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STUDY AND INVESTIGATION OF 11kV ELECTRICAL POWER SUPPLY FOR IMPROVED PERFORMANCE.

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ABSTRACT

This dissertation studies and investigates 11kv Electric Power Supply for Improved Performance**,** exploring the interrelationship between optimal performances of the electrical network with respect to the properties of the study feeder; loading, conductor sizes, and possible means to improve the present network. Two 11kv feeders in Port Harcourt Electricity Distribution company (PHED) network which are Nvigwe and Ogbatai 11 kv feeders having thirty-one (31) and twenty-one (21) distribution substations respectively, which emanate from RSPUB-1 injection substation was selected for this study, as these feeders provide the required change in the infrastructure over a 3year period (reduced load due to mass metering and periodic maintenance). Load flow studies was carried out using Electrical Transient and Analysis Program (ETAP) version 12.6. The software ran a load flow using Newton Raphson method and the results were generated after ninety-nine (99) iterations, with a precision of 0.000100 in four (4) stages, before, during and after metering , after proposed upgrade respectively, covering the three (3) year span. Before the metering process, voltage magnitude had the least values of 92.21%, 84.83%, 89.27% for the injection substation Nvigwe and Ogbatai feeders respectively, which improved a bit during the metering process and tremendous improvement was realized after the metering process as a result of reduction in network load; (recording voltage magnitude values of the injection substation, Nvigwe and Ogbatai feeders where 96.03%, 92.21%, 94.43% respectively) which are attribute to a large difference in the load from 7.5MW to 5.69MW for Nvigwe feeder. It was also noticed that the injection substation 15MVA transformer was overloaded, but with the help of mass metering, the load consumed was driven low by customer's energy utilization awareness, as they are directly responsible for the load they use. The study showed that the reduction in feeder load goes a long way to improve the network system performance by increasing the amount of useful load available and severely reducing the losses along the system. With further investigation it was also noticed that the route length of the feeders also plays a vital role in the amount of power loss as it travels along conductors to the customers.

1. INTRODUCTION

An electric power system is a network of electrical components deployed to supply, transfer, and utilization of electric power, that is generate, transmit and distribute. An example of an electric power system is the grid that provides power to an extended area. An electrical grid power system can be broadly divided into the generators that supply the power, the transmission system that carries the power from the generating stations to the load centres, and the distribution system that feeds the power to nearby homes and industries. Smaller power systems are also found in industry, hospitals, commercial buildings and homes.

An Electric Power System consists basically of 3 major sections; namely the Generation, Transmission and Distribution respectively. The transmission system is further divided into primary and secondary transmission. Distribution substations connect to the transmission system and lower the transmission voltage to medium voltage with the use of transformers. As Nigeria is blessed with excessive human and natural resources, it becomes paradoxical that after over a hundred years of existence and fifty-nine years of independence, Nigeria is still not getting it right in terms of energy sufficiency. If the problem is only that the power is insufficient, it would have been a much more bearable situation but the major problem is that the power supply is inconsistent due to heavy revenue and power losses. Hence, residents and companies requiring electric power cannot predict when the national grid will be available for their consumption (Ohajianya et., al 2014).

Electric power distribution network system forms the last part of the network that delivers electricity from the generating station through the transmission lines (National Grid) to the consumers via service conductors. The first component of the electrical distribution system is the distribution substation, which is a location where the transmission line voltage (132KV) or sub transmission line voltage (33KV) is lowered by step down transformer to obtain primary distribution line voltage (11KV) and this primary distribution line called feeders transports power to different distribution transformers that further steps down the voltage to secondary distribution line voltages, which are: 415volts for three phase supply while 240volts for single phase supply and neutral (Luis, 2016).

However, challenges emerge as the city expands; low voltages are experienced in some areas which led to the installation of transformers without planning, resulting to overloading of the feeder and also drop in voltage due to the distance covered by the transmission line which serves the area. Despite these challenges, there is the insufficient megawatt from the National Grid to the state. Electrical Energy plays a dominant role in the socio-economic development of the state.

The distribution system is arranged or configured based on the area served (rural, urban or suburban), the load level, reliability and supplementary equipment. The rural distribution configuration presents a radial structure and one transformer is sufficient to deliver electric power demanded by customers and the transformer is protected based on the earthing of the transformer. This configuration consists of high voltage and medium voltage buses. The medium voltage bus is connected to the primary distribution line and over current relay is employed for the protection of the system. This type of configuration is less expensive and simple in nature. The urban distribution configuration presents a close loop arrangement. In this configuration, the medium voltage buses take a closed loop and circuit breakers connected to separate different parts, so that load transfer can be done and maintenance services can be carried out with ease. This type of configuration requires more equipment and it is more expensive than the rural configuration. The suburban distribution configuration requires two more transformers to deliver electric power to the load centers and a normally open-tie switch, so that in the event of fault on one transformer; electric power can be delivered to the load centers by the remaining transformers when the normally open-tie switch is operated. This type of configuration facilitates voltage control, minimize fault level and more expensive than the rural configuration, it is known as the n-1 criteria.

A good distribution system must have the following requirements: the rated voltage of the system must not be interrupted, the distribution system should not over loaded, the dielectric strength of the insulation used in the system should be high, the system should be reliable and losses in the line should be minimum and the efficiency should be high (Patil and Kiran, 2013). The role of an electric power system is to fulfil the customers demand requirements with good assurance of quality and supply continuity, electric power is the utmost engine for any form of development such as: economic development and technological development, so the availability of electric power is very crucial for any form of development in any nation (Jaya *et al.*, 2017).

The power system value chain is illustrated in figure 1.1

Figure 1.1 Power System Sections

The factors that affect the efficiency and stability of power supply in any developing country/region can be classified as follows: government policy; economic factor; natural factor; society/community factor; effective energy management; skilled personnel; efficient technology and security factor (Oricha et al., 2012). Other problems include, over loading of distribution transformers, poor maintenance culture, lack of funds to procure materials and accessories.In view of this, the research would identify some problems on the network by carrying out a load flow analysis with a view to achieve efficient supply of power in the area in particular and the state at large.The aim of this research work is to conduct analysis of electric power supply from Port Harcourt main (Z2, Trans-Amadi) for improved distribution in the study case. The objectives of this research work are:

i. To collect data from the supply network to the study case for improved distribution.
ii. To investigate the electric power distribution problems facing Nvigwe and Ogbatai Environs.
iii. Modelling of the study network using ETAP and perform load flow analysis and simulation.

The research work is considered a load flow studies using ETAP platform to investigate the activities of 2x11kV distribution feeders in Nvigwe and Ogbatai distribution network. Electrical power sector has been operating for many years. However, due to poor maintenance culture, the electric power network suffers overloading, poor reliability and high losses, which results into lots of power interruption. Hence this project intends to:

i. Improve electric power distribution network for Trans-Amadi, Port Harcourt by modelling it and identifying possible problems.
ii. Recommend ways to reduce the rate at which electricity interruption occurs daily in Trans-Amadi, Port Harcourt
iii. Prescribe solutions to minimize overloading and losses along the distribution line.

2. RELATED WORKS

(Adeba, 2016), this research paper focused on the study of distributed generation in enhancing the power system reliability (Addis center substation a case study). According to the research paper, the substation suffered regular electricity interruptions and energy reliability problems and these problems were caused by earth fault and short circuit conditions. The average electricity interruption duration and frequency was below standard and this called for research work to provide adequate technique for enhancing the reliability of the grid which serves as a backup when electricity interrupt occurs. The kind of technology employed for the distributed generation is the fuel cell, for the reliability analysis Dig Silent software is employed for the simulation and the placement or location of the distribution generation is done at the place of the load point.

(Adegboye, 2010), In his research, analyses on daily outage data collected for a period of about twelve (12) months (April 2003 to April 2004) was done. From these data, the type, number and duration of the outrages were recognized, the plots of outrage distribution of five 11KV feeders were obtained and their forced outrages compared. Power losses due to the feeder outrage were considered and the feeders, at each voltage level were investigated for power loss. The results obtained were discussed, possible reasons for the causes of the outrages were presented and befitting recommendations and solutions were proposed.

(Beehailu, 2014), this research is a study on improved distribution substation at Beshoflu city. After evaluating and analyzing the data collected from the existing substation, it is observed that the substation is faced with the following problems: the energy management ability is low the maintenance service is poor and very low reliability level. The following design and simulation software are used: Dig Silent, Auto CAD and ETAP. A new substation that having automatic switches, communication and earthing systems to reduce electricity interruption durations, to pass information from control room to load dispatcher center and to provide safe working environment is proposed. After simulating the new substation, it shows that it yields the required and desired improvements.

3. METHODOLOGY

3.1 Materials

The major data source for this research work was obtained from Port Harcourt Electricity Distribution Company (PHEDC). In the course of the study, gathering of important data of different types is an essential task, the data gathered are: installed capacity of transmission substation, installed capacity of injection substation, examined feeders, total number and power rating of distribution transformers and singe line diagram of power distribution network for TransAmadi town, Port Harcourt. Source: (PHEDC).

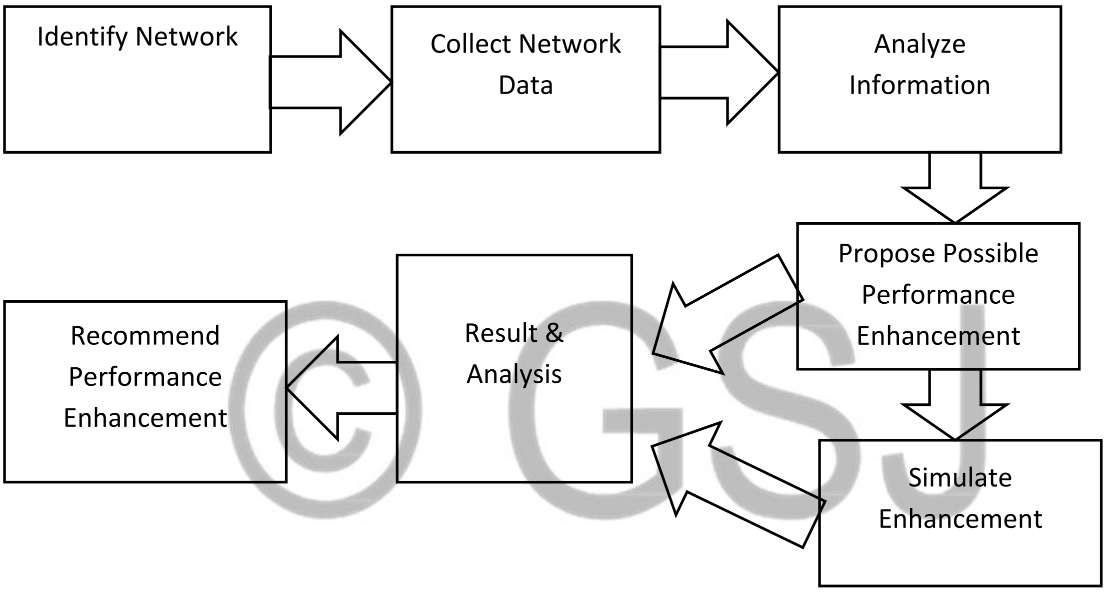

Figure 3.1 Proposed Method Block Diagram

As stated initially Computer Aided Design software known as ETAP version 12.6 would be used to model and simulate the flow of power on the selected network.

3.2 Description of 132/33kv Transmission Substation

The Port Harcourt Mains [Z2] Transmission Substation is located at Oginigba area of Rumuibekwe, along old aba road with an installed capacity of 180MVA and 10 number 33kv feeders emanating from the station. The transmission station receives its supply via double circuit transmission line from Afam 132KV switch yard duly linked to the 330KV national grid at Aloaji substation, and single circuit 132kv lines from Omoku GT, Trans Amadi GT owned by FIPL. Table 3.1 below shows the installed capacity of transmission substation, rated voltage and the number of feeders respectively.

