.12	Acceptable Voltage limit
14	JEBBA G.S	330	330	1	1	Acceptable Voltage limit
15	JEBBA T.S	330	330.16	1	1	Acceptable Voltage limit
16	JOS T.S	330	263.05	0.8	20.29	Below acceptable Volt. Limit
17	KAINJI G.S	330	330	1	0	Acceptable Voltage limit
18	KATAMPE T.S	330	326.68	0.99	1.01	Acceptable Voltage limit
19	KUMBOTSO T.S	330	280.25	0.85	15.08	Below acceptable Volt. Limit
20	MANDO T.S	330	308	0.93	6.67	Below acceptable Volt. Limit
21	NEW HAVEN T.S	330	326.16	0.99	1.16	Acceptable Voltage limit
22	OKPAI G.S	330	330	1	0	Acceptable Voltage limit
23	ONITSHA T.S	330	329.38	1	0	Acceptable Voltage limit
24	OSOGBO T.S	330	325.96	0.99	1.22	Acceptable Voltage limit
25	SAPELE G.S	330	330	1	0	Acceptable Voltage limit
26	SHIRORO G.S	330	330	1	0	Acceptable Voltage limit

The result in Table 1 indicates that four (4) out of the thirty (30) buses of the existing 330KV network are out of acceptable voltage limit which is ±5% of nominal voltage, this implies that these transmission stations will go out one after the other thus causing system instability in the entire network that may result to system collapse. This is the major cause of system collapses that occur in the network. The graph of % Voltage Drop versus Bus number of the existing 330KV network using MATLAB 7.5.0 is shown in figure 5. The graph clearly shows the four buses that are out of acceptable limit.