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Table 3.1: Installed Capacity of PH Mains (Z2) Transmission Substation

Transformer ID	**Transformer Rating**	**Rated Voltage**	**No of Feeders**
T1	60MVA	132/33kV	3
T2	60MVA	132/33kV	3
T3	60MVA	132/33kV	4

Source: Port Harcourt Electricity Distribution Company (PHEDC)

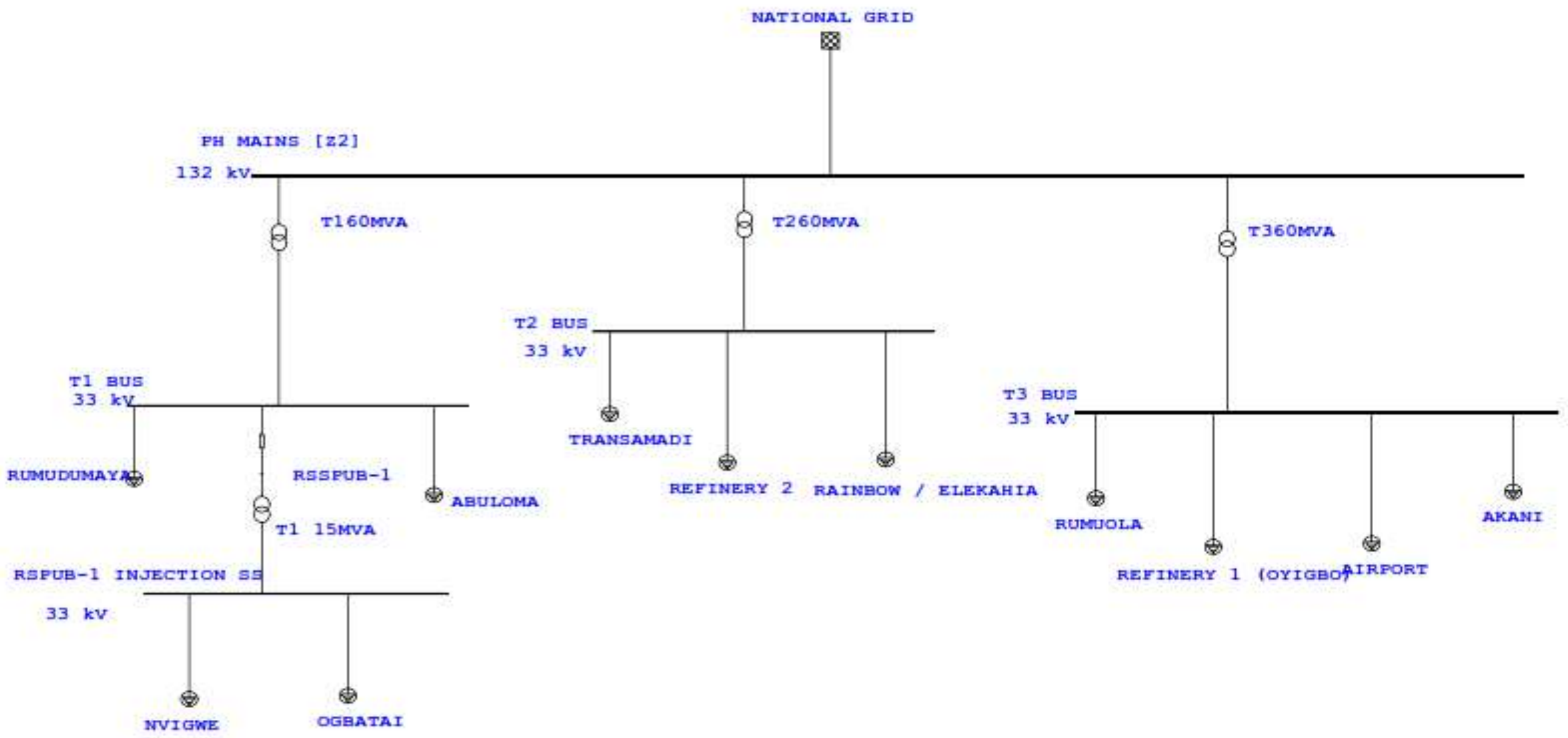

Figure 3.2: The Existing Power Supply Network

3.2.1 Description of 33/11kv Injection Substations

The injection substation covered in this study is RSPUB-1 1 x 15 MVA 33/11KV Injection substation, which receives supply from Port Harcourt Mains (Z2) Transmission Station. Table 3.2 shows the installed capacity, rated voltage and the number of feeders respectively.

Table 3.2: Installed Capacity of Injection Substation

Injection Substations	**Installed Capacity**	**No of Feeders**	**Examined Feeders**
RSPUB-1	2x15MVA, 33/11kV	2	Nvigwe and Ogbatai

3.2.2 Description of 11KV Feeders

The distribution of electricity to the distribution transformers within the network is done through the respective 11KV feeders. The examined feeders in this study are Nvigwe Feeder and Ogbatai Feeder.

Table 3.3: Data table for Nvigwe and Ogbatai 11kv feeders

Injection Substations	Study Feeders	Feeder Route Length (KM)	Feeder Size(mm^2)	Feeder Type	No of Distribution Transformers in KVA		
					500	300	200
RSPUB-1 1x 15 MVA	Nvigwe	10.0	150	AAC	30	0	1
	Ogbatai	8.65	150	AAC	17	4	0

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Table 3.4 RSPUB-1 feeder monthly average load readings (Before and After Metering 2016 – 2018)

2016	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**HIGHEST AVERAGE LOAD (MW)**	**AVERAGE CURRENT (A)**
RSPUB-1	9.3	8.9	8.6	8	9.2	12.7	7.8	8	10.6	8.6	8.9	8.4	9.08	181.67
NVIGWE	7.4	7.5	7.3	7.3	7.65	7.3	7.765	7.53	7.61	7.5	8	7.54	7.53	451.98
OGBATAI	4.8	4.9	4.5	4.3	4.5	4.6	4.5	4.6	3.9	4.8	4.7	4.4	4.54	272.50
2017	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**		
RSPUB-1	8.3	9.5	15.1	13	11.2	8.2	7.6	8.8	8.4	7.4	6.5	9.4	9.45	189.00
NVIGWE	7.6	7.5	7.3	6.9	6.87	6.5	6.3	6.8	6.7	6.3	6.8	6.6	6.85	410.85
OGBATAI	4.7	4.6	5.1	4	5.3	3.8	5	4.5	3.3	3.3	3.5	3.4	4.21	252.50
2018	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**		
RSPUB-1	7.6	10.8	7.8	8.7	8.7	7.8	8.2	7.9	6.5	9.85	10.2	8.6	8.55	171.08
NVIGWE	6.5	5.6	5.7	6.3	6.3	5.99	5.8	5.7	5.5	5.2	5	4.7	5.69	341.45
OGBATAI	4.6	4.4	3.6	3.5	3.4	3.45	3.33	3.35	3.3	3.3	3.2	3.18	3.55	213.05

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3.3 Determination of Distribution Transformer Loadings

The apparent power performance index is used to determine the percentage loading of transformers in the network. Based on the principle of loading of distribution transformers being 60% on rating for design purpose, transformers with loadings in excess of this figure are considered overloaded.

$$\% \, Loading = \left(\frac{S_{MVA}}{S_{MAX}} \right) \times 100$$

Where;

S_{MAX} is the MVA rating of the transformer

S_{MVA} is the operating MVA from power flow calculation

N_T is the number of transformers

3.3.1 Transformer Load Calculation for Nvigwe 11 Kv Feeder Distribution Network

Table 3.5 Distribution transformers, rating and current reading on Nvigwe 11kV feeder

S/N	DISTRIBUTION SUBSTATION	CAPACITY (KVA)	RATING (KV)	LOAD (A) BEFORE	DURING	AFTER
1	ECHENDU	500	11/0.415	598	473	362.3
2	ALCON I	500	11/0.415	647	603	317.3
3	ALCON II	500	11/0.415	635	576	423.3
4	CIRCULAR ROAD I	500	11/0.415	584	492	302.3
5	CIRCULAR ROAD II	500	11/0.415	612	489	389.7
6	CIRCULAR ROAD III	500	11/0.415	624	508	292.0
7	FYNEFACE	500	11/0.415	576	447	321.7
8	SAMPSON CHUKWU	500	11/0.415	568	429	328.3
9	KINGSLOPE	500	11/0.415	542	461	297.0

10	ZACOZEN	200	11/0.415	269.67	249.12	235.2
11	NVIGWE I	500	11/0.415	667	572	365.0
12	NVIGWE II	500	11/0.415	638	508	312.0
13	SIMON EKE	500	11/0.415	538	482	242.0
14	IHEWU CHINWU	500	11/0.415	529	456	417.0
15	CHIJIOKE	500	11/0.415	519	401	208.3
16	AMBROSE I	500	11/0.415	562	421	449.3
17	AMBROSE II	500	11/0.415	478	328	312.0
18	ABEC	500	11/0.415	643	525	331.3
19	ROAD 26 I	500	11/0.415	548	476	331.3
20	ROAD 26 II	500	11/0.415	523	462	308.3
21	ROAD 26 III	500	11/0.415	581	503	279.7
22	ROAD 21	500	11/0.415	595	516	305.7
23	NPALLAJA	500	11/0.415	509	431	403.7
24	ROAD 23	500	11/0.415	472	419	309.0
25	ROAD 1	500	11/0.415	546	482	297.0
26	ROAD 18	500	11/0.415	527	445	395.0
27	ROAD 16	500	11/0.415	446	398	316.3
28	ROAD 28	500	11/0.415	484	409	322.3
29	ROAD 7	500	11/0.415	507	415	353.3
30	ROAD 2	500	11/0.415	584	457	376.7
31	ROAD 3	500	11/0.415	572	483	355.7
				17,123.7	**14,316.1**	**10,260.2**

Source: Port Harcourt Electricity Distribution Company (PHEDC)

a. Calculating the transformer load on Nvigwe 11KV feeder.

The secondary current data in table 3.4 above are used in calculating the transformer load as shown below:

1. **Echendu Distribution Transformer (500kVA)**

Before Metering

The current, I = 598.0 A, Load S_{VA} on the transformer, $S_{VA} = \sqrt{3} \times V \times I$

$S_{VA} = \sqrt{3} \times 0.415 \times 10^3 \times 598.0$

$S_{VA} = 1.7320 \times 0.415 \times 10^3 \times 598.0$ = 429.8 KVA

During Metering

The current, I = 339.99 A, Load S_{VA} on the transformer, $S_{VA} = \sqrt{3} \times V \times I$

$S_{VA} = \sqrt{3} \times 0.415 \times 10^3 \times 473.0$

$S_{VA} = 1.7320 \times 0.415 \times 10^3 \times 473.0$ = 339.99KVA

After Metering

The current, I = 362.33 A, Load S_{VA} on the transformer, $S_{VA} = \sqrt{3} \times V \times I$

$S_{VA} = \sqrt{3} \times 0.415 \times 10^3 \times 362.33$

$S_{VA} = 1.7320 \times 0.415 \times 10^3 \times 362.33$ = 260.44 KVA

2. Alcon1 Distribution Transformer (500kVA),

Before Metering

The current, I = 362.33 A, Load S_{VA} on the transformer, $S_{VA} = \sqrt{3} \times V \times I$

$S_{VA} = \sqrt{3} \times 0.415 \times 10^3 \times 647$

$S_{VA} = 1.7320 \times 0.415 \times 10^3 \times 647$ = 465.06 KVA

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During Metering

The current, I = 603.0 A, Load S_{VA} on the transformer, $S_{VA} = \sqrt{3} \times V \times I$

$S_{VA} = \sqrt{3} \times 0.415 \times 10^3 \times 603.0$

$S_{VA} = 1.7320 \times 0.415 \times 10^3 \times 603.0$ = 433.44 KVA

After Metering

The current, I = 317.33 A, Load S_{VA} on the transformer, $S_{VA} = \sqrt{3} \times V \times I$

$S_{VA} = \sqrt{3} \times 0.415 \times 10^3 \times 317.33$

$S_{VA} = 1.7320 \times 0.415 \times 10^3 \times 317.33$ = 228.10 KVA

3. Alcon II Distribution Transformer (500kVA),

Before Metering

The current, I = 635.0 A, Load S_{VA} on the transformer, $S_{VA} = \sqrt{3} \times V \times I$

$S_{VA} = \sqrt{3} \times 0.415 \times 10^3 \times 635.0$

$S_{VA} = 1.7320 \times 0.415 \times 10^3 \times 635.0$ = 456.4 KVA

During Metering

The current, I = 576.0 A, Load S_{VA} on the transformer, $S_{VA} = \sqrt{3} \times V \times I$

$S_{VA} = \sqrt{3} \times 0.415 \times 10^3 \times 576.0$

$S_{VA} = 1.7320 \times 0.415 \times 10^3 \times 576$ = 414.03 KVA

After Metering

The current, I = 423.3 A, Load S_{VA} on the transformer, $S_{VA} = \sqrt{3} \times V \times I$

$S_{VA} = \sqrt{3} \times 0.415 \times 10^3 \times 423.3$

$S_{VA} = 1.7320 \times 0.415 \times 10^3 \times 423.3$ = 304.29 KVA

3.3.2 Transformer Load Calculation for Ogbatai 11 KV feeder Distribution Network

Table 3.6 Distribution transformers, rating and current reading on Ogbatai 11kV feeder

S/N	DISTRIBUTION SUBSTATION	CAPACITY (KVA)	RATING (KV)	LOAD (A) BEFORE	DURING	AFTER
1	WOJI HEALTH CENTER	300	11/0.415	398.0	292.0	262.7
2	PEACE VALLEY	500	11/0.415	527.0	439.0	335.7
3	ONU OKORO	500	11/0.415	640.0	610.0	308.7
4	GOLDEN VALLEY	500	11/0.415	503.0	462.0	250.7
5	KING SOLOMON ESTATE	500	11/0.415	472.0	416.0	294.3
6	UNITY ROAD	500	11/0.415	565.0	417.7	293.7
7	POST OFFICE	500	11/0.415	470.0	411.0	363.0
8	DENISE UFOT	300	11/0.415	376.0	298.0	286.0
9	MAJOR OBI	500	11/0.415	638.0	513.0	285.3
10	FAITH AVENUE I	500	11/0.415	411.0	363.0	238.7
11	FAITH AVENUE II	300	11/0.415	398.0	299.0	203.7
12	FAITH AVENUE III	300	11/0.415	412.8	390.1	281.0
13	CREEK VIEW	500	11/0.415	565.0	489.0	308.7
14	WOJI NEW LAYOUT	500	11/0.415	401.0	314.0	234.0
15	ELITOR III	500	11/0.415	498.0	409.0	229.0
16	ENDLESS	500	11/0.415	586.0	427.0	296.0
17	JERRY LANE	500	11/0.415	463.0	391.0	279.3
18	WOJI STREET I	500	11/0.415	363.0	315.0	246.3
19	WOJI STREET II	500	11/0.415	347.0	337.7	302.0
20	AMADI ODUM	500	11/0.415	663.0	498.0	364.7
21	PALACE STREET	500	11/0.415	306.0	257.0	225.0
				10,002.8	**8,348.4**	**5,888.4**

Source: Port Harcourt Electricity Distribution Company (PHEDC)

a. Calculating the transformer load and percentage load in Ogbatai 11KV feeder.

The secondary current data in table 3.5 above are used in calculating the transformer load, percentage loading, as shown below:

1. **Woji Health Center (WHC) Distribution Transformer (300kVA)**

Before Metering

The current, I = 398 A, Load S_{VA} on the transformer, $S_{VA} = \sqrt{3} \times V \times I$
$S_{VA} = \sqrt{3} \times 0.415 \times 10^3 \times 398.0$

$S_{VA} = 1.7320 \times 0.415 \times 10^3 \times 398.0 = 286.67$ KVA

During Metering

The current, I = 398 A, Load S_{VA} on the transformer, $S_{VA} = \sqrt{3} \times V \times I$
$S_{VA} = \sqrt{3} \times 0.415 \times 10^3 \times 398$

$S_{VA} = 1.7320 \times 0.415 \times 10^3 \times 398 = 209.89$KVA

After Metering

The current, I = 292 A, Load S_{VA} on the transformer, $S_{VA} = \sqrt{3} \times V \times I$
$S_{VA} = \sqrt{3} \times 0.415 \times 10^3 \times 292$

$S_{VA} = 1.7320 \times 0.415 \times 10^3 \times 292 = 188.8$ KVA

2. Peace Valley Distribution Transformer (500kVA),

Before Metering

The current, I = 527 A, Load S_{VA} on the transformer, $S_{VA} = \sqrt{3} \times V \times I$
$S_{VA} = \sqrt{3} \times 0.415 \times 10^3 \times 527$

$S_{VA} = 1.7320 \times 0.415 \times 10^3 \times 527 = 378.8$ KVA

During Metering

The current, I = 439 A, Load S_{VA} on the transformer, $S_{VA} = \sqrt{3} \times V \times I$
$S_{VA} = \sqrt{3} \times 0.415 \times 10^3 \times 439$

$S_{VA} = 1.7320 \times 0.415 \times 10^3 \times 439 = 315.6$ KVA

After Metering

The current, I = 335.67 A, Load S_{VA} on the transformer, $S_{VA} = \sqrt{3} \times V \times I$

$S_{VA} = \sqrt{3} \times 0.415 \times 10^3 \times 335.67$

$S_{VA} = 1.7320 \times 0.415 \times 10^3 \times 335.67$ = 241.3 KVA

3. Onu Okoro Distribution Transformer (500kVA),

Before Metering

The current, I = 640 A, Load S_{VA} on the transformer, $S_{VA} = \sqrt{3} \times V \times I$
$S_{VA} = \sqrt{3} \times 0.415 \times 10^3 \times 640$

$S_{VA} = 1.7320 \times 0.415 \times 10^3 \times 640$ = 460.03 KVA

During Metering

The current, I = 610 A, Load S_{VA} on the transformer, $S_{VA} = \sqrt{3} \times V \times I$
$S_{VA} = \sqrt{3} \times 0.415 \times 10^3 \times 610$

$S_{VA} = 1.7320 \times 0.415 \times 10^3 \times 610$ = 438.46 KVA

After Metering

The current, I = 308.67 A, Load S_{VA} on the transformer, $S_{VA} = \sqrt{3} \times V \times I$

$S_{VA} = \sqrt{3} \times 0.415 \times 10^3 \times 308.67$

$S_{VA} = 1.7320 \times 0.415 \times 10^3 \times 308.67$ = 221.87 KVA

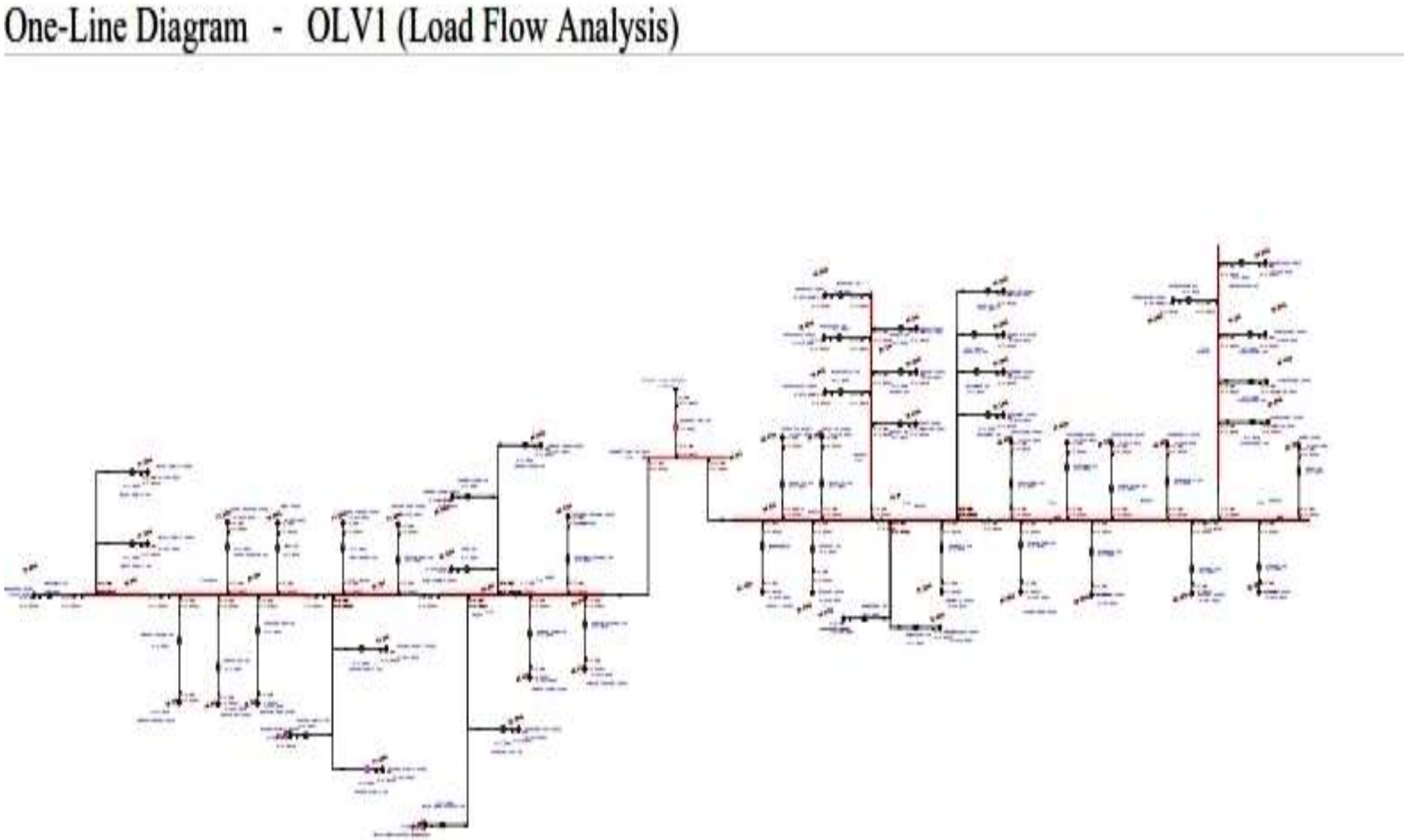

Figure 3.8: Developed Model of the entire Study Network

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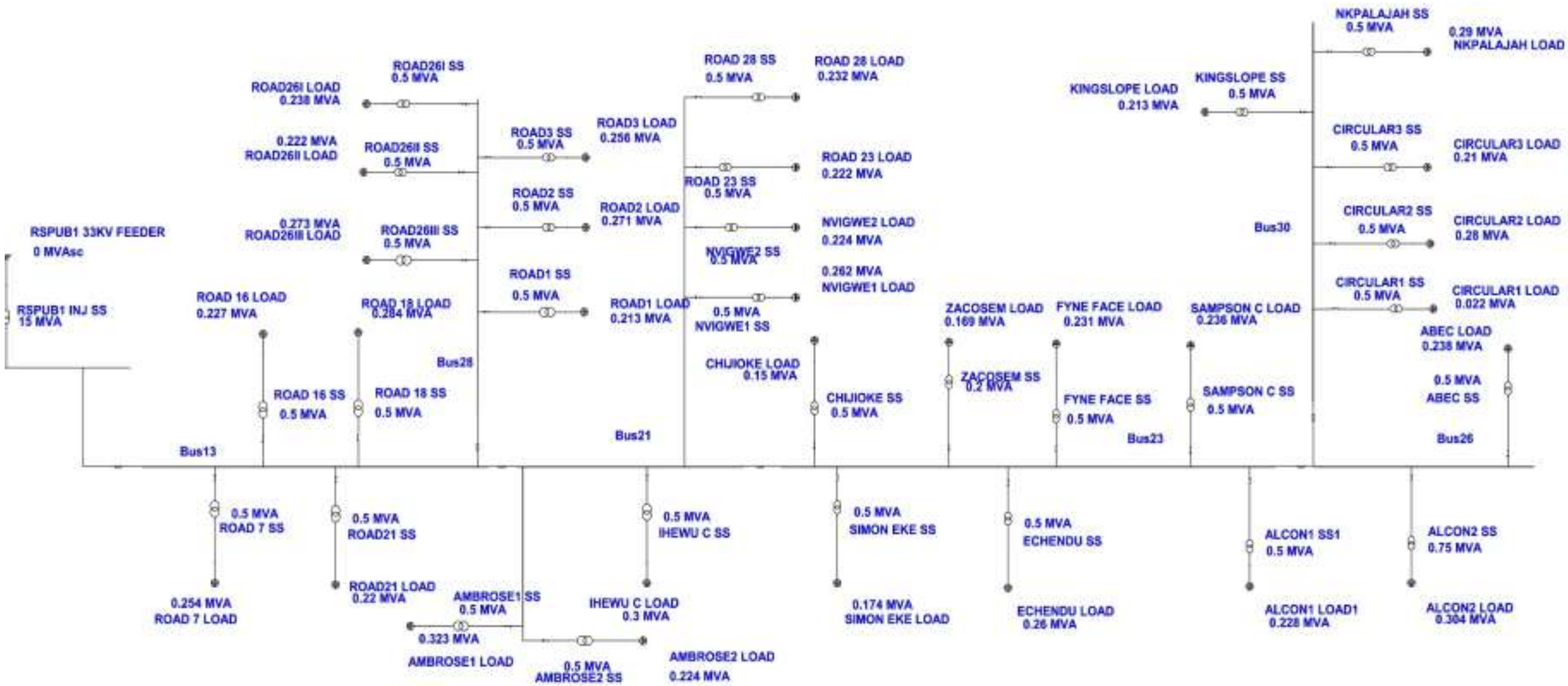

Figure 3.9: Developed Model of the Nvigwe 11KV Network

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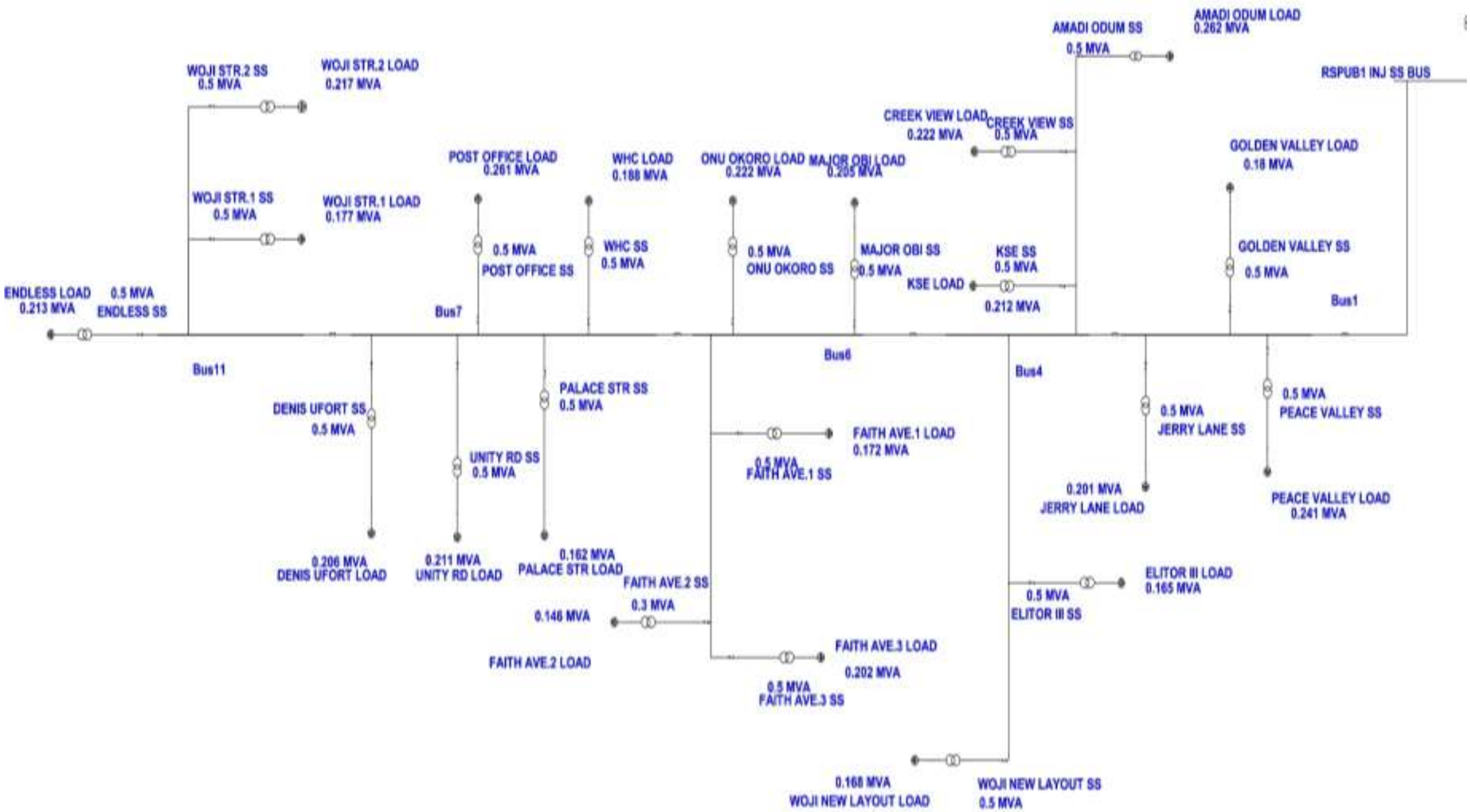

Figure 3.10: Developed Model of the Ogbatai 11KV Network

4. RESULTS AND DISCUSSION

4.1 Load Flow Simulation Results

The ETAP 12.6.0 load flow interface displays the required results Realtime on the interface screen and also generates detailed reports for numerical analysis and information reporting.