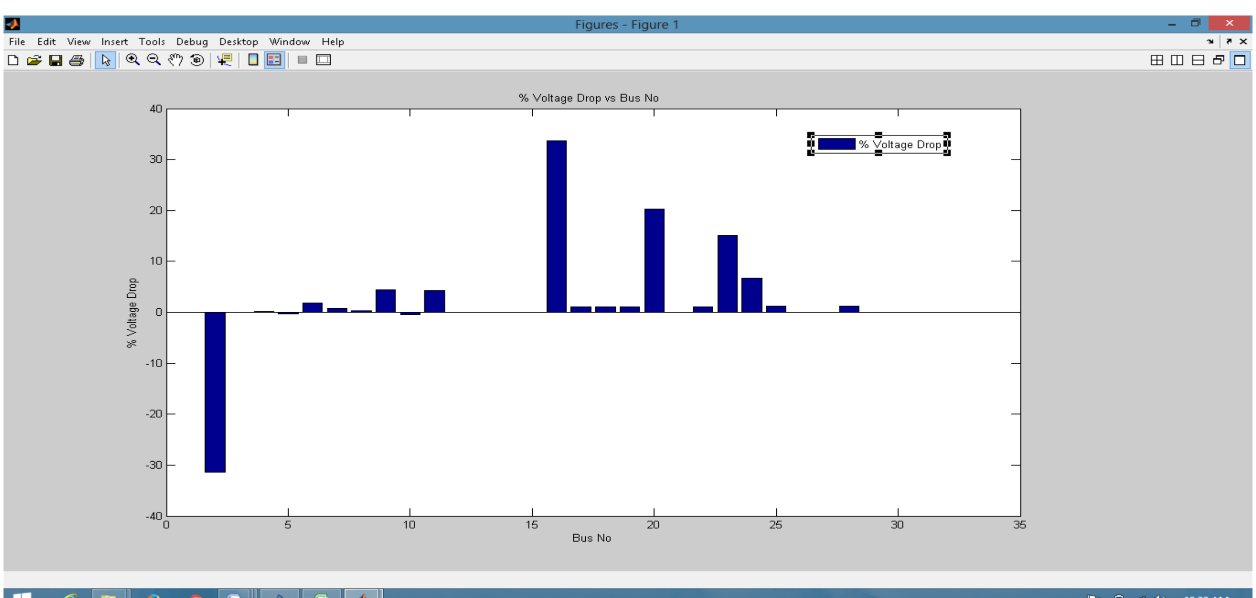

Figure 5: % Voltage Drop Vs Bus No of Existing 330KV Network

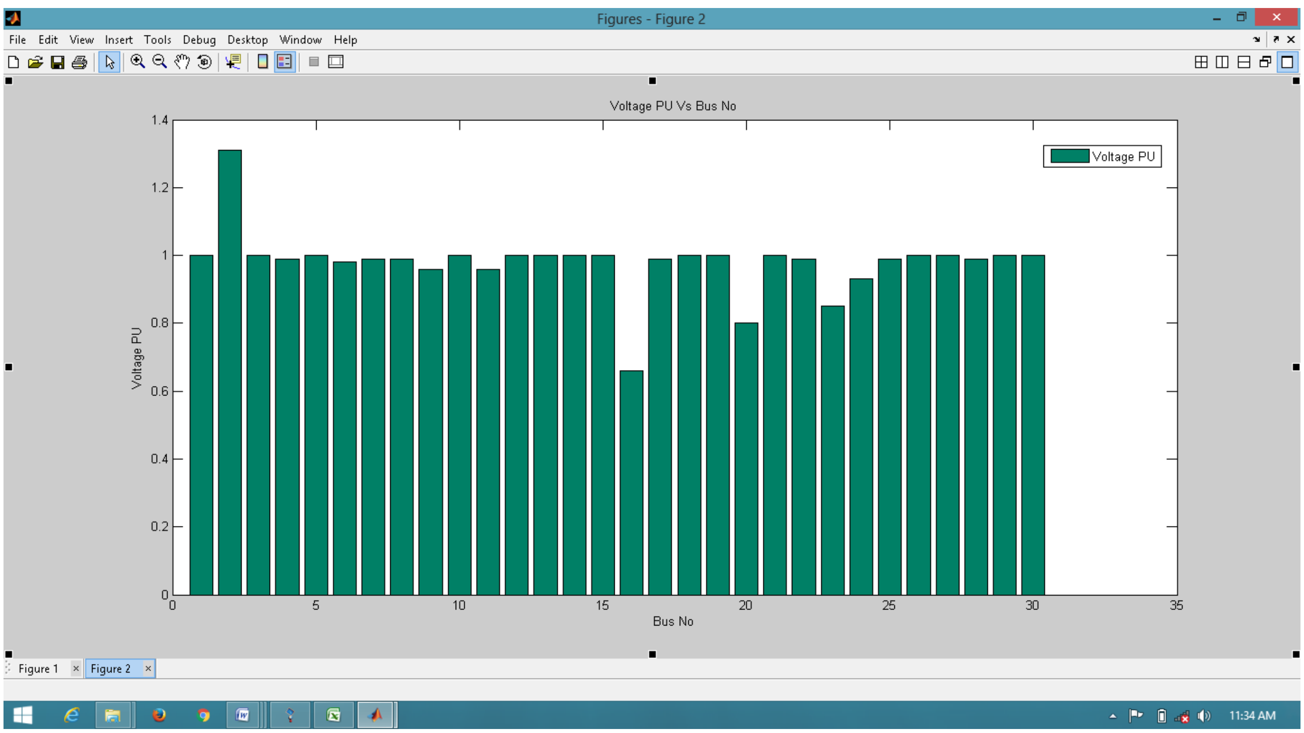

Figure 6: Voltage per unit Vs Bus No of Existing 330KV Network

Similarly, plotting the graph of Voltage per unit versus Bus number of the existing 330KV network using MATLAB 7.5.0 as shown in figure 6 was obtained.

This graph also clearly indicate the buses that were out of acceptable per unit value of (0.95-1.05) per unit which are Gombe T.S 218.91KV, Jos T.S 263.05KV, Kumbotso T.S 280.25KV and Mando T.S 308KV. This analysis reveals that the Existing 330KVnetwork has to be improved upon by the integration of the NIPP and the IPP generated power.

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Proposed Integrated 330KV Network: The Proposed Integrated 330KV transmission network consists of twenty-four (24) generating stations with an installed capacity of 12,510MW. It has sixty-one (61) buses with one hundred and eleven (111) branches with a transmission route length of 7,250km, having four national control centres at Osogbo, Benin, Ajaokuta and Onitsha. The following results were obtained from the load flow analysis of the Proposed Integrated 330KV network. The results obtained from the load flow analysis of the Proposed Integrated 330KV network is given in table 2.