The typical load flow result screen displaying results is shown in figure 4.1

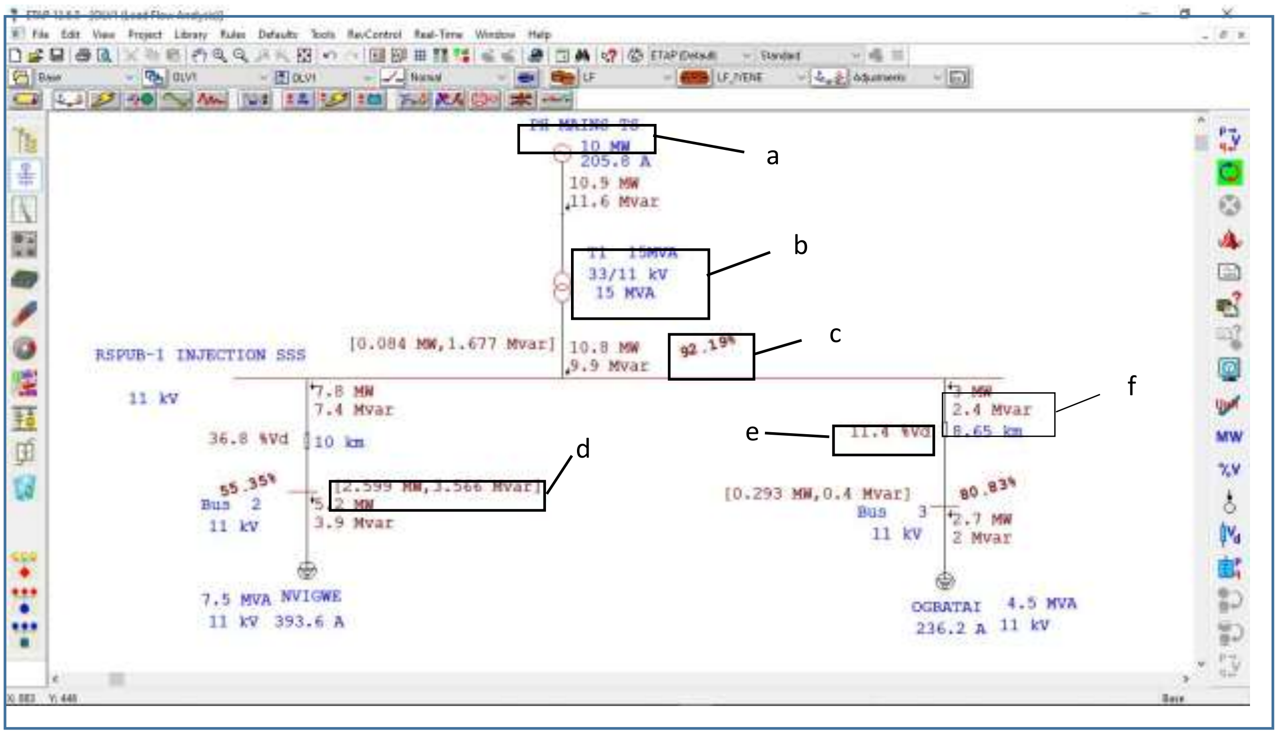

Figure 4.1 typical load flow result screen on ETAP 12.6.0

Information gotten from the real-time interface screen are;

a. Identification tags and names of machines and equipment.
b. Ratings of the machines, lines and bus bars.
c. Percentage load intercepted on each bus bar.
d. The power loss on each bus bar (MW and Mvar).
e. Voltage dropped along each transmission line (percentage drop).

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f. Real and imaginary power loading of each bus, line and load.

The simulation was done in three phases; which are before metering, during metering and after metering, it covers a span of three (3) years.

4.2 Load Flow Analysis Before Metering (2016)

The data on feeder loadings and conductor parameters during the period of no electronic prepaid meters on the customer side was utilized to drive this part of the simulation. The load flow simulation result screen is shown in figure 4.2a, which is further broken into 4.2 b and 4.2 c, this is due to the vast nature of the study network, hence the sectioning of the system into the component 11 kv feeder network comprising distribution substations.

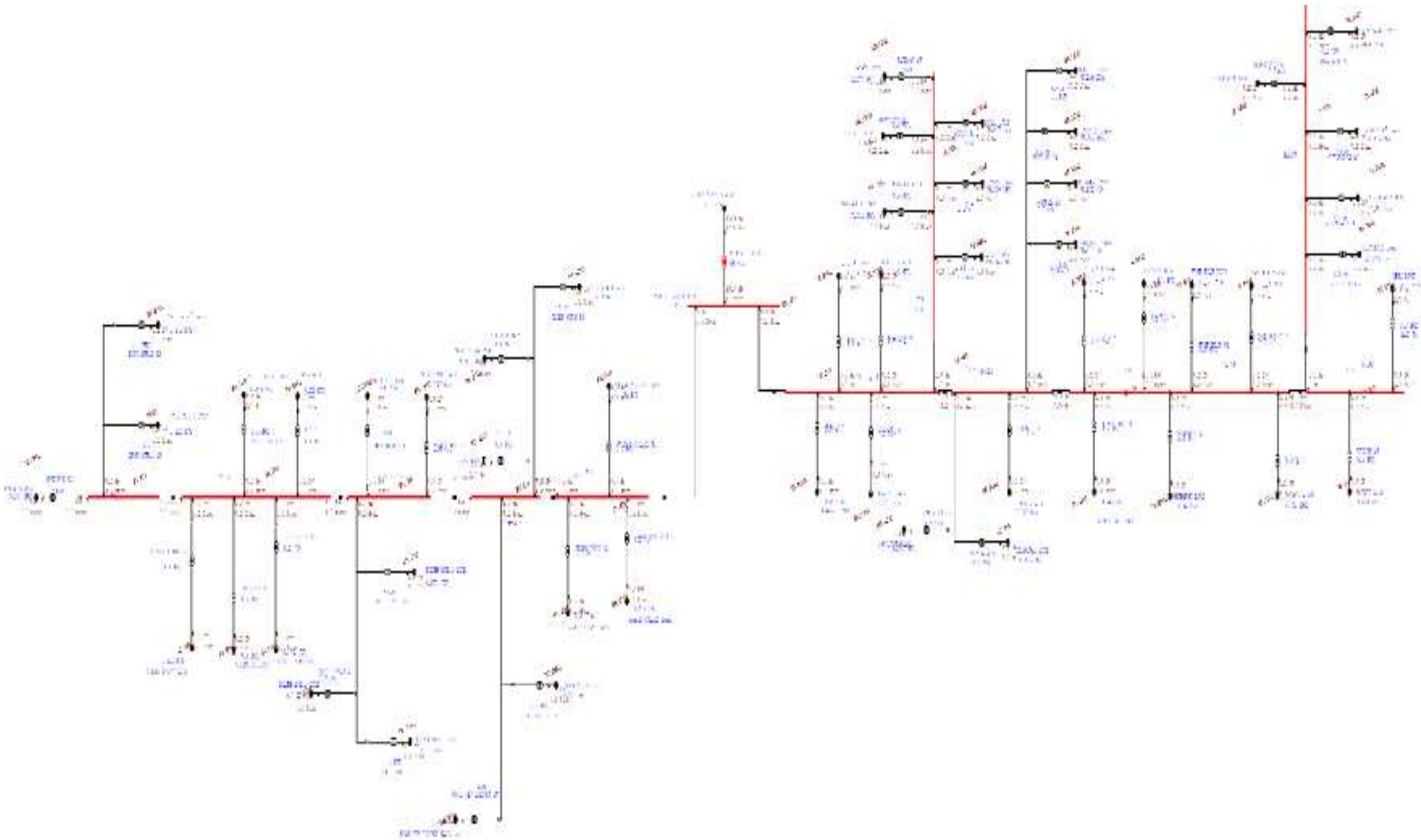

Figure 4.2a ETAP 12.6.0 Load flow result screen of the Entire network before metering

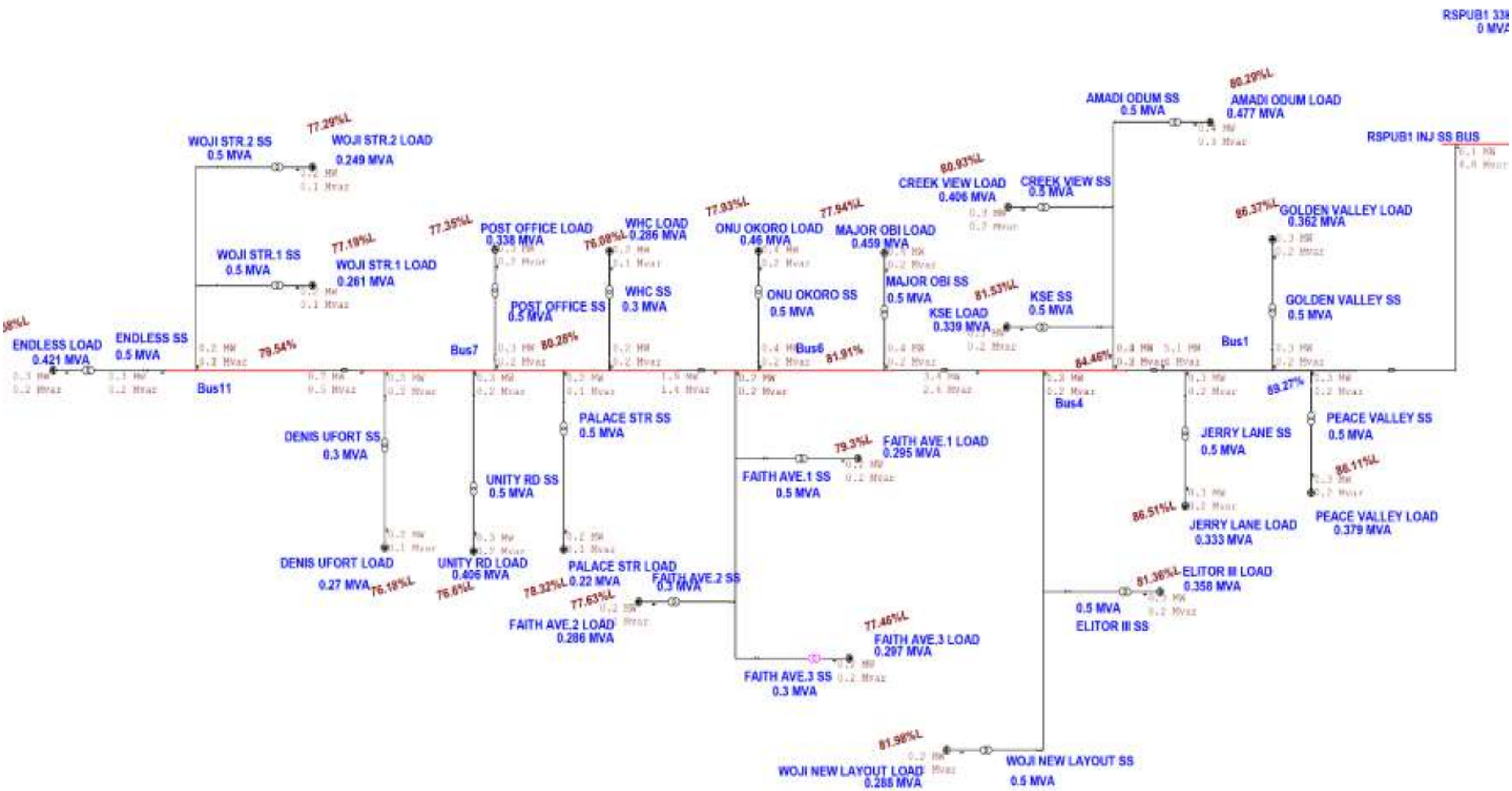

Figure 4.2b ETAP 12.6.0 Load flow result screen of Ogbatai 11kv feeder network just before metering