Table 2: Performance of proposed integrated 330KV network with ETAP 12.6

Bus No	Bus ID	Nominal kV	Voltage	Voltage PU	% Voltage Drop	Remark
1	AES G.S	11.5	11.50	1.00	0.00	Acceptable Voltage limit
2	AFAM IV & V G.S	330.0	330.00	1.00	0.00	Acceptable Voltage limit
3	AHOADA 132KV T.S	132.0	132.46	1.00	-0.35	Acceptable Voltage limit
4	AJA T.S	330.0	329.73	1.00	0.08	Acceptable Voltage limit
5	AJAOKUTA T.S	330.0	330.21	1.00	-0.06	Acceptable Voltage limit
6	AKANGBA T.S	330.0	324.69	0.98	1.61	Acceptable Voltage limit
7	ALADJA T.S	330.0	327.44	0.99	0.78	Acceptable Voltage limit
8	ALAGBON T.S	330.0	329.85	1.00	0.05	Acceptable Voltage limit
9	ALAOJI G.S	330.0	330.00	1.00	0.00	Acceptable Voltage limit
10	ALIADE T.S	330.0	370.31	1.12	-12.22	Above acceptable Volt. Limit
11	AYEDE T.S	330.0	322.02	0.98	2.42	Acceptable Voltage limit
12	B. KEBBI T.S	330.0	316.66	0.96	4.04	Acceptable Voltage limit
13	BENIN NORTH 3 T.S	330.0	330.09	1.00	-0.03	Acceptable Voltage limit
14	BENIN T.S	330.0	330.77	1.00	-0.23	Acceptable Voltage limit

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15	CALABAR G.S	330.0	330.00	1.00	0.00	Acceptable Voltage limit
16	DAMATURU T.S	330.0	476.61	1.45	-44.43	Above acceptable Volt. Limit
17	DELTA 1 G.S	11.5	11.50	1.00	0.00	Acceptable Voltage limit
18	DELTA 3 G.S	330.0	330.00	1.00	0.00	Acceptable Voltage limit
19	EGBEMA G.S	330.0	330.00	1.00	0.00	Acceptable Voltage limit
20	EGBIN 132KV T.S	132.0	132.00	1.00	0.00	Acceptable Voltage limit
21	EGBIN G.S	330.0	330.00	1.00	0.00	Acceptable Voltage limit
22	ERUNKAN T.S	330.0	328.63	0.99	0.42	Acceptable Voltage limit
23	EYEAN G.S	330.0	330.00	1.00	0.00	Acceptable Voltage limit
24	GANMO T.S	330.0	330.24	1.00	-0.07	Acceptable Voltage limit
25	GBARAN-UBIE G.S	132.0	132.00	1.00	0.00	Acceptable Voltage limit
26	GEREGU G.S	330.0	330.00	1.00	0.00	Acceptable Voltage limit
27	GOMBE T.S	330.0	461.61	1.40	-39.88	Above acceptable Volt. Limit
28	GWAGWALADA T.S	330.0	331.56	1.01	-0.47	Acceptable Voltage limit
29	IKEJA WEST T.S	330.0	326.83	0.99	0.96	Acceptable Voltage limit
30	IKOT ABASI 1 G.S	15.0	15.00	1.00	0.00	Acceptable Voltage limit
31	IKOT ABASI 3 G.S	330.0	330.00	1.00	0.00	Acceptable Voltage limit
32	IKOT EKPENE T.S	330.0	334.47	1.01	-1.35	Acceptable Voltage limit
33	JALINGO T.S	330.0	495.16	1.50	-50.05	Above acceptable Volt. Limit

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34	JEBBA G.S	330.0	330.00	1.00	0.00	Acceptable Voltage limit
35	JEBBA T.S	330.0	330.23	1.00	-0.07	Acceptable Voltage limit
36	JOS T.S	330.0	388.33	1.18	-17.68	Above acceptable Volt. Limit
37	KAINJI G.S	330.0	330.00	1.00	0.00	Acceptable Voltage limit
38	KATAMPE T.S	330.0	329.69	1.00	0.09	Acceptable Voltage limit
39	KUMBOSO T.S	330.0	311.29	0.94	5.67	Acceptable Voltage limit
40	LOKOJA T.S	330.0	331.48	1.00	-0.45	Acceptable Voltage limit
41	MADUGURI T.S	330.0	481.91	1.46	-46.03	Above acceptable Volt. Limit
42	MAKURDI T.S	330.0	375.85	1.14	-13.89	Above acceptable Volt. Limit
43	MANDO T.S	330.0	335.39	1.02	-1.63	Acceptable Voltage limit
44	NEW HAVEN SOUTH T.S	330.0	347.82	1.05	-5.40	Above acceptable Volt. Limit
45	NEW HAVEN T.S	330.0	347.60	1.05	-5.33	Above acceptable Volt. Limit
46	OKPAI G.S	330.0	330.00	1.00	0.00	Acceptable Voltage limit
47	OMOKU 1 G.S	15.0	15.00	1.00	0.00	Acceptable Voltage limit
48	OMOKU 3 G.S	330.0	330.00	1.00	0.00	Acceptable Voltage limit
49	OMOTOSO G.S	330.0	330.00	1.00	0.00	Acceptable Voltage limit
50	ONITSHA T.S	330.0	331.90	1.00	-0.58	Acceptable Voltage limit
51	OSOGBO T.S	330.0	327.83	0.99	0.66	Acceptable Voltage limit
52	OWERRI 132KV T.S	132.0	132.49	1.00	-0.37	Acceptable Voltage limit