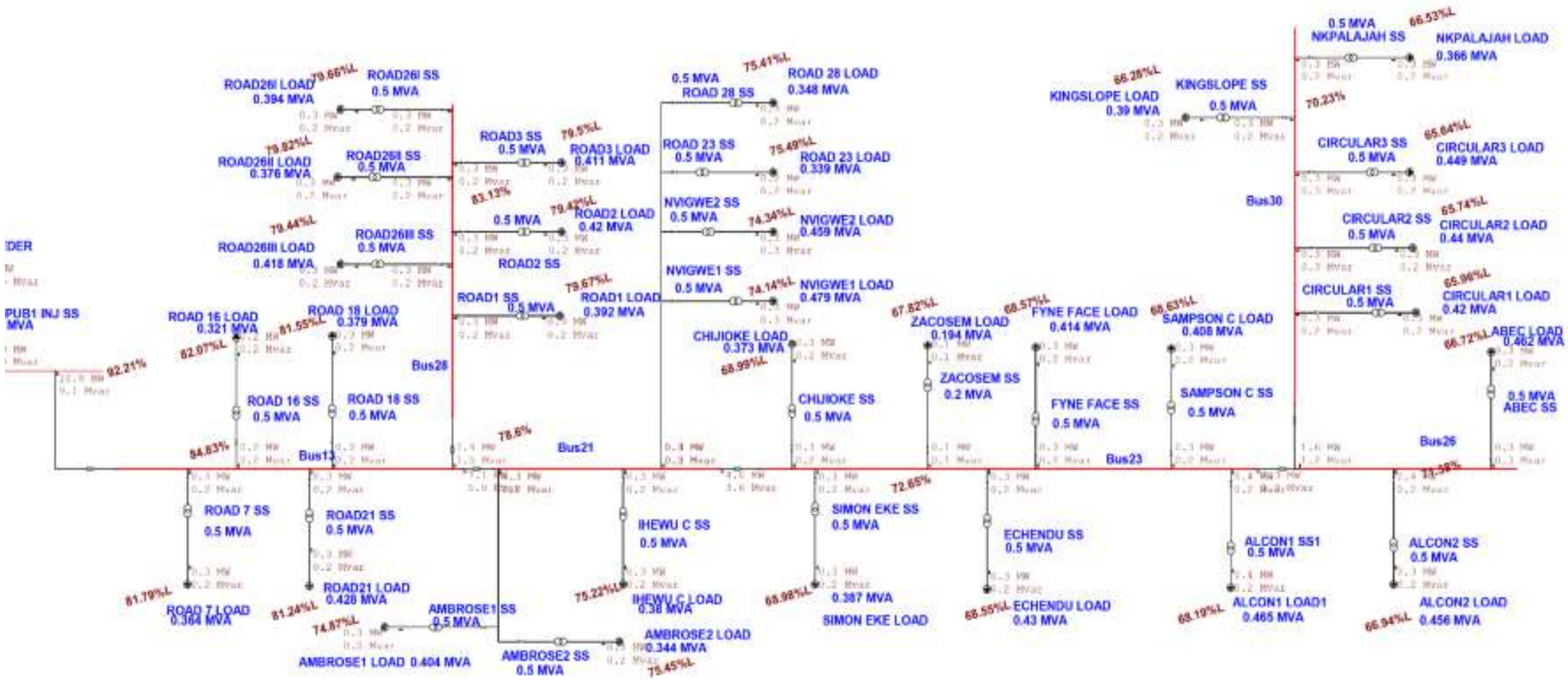

Figure 4.2c ETAP 12.6.0 Load flow result screen of the Nvigwe 11kv feeder network just before metering

The simulation indicates the status of the 31 number substations at Nvigwe and 21 number Distribution substations at Obgatai 11kv feeders, which are detailed in tables 4.1a and 4.1b for the Nvigwe and Ogbatai feeders respectively, showing the percentage loading of the distribution transformers, voltage drop on the transformers and loads, the power flow and the power lost across the system.

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Table 4.1a Simulation results of the Distribution Substation transformers on Nvigwe 11kv feeder gotten before the Metering project

S/NO	SUBSTATION NAME	Rating (MVA)	MW Flow	Mvar Flow	% Loading	% Voltage Drop	kW Losses	kvar Losses	STATUS
1	ABEC SS	0.5	0.346	0.272	87.9	4.66	16.832	25.248	OVER LOADED
2	ALCON1 SS1	0.5	0.369	0.243	88.5	4.46	16.459	24.688	OVER LOADED
3	ALCON2 SS	0.5	0.361	0.238	86.6	4.44	16.329	24.494	OVER LOADED
4	AMBROSE1 SS	0.5	0.306	0.237	77.4	3.72	10.747	16.121	ALMOST OVERLOADED
5	AMBROSE2 SS	0.5	0.259	0.2	65.4	3.15	7.685	11.528	OK
6	CHIJIOKE SS	0.5	0.278	0.216	70.3	3.66	10.398	15.597	OK
7	CIRCULAR1 SS	0.5	0.312	0.245	79.3	4.27	14.143	21.214	ALMOST OVERLOADED
8	CIRCULAR2 SS	0.5	0.328	0.257	83.3	4.49	15.614	23.421	OVER LOADED
9	CIRCULAR3 SS	0.5	0.334	0.263	85	4.59	16.27	24.405	OVER LOADED
10	ECHENDU SS	0.5	0.341	0.223	81.5	4.1	13.945	20.917	OVER LOADED
11	FYNE FACE SS	0.5	0.309	0.241	78.4	4.09	12.933	19.399	ALMOST OVERLOADED
12	IHEWU C SS	0.5	0.305	0.197	72.6	3.37	9.456	14.183	OK
13	NKPALAJAH SS	0.5	0.271	0.211	68.6	3.7	10.594	15.892	OK
14	NVIGWE1 SS	0.5	0.364	0.285	92.5	4.45	15.364	23.047	OVER LOADED
15	NVIGWE2 SS	0.5	0.348	0.272	88.3	4.25	13.999	20.999	OVER LOADED
16	ROAD1 SS	0.5	0.3	0.232	75.9	3.45	9.252	13.878	ALMOST OVERLOADED
17	ROAD2 SS	0.5	0.322	0.249	81.4	3.7	10.633	15.95	OVER LOADED
18	ROAD3 SS	0.5	0.315	0.244	79.7	3.62	10.186	15.279	ALMOST OVERLOADED
19	ROAD 7 SS	0.5	0.297	0.191	70.6	3.04	7.682	11.524	OK
20	ROAD 16 SS	0.5	0.246	0.189	61.9	2.76	5.916	8.874	OK
21	ROAD 18 SS	0.5	0.291	0.225	73.5	3.28	8.335	12.503	OK
22	ROAD21 SS	0.5	0.349	0.226	83.2	3.59	10.683	16.024	OVER LOADED
23	ROAD 23 SS	0.5	0.256	0.197	64.6	3.11	7.488	11.231	OK
24	ROAD26I SS	0.5	0.301	0.233	76.2	3.47	9.322	13.983	ALMOST OVERLOADED
25	ROAD26II SS	0.5	0.287	0.222	72.6	3.3	8.466	12.699	OK
26	ROAD26III SS	0.5	0.32	0.248	80.9	3.68	10.52	15.781	OVER LOADED
27	ROAD 28 SS	0.5	0.262	0.203	66.3	3.19	7.886	11.829	OK
28	KINGSLOPE SS	0.5	0.289	0.226	73.3	3.95	12.086	18.129	OK
29	SAMPSON C SS	0.5	0.305	0.238	77.3	4.03	12.559	18.838	ALMOST OVERLOADED
30	SIMON EKE SS	0.5	0.305	0.199	72.9	3.67	11.176	16.763	OK
31	ZACOSEM SS	0.2	0.146	0.115	92.6	4.83	7.211	10.817	OVER LOADED

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S/NO	SUBSTATION NAME	Rating (MVA)	MW Flow	Mvar Flow	% Loading	% Voltage Drop	kW Losses	kvar Losses	STATUS
		15.2	**9.422**	**7.037**	**0**	**118.07**	**350.169**	**525.255**	

Table 4.1b Simulation results of the Distribution Substation transformer on Ogbatai 11kv feeder gotten before the Metering project

S/NO	SUBSTATION NAME	Rating (MVA)	MW Flow	Mvar Flow	% Loading	% Voltage Drop	kW Losses	kvar Losses	STATUS
1	AMADI ODUM SS	0.5	0.368	0.286	93.1	4.17	13.491	20.237	OVER LOADED
2	CREEK VIEW SS	0.5	0.312	0.241	78.9	3.53	9.686	14.53	ALMOST OVERLOADED
3	DENIS UFORT SS	0.3	0.206	0.16	87	4.1	7.812	11.717	OVER LOADED
4	ELITOR III SS	0.5	0.274	0.211	69.3	3.1	7.468	11.202	OK
5	ENDLESS SS	0.5	0.32	0.248	81	3.85	11.497	17.245	OVER LOADED
6	FAITH AVE.1 SS	0.5	0.224	0.172	56.5	2.61	5.279	7.918	OK
7	FAITH AVE.2 SS	0.3	0.219	0.171	92.6	4.28	8.512	12.768	OVER LOADED
8	FAITH AVE.3 SS	0.3	0.228	0.178	96.2	4.45	9.186	13.779	OVER LOADED
9	GOLDEN VALLEY SS	0.5	0.299	0.191	70.9	2.9	7.007	10.51	OK
10	JERRY LANE SS	0.5	0.259	0.199	65.2	2.76	5.923	8.885	OK
11	KSE SS	0.5	0.26	0.2	65.6	2.94	6.689	10.033	OK
12	MAJOR OBI SS	0.5	0.372	0.242	88.8	3.97	13.046	19.569	OVER LOADED
13	ONU OKORO SS	0.5	0.373	0.243	89.1	3.98	13.131	19.697	OVER LOADED
14	PALACE STR SS	0.5	0.165	0.126	41.6	1.96	2.979	4.469	OK
15	PEACE VALLEY SS	0.5	0.295	0.227	74.5	3.15	7.722	11.583	OK
16	POST OFFICE SS	0.5	0.271	0.174	64.5	2.93	7.16	10.74	OK
17	UNITY RD SS	0.5	0.309	0.239	78.1	3.68	10.497	15.745	ALMOST OVERLOADED
18	WHC SS	0.3	0.231	0.151	92.1	4.2	8.77	13.155	OVER LOADED
19	WOJI NEW LAYOUT SS	0.5	0.22	0.169	55.5	2.48	4.79	7.185	OK
20	WOJI STR.1 SS	0.5	0.196	0.15	49.4	2.35	4.284	6.426	OK
21	WOJI STR.2 SS	0.5	0.187	0.143	47.2	2.24	3.907	5.86	OK
		9.7	**5.588**	**4.121**	**0**	**69.63**	**168.836**	**253.253**	

Using a margin of 70% loading to indicate partially overloaded and greater than 80% loading as overloaded, the software program report generated during the simulation of the Nvigwe network, it was noticed that Twelve (12) number DTRs are fully overloaded, 7 number partially overloaded and 12 number are loaded efficiently. A voltage drop of 118.1% is noticed along the feeder, with a maximum and minimum drop on the DTRs at 4.83% and 2.76% respectively. The total power losses displayed is 350.17 kW and 525.3 KVR.

While the report generated during the simulation of the Ogbatai 11kv Network indicated that 8 number substations are fully overloaded with values ranging from 81.5% - 96.2%, 2 number partially overloaded and 11 number substations are well efficiently loaded. A total voltage drop of 75.58% is noticed along the feeder, which is less than the Nvigwe section, peaking at 4.45% and lowest at 1.96 %. The total power lost as simulated is 168.8 kW.

The report further indicated that the injection substation 1 x 15MVA 33/11kv transformer is heavily overloaded with a loading of 145%, which far beyond the capacity, and a voltage drop of 7.79 % and losses up to 141 kw + j 2617 kvr..The entire reports generated for this simulation is added in the appendix for detailed view.

4.3 Load Flow Analysis During Metering

The data utilized for this simulation segment was also collected from data acquired from design calculations of the 3.2.3.1, 3.2.3.2, which are distribution transformer apparent power calculation and PHED load data on the study network during the metering time line (2017). The load flow simulation scree is shown in figure 4.3a and 4.3b for Ogbatai and Nvigwe 11 kv network respectively.

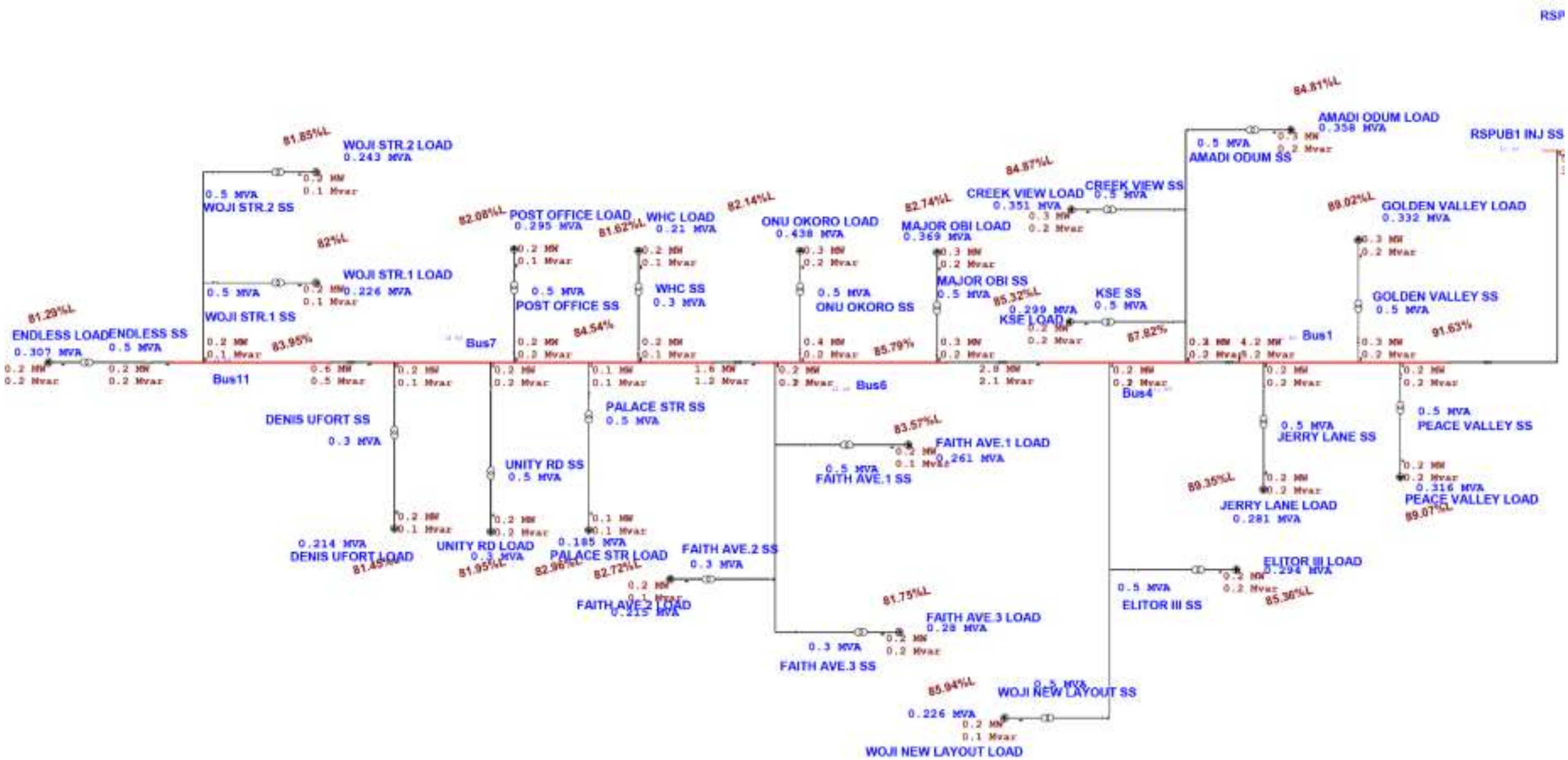

Figure 4.3a ETAP 12.6.0 Load flow result screen during the metering program on Ogbatai 11kv feeder network

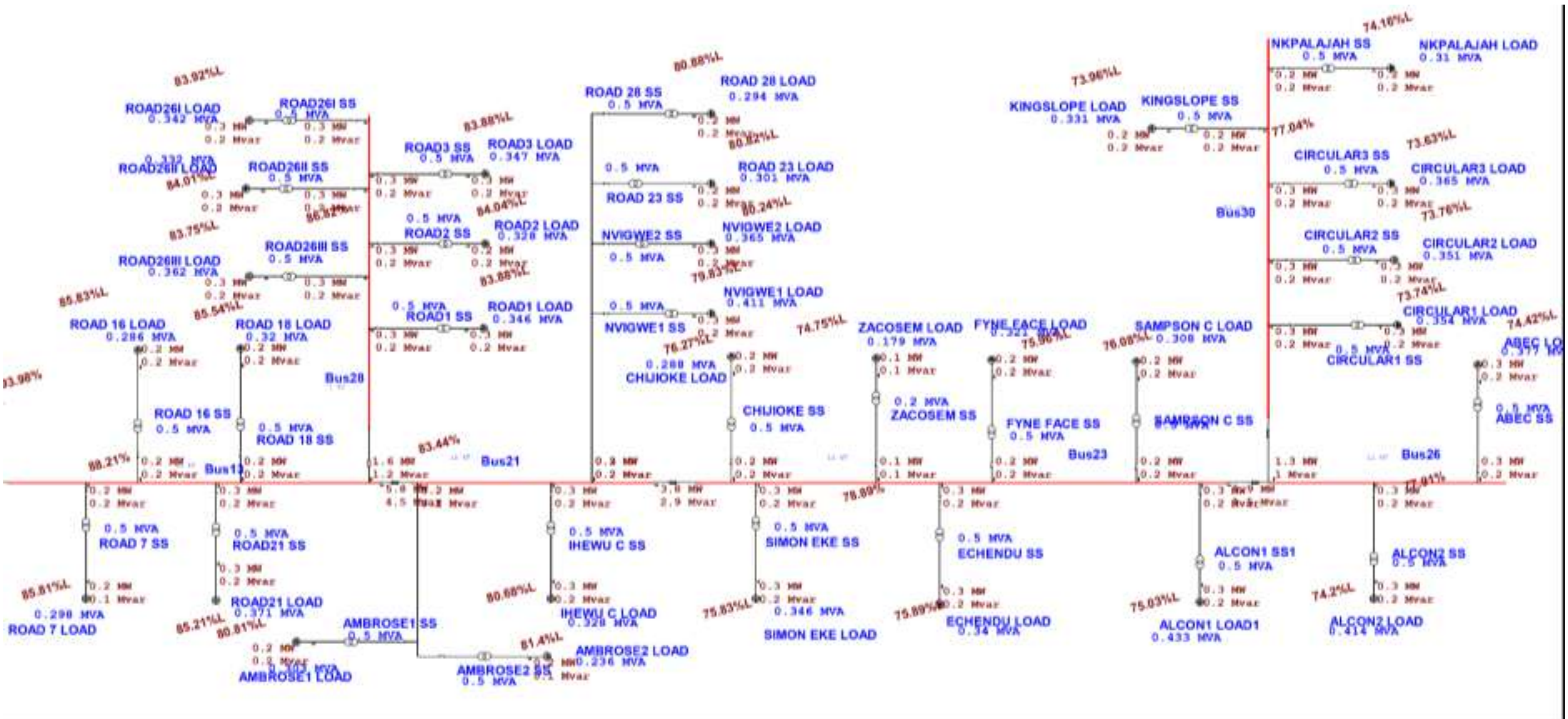

Figure 4.3b ETAP 12.6.0 Load flow result screen during the metering program on Nvigwe11kv feeder network

The results gotten from the simulation are tabulated in table 4.2a and 4.2b showing the Substation loadings (%), voltage drop along the 11kv distribution line (%), and the power flow and losses both study network of the system.

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Table 4.2a Simulation results for data gotten from the Nvigwe 11kv feeder network during the Metering project

S/NO	SUBSTATION NAME	Rating (MVA)	MW Flow	Mvar Flow	% Loading	% Voltage Drop	kW Losses	kvar Losses	STATUS
1	ABEC SS	0.5	0.284	0.22	72	3.49	9.466	14.199	ALMOST OVERLOADED
2	ALCON1 SS1	0.5	0.349	0.227	83.2	3.86	12.333	18.5	OVER LOADED
3	ALCON2 SS	0.5	0.332	0.216	79.1	3.71	11.445	17.168	ALMOST OVERLOADED
4	AMBROSE1 SS	0.5	0.231	0.177	58.2	2.63	5.39	8.084	OK
5	AMBROSE2 SS	0.5	0.179	0.137	45.1	2.04	3.237	4.856	OK
6	CHIJIOKE SS	0.5	0.217	0.166	54.6	2.62	5.322	7.983	OK
7	CIRCULAR1 SS	0.5	0.266	0.205	67.1	3.3	8.429	12.643	OK
8	CIRCULAR2 SS	0.5	0.264	0.204	66.7	3.28	8.323	12.484	OK
9	CIRCULAR3 SS	0.5	0.274	0.213	69.4	3.41	9.007	13.51	OK
10	ECHENDU SS	0.5	0.272	0.175	64.7	3	7.46	11.19	OK
11	FYNE FACE SS	0.5	0.242	0.186	61.1	2.93	6.653	9.98	OK
12	IHEWU C SS	0.5	0.265	0.17	63.1	2.76	6.337	9.506	OK
13	NKPALAJAH SS	0.5	0.232	0.179	58.6	2.87	6.413	9.619	OK
14	NVIGWE1 SS	0.5	0.315	0.244	79.7	3.61	10.126	15.189	ALMOST OVERLOADED
15	NVIGWE2 SS	0.5	0.279	0.215	70.5	3.2	7.927	11.89	ALMOST OVERLOADED
16	ROAD1 SS	0.5	0.267	0.206	67.5	2.94	6.7	10.049	OK
17	ROAD2 SS	0.5	0.253	0.195	63.9	2.78	6.007	9.01	OK
18	ROAD3 SS	0.5	0.268	0.206	67.6	2.94	6.728	10.092	OK
19	ROAD 7 SS	0.5	0.245	0.156	58.1	2.4	4.812	7.218	OK
20	ROAD 16 SS	0.5	0.221	0.169	55.7	2.39	4.425	6.637	OK
21	ROAD 18 SS	0.5	0.248	0.19	62.4	2.67	5.557	8.336	OK
22	ROAD21 SS	0.5	0.306	0.196	72.6	3.01	7.512	11.268	ALMOST OVERLOADED
23	ROAD 23 SS	0.5	0.23	0.176	57.9	2.62	5.337	8.006	OK
24	ROAD26I SS	0.5	0.264	0.203	66.6	2.9	6.53	9.795	OK
25	ROAD26II SS	0.5	0.256	0.197	64.6	2.81	6.142	9.213	OK
26	ROAD26III SS	0.5	0.279	0.215	70.5	3.07	7.312	10.968	ALMOST OVERLOADED
27	ROAD 28 SS	0.5	0.224	0.172	56.5	2.56	5.08	7.62	OK
28	KINGSLOPE SS	0.5	0.248	0.192	62.8	3.08	7.368	11.051	OK
29	SAMPSON C SS	0.5	0.232	0.179	58.6	2.81	6.114	9.171	OK
30	SIMON EKE SS	0.5	0.277	0.179	66	3.05	7.756	11.633	OK
31	ZACOSEM SS	0.2	0.136	0.106	86.1	4.13	5.291	7.937	OVER LOADED
		15.2	**7.955**	**5.871**	**0**	**92.87**	**216.539**	**324.805**	

Table 4.2b Simulation results for data gotten from the Ogbatai 11kv feeder network during the Metering project

S/NO	SUBSTATION NAME	Rating (MVA)	MW Flow	Mvar Flow	% Loading	% Voltage Drop	kW Losses	kvar Losses	STATUS
1	AMADI ODUM SS	0.5	0.277	0.213	70	3.01	7.043	10.564	OK
2	CREEK VIEW SS	0.5	0.272	0.209	68.7	2.96	6.784	10.177	OK
3	DENIS UFORT SS	0.3	0.164	0.127	69.1	3.09	4.45	6.675	OK
4	ELITOR III SS	0.5	0.227	0.174	57.2	2.46	4.708	7.062	OK
5	ENDLESS SS	0.5	0.234	0.18	59.1	2.66	5.497	8.246	OK
6	FAITH AVE.1 SS	0.5	0.2	0.153	50.3	2.22	3.82	5.73	OK
7	FAITH AVE.2 SS	0.3	0.165	0.127	69.6	3.07	4.382	6.573	OK
8	FAITH AVE.3 SS	0.3	0.217	0.168	91.6	4.04	7.585	11.378	OVER LOADED
9	GOLDEN VALLEY SS	0.5	0.276	0.176	65.5	2.61	5.673	8.51	OK
10	JERRY LANE SS	0.5	0.22	0.168	55.3	2.28	4.043	6.065	OK
11	KSE SS	0.5	0.231	0.177	58.2	2.5	4.874	7.311	OK
12	MAJOR OBI SS	0.5	0.301	0.194	71.6	3.05	7.737	11.606	ALMOST OVERLOADED
13	ONU OKORO SS	0.5	0.36	0.233	85.6	3.65	11.053	16.58	OVER LOADED
14	PALACE STR SS	0.5	0.141	0.107	35.3	1.58	1.934	2.902	OK
15	PEACE VALLEY SS	0.5	0.247	0.189	62.2	2.57	5.119	7.679	OK
16	POST OFFICE SS	0.5	0.24	0.153	56.9	2.46	5.023	7.534	OK
17	UNITY RD SS	0.5	0.23	0.176	57.9	2.59	5.2	7.799	OK
18	WHC SS	0.3	0.171	0.11	67.6	2.92	4.26	6.39	OK
19	WOJI NEW LAYOUT SS	0.5	0.174	0.132	43.7	1.88	2.749	4.124	OK
20	WOJI STR.1 SS	0.5	0.172	0.131	43.3	1.95	2.955	4.432	OK
21	WOJI STR.2 SS	0.5	0.185	0.141	46.5	2.09	3.404	5.107	OK
		9.7	**4.704**	**3.438**	**0**	**55.64**	**108.293**	**162.444**	

The simulation shows a 93.98 % voltage magnitude experienced on the injection substation bus bar, while 88.21 % and 91.63 % Voltage magnitude was experienced on the Nvigwe and Ogbatai feeders respectively. These values indicate a larger voltage drop along the Nvigwe Bus.

The generated ETAP report indicated that during the simulation of the Ogbatai 11kv Network showing that 2 number substations are fully overloaded with values ranging from 85.6% and 91.6%, 1 number partially overloaded at 71.6% and 18 number substations are efficiently loaded. A total voltage drop of 55.64 % is noticed along the feeder, which is less than the Nvigwe section, with the average voltage drop of 2.65%. The total power loss on the Ogbatai 11kv network is 108.3 kW.

Meanwhile, the Nvigwe Network also had Two (2) number substations overloaded, six (6) partially overloaded distribution substations and twenty-three (23) number are functionally loaded. A total voltage drop of 92.87% is stipulated along the feeder, with Zacosem 200kVA 11/0.415 kv substation having the largest voltage drop of 4.13% and Ambrose II 500MVA 11/0.415kv substation having the least voltage drop of 2.04%. The total power losses displayed is 216.5 kW and 324.8 kvr.

The percentage loading on the injection substation 1 x 15MVA 33/11kv transformer is not as loaded as before the metering procedure began, still high with a value of 117%. This is still beyond the capacity, and a voltage drop of 6.02% and losses up to 88.2kw + j 1640kvr. Other reports generated for this simulation can be found in the appendix.