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53	OWERRI T.S	330.0	330.89	1.00	-0.27	Acceptable Voltage limit
54	PAPALANTO G.S	330.0	330.00	1.00	0.00	Acceptable Voltage limit
55	PHCT(ONNE) G.S	330.0	330.00	1.00	0.00	Acceptable Voltage limit
56	SAKETE T.S	330.0	327.73	0.99	0.69	Acceptable Voltage limit
57	SAPELE G.S	330.0	330.00	1.00	0.00	Acceptable Voltage limit
58	SAPELE NIPP G.S	330.0	330.00	1.00	0.00	Acceptable Voltage limit
59	SHIRORO G.S	330.0	330.00	1.00	0.00	Acceptable Voltage limit
60	YENAGOA 132KV T.S	132.0	132.06	1.00	-0.05	Acceptable Voltage limit
61	YOLA T.S	330.0	490.33	1.48	-48.58	Above acceptable Volt. Limit

The buses with the voltage level above acceptable voltage limit are as a result of the low load demand on the transmission station hence a more stable and reliable network will be obtained by this integration. The results obtained in table 2 was analyzed graphically using MATLAB 7.5.0. Software, hence plotting the graph of %Voltage Drop versus Bus number for the Proposed Integrated 330kV network, figure 7 was obtained.

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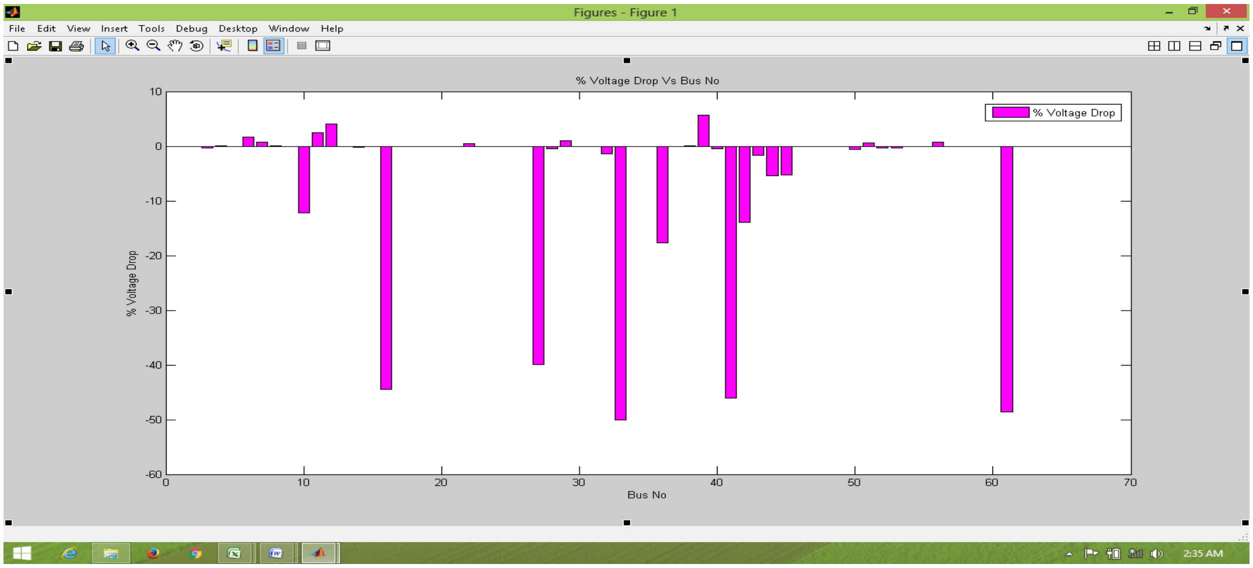

Figure 7: Percentage Voltage Drop Vs Bus No of Proposed Integrated 330kV Network

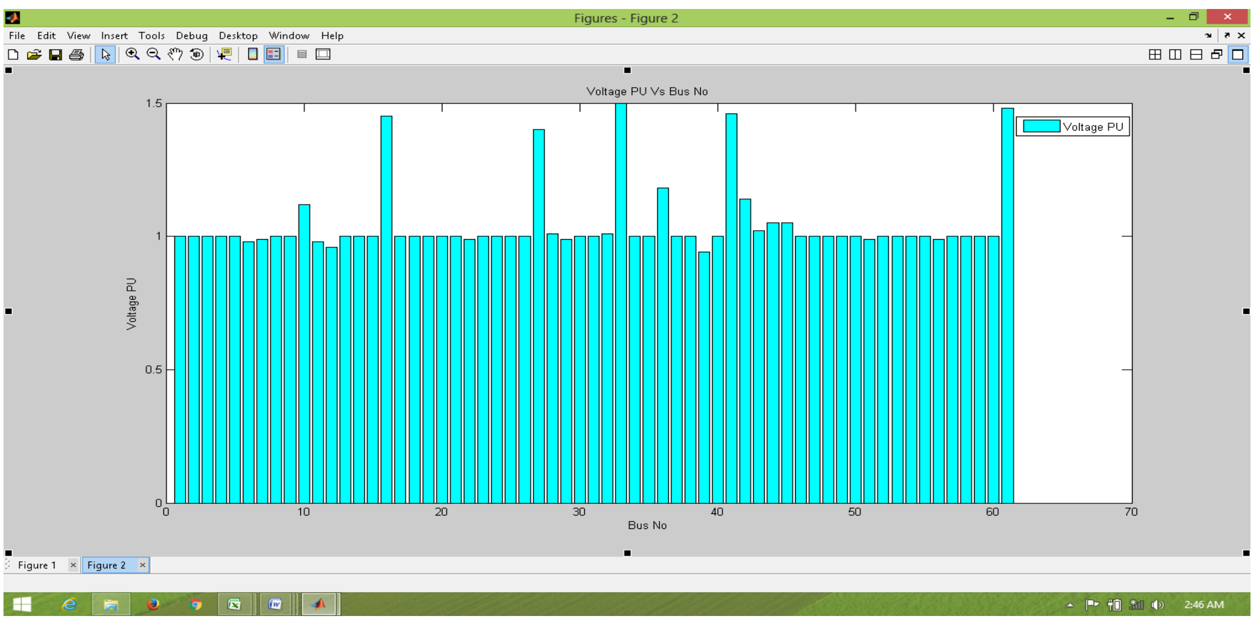

Figure 8: Voltage per unit Vs Bus No of Proposed Integrated 330KV Network

Similarly, plotting the graph of Voltage per unit Vs Bus No. of the Proposed Integrated 330KV network using MATLAB 7.5.0, figure 8 was obtained.

The real and reactive power losses in the network are 62.281MW and -3850.717MVar. The following transmission stations that were operating below the acceptable voltage limit of ±5% were improved as follows; Gombe T.S from 218.91KV to 461.61KV, Jos T.S from 263.05KV to 388.33KV, Kumbotso T.S from 280.25KV to 311.29KV and Mando T.S from 308KV to 335.39KV. Other buses in the network also have relative improvement on their bus voltages, thus resulting to improved voltage profile on the entire network.

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The summary of the results of the Existing 330KV network and the Proposed Integrated 330KV network using ETAP 12.6 Software is tabulated in table 3.

Table 3: Summary of the result of existing and proposed 330KV network from ETAP 12.6

Network	Voltage Profile (PU)	Active Load Demand (MW)	Reactive Load Demand (Mvar)	Losses (Real) MW	Losses (Reactive) Mvar
Existing 330KV	0.66 - 1.31	3232.42	337.91	49.72	-1525.49
Proposed Integrated 330KV	0.94 - 1.50	3311.11	-1949.695	62.28	-3850.72

From the load flow analysis summarized in table 3, by the Rule of thumb, the average losses on each transmission line can be analyzed as follows;

For the existing 330kV network, 48 transmission lines exist and the losses in megawatt as indicated in ETAP 12.6 software is 49.72MW, hence the average loss in each of the transmission lines is therefore 1.04MW and the losses in MVar in the network is -1525.49MVar.

Similarly, for Proposed Integrated 330KV Network, the number of transmission line is 111, the losses in megawatt as indicated by ETAP 12.6 is 62.28MW, hence the average loss in each transmission line is 0.56MW and the losses in MVar on the network is -3850.72MVar.

From the analysis, with the Proposed Integrated 330KV Network, the average loss on each transmission line has been reduced by 0.48MW, which indicates 46% improvement on the Existing 330kV transmission network and the voltage profile on each bus of the entire network has also improved from 0.66PU - 1.31PU to 0.94PU - 1.50PU.

IV. CONCLUSION

With the integration of the proposed 330KV network, electricity supply in the national grid will be more stable, reliable and efficient as a result of the improved voltage profile on the buses and reduced transmission losses on the entire the network.

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