4.4 Load Flow Analysis after Metering

In 2018, after the entire mass metering project was conducted, the data collected on the system was utilized to run the final segment of the load flow simulation. The load flow screen is illustrated in figure 4.4a and 4.4b.

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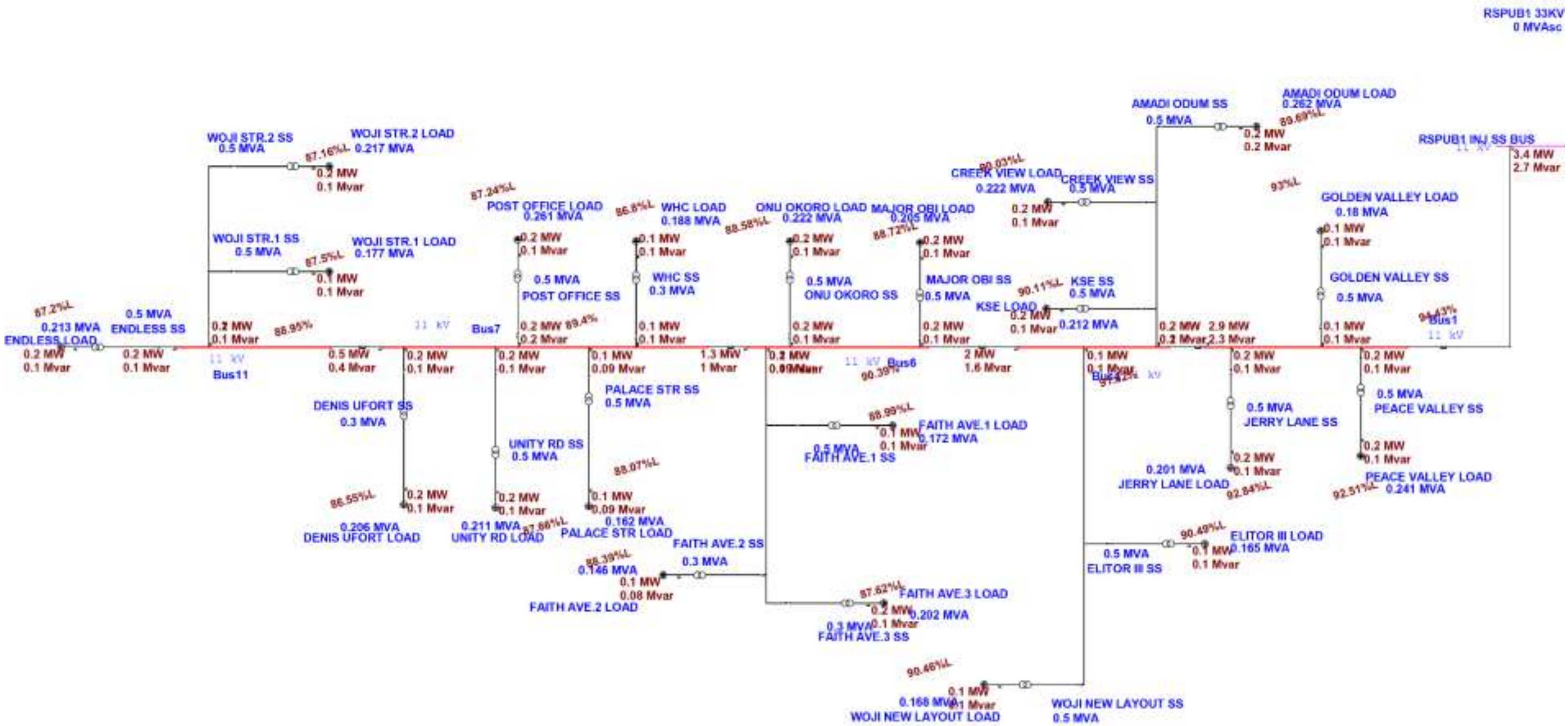

Figure 4.4a ETAP 12.6.0 Load flow result screen after metering on Ogbatai11kv distribution network

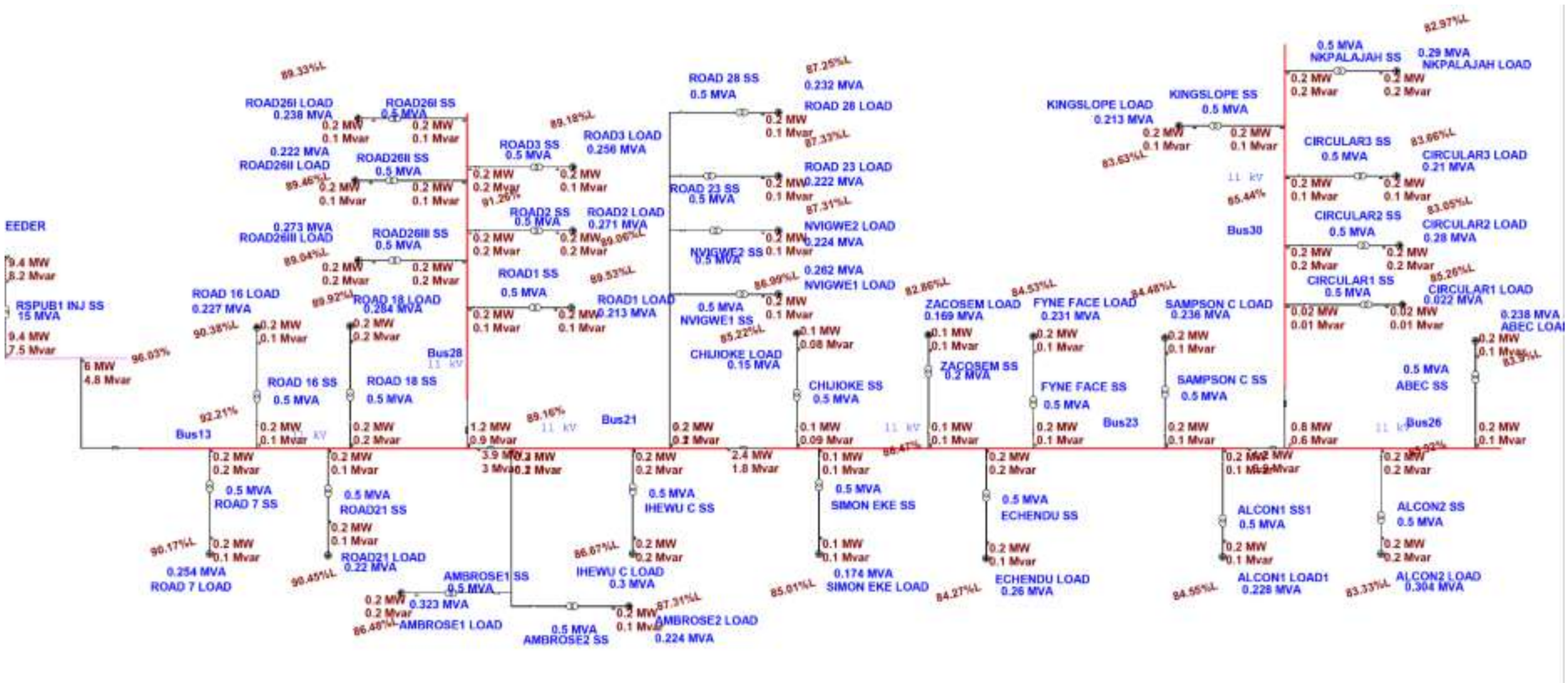

Figure 4.4b ETAP 12.6.0 Load flow result screen after metering on Nvigwe11kv distribution network

The load flow analysis carried out on the data derived from the feeders after the metering period yielded voltage magnitudes of 96.03%, 92.21 % and 94.43 % on the injection substation bus bar, Nvige and Ogbatai 11kv feeder network respectively. The voltage drops and power losses along the Ogbatai and Nvigwe distribution network are further detailed in table 4.3a and 4.3b.

Table 4.3a Simulation results for data gotten After the Metering project on Nvigwe 11 kv distribution network

SNO	SUBSTATION NAME	Rating (MVA)	MW Flow	Mvar Flow	% Loading	% Voltage Drop	kW Losses	kvar Losses	STATUS
1	ABEC SS	0.5	0.182	0.139	45.9	2.02	3.164	4.746	OK
2	ALCON1 SS1	0.5	0.175	0.133	44	1.92	2.871	4.307	OK
3	ALCON2 SS	0.5	0.234	0.179	58.9	2.59	5.216	7.824	OK
4	AMBROSE1 SS	0.5	0.251	0.192	63.2	2.68	5.581	8.371	OK
5	AMBROSE2 SS	0.5	0.174	0.132	43.6	1.85	2.656	3.984	OK
6	CHIJIOKE SS	0.5	0.114	0.087	28.7	1.25	1.224	1.836	OK
7	CIRCULAR1 SS	0.5	0.016	0.012	4.1	0.18	0.026	0.039	OK
8	CIRCULAR2 SS	0.5	0.215	0.164	54.1	2.39	4.441	6.661	OK
9	CIRCULAR3 SS	0.5	0.16	0.122	40.3	1.78	2.468	3.702	OK
10	ECHENDU SS	0.5	0.2	0.153	50.3	2.2	3.761	5.641	OK
11	FYNE FACE SS	0.5	0.177	0.135	44.6	1.95	2.953	4.429	OK
12	IHEWU C SS	0.5	0.233	0.178	58.6	2.48	4.792	7.188	OK
13	NKPALAJAH SS	0.5	0.222	0.17	56	2.48	4.773	7.159	OK
14	NVIGWE1 SS	0.5	0.203	0.155	51.2	2.17	3.653	5.48	OK
15	NVIGWE2 SS	0.5	0.174	0.132	43.6	1.85	2.656	3.984	OK
16	ROAD1 SS	0.5	0.166	0.126	41.8	1.73	2.327	3.49	OK
17	ROAD2 SS	0.5	0.211	0.161	53.2	2.2	3.77	5.655	OK
18	ROAD3 SS	0.5	0.2	0.152	50.2	2.08	3.355	5.032	OK
19	ROAD 7 SS	0.5	0.199	0.152	50	2.05	3.262	4.893	OK
20	ROAD 16 SS	0.5	0.178	0.135	44.7	1.83	2.606	3.909	OK
21	ROAD 18 SS	0.5	0.223	0.17	56	2.29	4.092	6.138	OK
22	ROAD21 SS	0.5	0.172	0.131	43.2	1.77	2.432	3.648	OK
23	ROAD 23 SS	0.5	0.172	0.131	43.2	1.83	2.605	3.907	OK
24	ROAD26I SS	0.5	0.186	0.141	46.7	1.93	2.904	4.356	OK
25	ROAD26II SS	0.5	0.173	0.131	43.4	1.8	2.51	3.765	OK
26	ROAD26III SS	0.5	0.213	0.163	53.6	2.22	3.831	5.747	OK
27	ROAD 28 SS	0.5	0.179	0.137	45.1	1.91	2.837	4.256	OK
28	KINGSLOPE SS	0.5	0.163	0.124	41	1.81	2.554	3.832	OK
29	SAMPSON C SS	0.5	0.181	0.138	45.5	1.99	3.077	4.616	OK
30	SIMON EKE SS	0.5	0.133	0.101	33.4	1.46	1.658	2.486	OK

SNO	SUBSTATION NAME	Rating (MVA)	MW Flow	Mvar Flow	% Loading	% Voltage Drop	kW Losses	kvar Losses	STATUS
31	ZACOSEM SS	0.2	0.131	0.101	82.7	3.62	4.058	6.087	OVER LOADED
		15.2	**5.61**	**4.277**	**0**	**62.31**	**98.113**	**147.168**	

Table 4.3b Simulation results for data gotten After the Metering project on Ogbatai 11 kv distribution network

SNO	SUBSTATION NAME	Rating (MVA)	MW Flow	Mvar Flow	% Loading	% Voltage Drop	kW Losses	kvar Losses	STATUS
1	AMADI ODUM SS	0.5	0.205	0.156	51.6	2.12	3.5	5.25	OK
2	CREEK VIEW SS	0.5	0.173	0.132	43.5	1.79	2.495	3.743	OK
3	DENIS UFORT SS	0.5	0.16	0.123	67.2	2.84	3.764	5.646	OK
4	ELITOR III SS	0.5	0.128	0.097	32.2	1.32	1.364	2.046	OK
5	ENDLESS SS	0.5	0.164	0.125	41.3	1.75	2.395	3.592	OK
6	FAITH AVE.1 SS	0.5	0.133	0.101	33.4	1.4	1.515	2.273	OK
7	FAITH AVE.2 SS	0.3	0.114	0.087	47.7	1.99	1.856	2.784	OK
8	FAITH AVE.3 SS	0.3	0.158	0.121	66.2	2.77	3.574	5.36	OK
9	GOLDEN VALLEY SS	0.5	0.142	0.108	35.6	1.42	1.577	2.366	OK
10	JERRY LANE SS	0.5	0.158	0.12	39.7	1.59	1.962	2.943	OK
11	KSE SS	0.5	0.165	0.126	41.5	1.71	2.265	3.398	OK
12	MAJOR OBI SS	0.5	0.159	0.121	40	1.67	2.173	3.26	OK
13	ONU OKORO SS	0.5	0.172	0.131	43.3	1.81	2.55	3.825	OK
14	PALACE STR SS	0.5	0.125	0.095	31.4	1.32	1.365	2.048	OK
15	PEACE VALLEY SS	0.5	0.19	0.145	47.8	1.91	2.847	4.271	OK
16	POST OFFICE SS	0.5	0.202	0.154	50.9	2.15	3.599	5.399	OK
17	UNITY RD SS	0.5	0.163	0.124	41.1	1.73	2.341	3.511	OK
18	WHC SS	0.3	0.146	0.112	61.5	2.6	3.147	4.72	OK
19	WOJI NEW LAYOUT SS	0.5	0.131	0.099	32.9	1.35	1.425	2.137	OK
20	WOJI STR.1 SS	0.5	0.137	0.104	34.3	1.46	1.65	2.476	OK
21	WOJI STR.2 SS	0.5	0.168	0.128	42.2	1.79	2.494	3.741	OK
		27.8	**9.903**	**7.55**	**0**	**113.81**	**165.986**	**248.981**	

After the metering process, the Nvigwe distribution Network has 1 number over loaded substation, no partially overloaded substation and 30 number proficiently loaded substations. A voltage drop of 62.31 % is noticed along the feeder, with a maximum and minimum drop on the distribution substation transformers at 3.62 % and 0.18% respectively. The total power losses incurred was 98.1 kW and 147.2 KVR.

Whereas the simulation of the Ogbatai 11kv Network after the metering process indicated that there was substation overloaded, and all distribution substations had reduced loadings, hence the network is well loaded. A total voltage drop of 38.5 % is achieved across the distribution substations on the feeder, which is still less than the Nvigwe section, and peaks at 2.86% on Denis Ufort 500kva 11/0.415 substation and least on Eliator III with a value of 1.32 %. The total power loss value is 49.9 kW and 7.48 kvr.

The report indicated that the injection substation 1 x 15MVA 33/11kv transformer is mildly overloaded with a loading value of 80.1% and within the rated capacity, and a voltage drop of 3.97 % and reduced losses value of 39.2 kW + j 729 kvr. Further details of the information generated during the simulation is affixed in the appendix.

4.5 Result Comparism

All simulation results on load flow across each network, voltage drop and power loss is shown in table 4.4, 4.5 and 4.6 respectively producing a broader view of the entire simulation segments and timeline. The tables give an overview of the change in the overall performance and efficiency of the study system from 2016 to 2018, which is the time it took to complete the customer metering of both feeders. These values indicate a massive increment in the voltage magnitude noted along the bus bars as compared to the results achieved when the feeders were unmetered. Also, a reduction in the voltage dropped along the 11kv distribution network and the extent of power loss from stage to stage on the network. Hence it was deducted that the load reduction on the feeders actually improved the efficiency and performance of the feeders, taking the Nvigwe feeder in particular which now has a higher performance due to the large reduction in load on the line.

For further analysis, the tables are illustrated as charts in figure 4.5, 4.6 and 4.7.

4.5.1 Transformer Loading in Percentage

The distribution substation recorded from the simulation is detailed in table 4.4a and 4.4b for Nvigwe and Ogbatai 11kv networks.

4.5.1.1 Nvigwe 11 KV Distribution Network Substation Loading

The 31 number individual distribution substation transformers on the Nvigwe feeder network active power and percentage loading

Table 4.4 a Showing the Distribution substation loadings and ratings on Nvigwe 11 kv network

				LOAD (A)			ACTIVE POWER (KVA)			% LOADING		
S/N	DISTRIBUTION SUBSTATION	CAPACITY (KVA)	RATING (KV)	BEFORE	DURING	AFTER	BEFORE	DURING	AFTER	BEFORE	DURING	AFTER
1	ECHENDU	500	11/0.415	598.0	473.0	362.3	429.8	340.0	260.4	85.97%	68.00%	52.09%
2	ALCON I	500	11/0.415	647.0	603.0	317.3	465.1	433.4	228.1	93.01%	86.69%	45.62%
3	ALCON II	500	11/0.415	635.0	576.0	423.3	456.4	414.0	304.3	91.29%	82.81%	60.86%
4	CIRCULAR ROAD I	500	11/0.415	584.0	492.0	302.3	419.8	353.7	217.3	83.96%	70.73%	43.46%
5	CIRCULAR ROAD II	500	11/0.415	612.0	489.0	389.7	439.9	351.5	280.1	87.98%	70.30%	56.02%
6	CIRCULAR ROAD III	500	11/0.415	624.0	508.0	292.0	448.5	365.2	209.9	89.71%	73.03%	41.98%
7	FYNEFACE	500	11/0.415	576.0	447.0	321.7	414.0	321.3	231.2	82.81%	64.26%	46.24%
8	SAMPSON CHUKWU	500	11/0.415	568.0	429.0	328.3	408.3	308.4	236.0	81.66%	61.67%	47.20%
9	KINGSLOPE	500	11/0.415	542.0	461.0	297.0	389.6	331.4	213.5	77.92%	66.27%	42.70%
10	ZACOZEN	200	11/0.415	269.7	249.1	235.2	193.8	179.1	169.1	96.92%	89.53%	84.54%
11	NVIGWE I	500	11/0.415	667.0	572.0	365.0	479.4	411.2	262.4	95.89%	82.23%	52.47%

S/N	DISTRIBUTION SUBSTATION	CAPACITY (KVA)	RATING (KV)	LOAD (A) BEFORE	LOAD (A) DURING	LOAD (A) AFTER	ACTIVE POWER (KVA) BEFORE	ACTIVE POWER (KVA) DURING	ACTIVE POWER (KVA) AFTER	% LOADING BEFORE	% LOADING DURING	% LOADING AFTER
12	NVIGWE II	500	11/0.415	638.0	508.0	312.0	458.6	365.2	224.3	91.72%	73.03%	44.85%
13	SIMON EKE	500	11/0.415	538.0	482.0	242.0	386.7	346.5	173.9	77.34%	69.29%	34.79%
14	IHEWU CHINWU	500	11/0.415	529.0	456.0	417.0	380.2	327.8	299.7	76.05%	65.55%	59.95%
15	CHIJIOKE	500	11/0.415	519.0	401.0	208.3	373.1	288.2	149.8	74.61%	57.65%	29.95%
16	AMBROSE I	500	11/0.415	562.0	421.0	449.3	404.0	302.6	323.0	80.79%	60.52%	64.60%
17	AMBROSE II	500	11/0.415	478.0	328.0	312.0	343.6	235.8	224.3	68.72%	47.15%	44.85%
18	ABEC	500	11/0.415	643.0	525.0	331.3	462.2	377.4	238.2	92.44%	75.47%	47.63%
19	ROAD 26 I	500	11/0.415	548.0	476.0	331.3	393.9	342.1	238.2	78.78%	68.43%	47.63%
20	ROAD 26 II	500	11/0.415	523.0	462.0	308.3	375.9	332.1	221.6	75.19%	66.42%	44.33%
21	ROAD 26 III	500	11/0.415	581.0	503.0	279.7	417.6	361.6	201.0	83.52%	72.31%	40.20%
22	ROAD 21	500	11/0.415	595.0	516.0	305.7	427.7	370.9	219.7	85.54%	74.18%	43.94%
23	NPALLAJA	500	11/0.415	509.0	431.0	403.7	365.9	309.8	290.2	73.17%	61.96%	58.03%
24	ROAD 23	500	11/0.415	472.0	419.0	309.0	339.3	301.2	222.1	67.85%	60.24%	44.42%
25	ROAD 1	500	11/0.415	546.0	482.0	297.0	392.5	346.5	213.5	78.49%	69.29%	42.70%
26	ROAD 18	500	11/0.415	527.0	445.0	395.0	378.8	319.9	283.9	75.76%	63.97%	56.79%
27	ROAD 16	500	11/0.415	446.0	398.0	316.3	320.6	286.1	227.4	64.12%	57.22%	45.48%
28	ROAD 28	500	11/0.415	484.0	409.0	322.3	347.9	294.0	231.7	69.58%	58.80%	46.34%
29	ROAD 7	500	11/0.415	507.0	415.0	353.3	364.4	298.3	254.0	72.89%	59.66%	50.80%
30	ROAD 2	500	11/0.415	584.0	457.0	376.7	419.8	328.5	270.7	83.96%	65.70%	54.15%
31	ROAD 3	500	11/0.415	572.0	483.0	355.7	411.2	347.2	255.7	82.23%	69.44%	51.13%
				17,123.7	**14,316.1**	**10,260.2**	**12,308.5**	**10,290.4**	**7,375.1**			

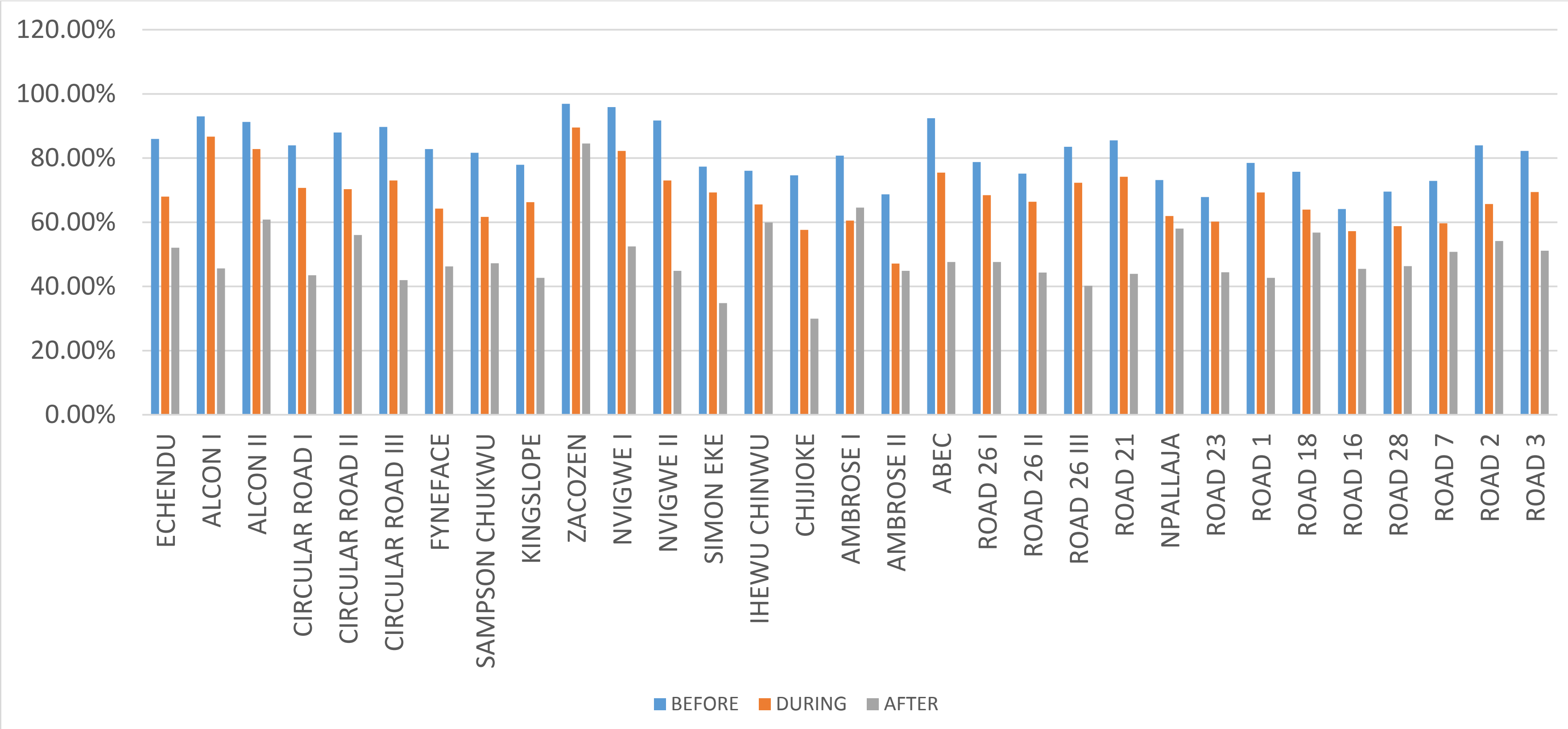

Figure 4.5 a Distribution substations % loading on Nvigwe 11 kv feeder

Figure 4.5a shows that there is a higher substation percentage loading before the metering process began as compared to after the metering was completed, with about 12 substations initially overloaded and just 1 left still overloaded after the program. This is due to the drop-in power consumption brought about by the awareness of customers being in charge of their energy utilization.

4.5.1.2 Voltage Drop along Ogbatai 11 KV Distribution Network

The drop in voltage by the DTrs on the Ogbatain 11 kv network across the years is displayed in table 4.4b, and further illustrated in figure 4.5b.

Table 4.4 b Showing the Distribution substation ratings and loadings on Ogbatai11 kv network

S/N				LOAD			ACTIVE POWER (KVA)			% LOADING		
	DISTRIBUTION SUBSTATION	CAPACITY (KVA)	RATING (KV)	BEFORE	DURING	AFTER	BEFORE	DURING	AFTER	BEFORE	DURING	AFTER
1	WOJI HEALTH CENTER	300	11/0.415	398.0	292.0	262.7	286.1	209.9	188.8	95.36%	69.96%	62.94%
2	PEACE VALLEY	500	11/0.415	527.0	439.0	335.7	378.8	315.6	241.3	75.76%	63.11%	48.26%
3	ONU OKORO	500	11/0.415	640.0	610.0	308.7	460.0	438.5	221.9	92.01%	87.69%	44.37%
4	GOLDEN VALLEY	500	11/0.415	503.0	462.0	250.7	361.6	332.1	180.2	72.31%	66.42%	36.04%
5	KING SOLOMON ESTATE	500	11/0.415	472.0	416.0	294.3	339.3	299.0	211.6	67.85%	59.80%	42.31%
6	UNITY ROAD	500	11/0.415	565.0	417.7	293.7	406.1	300.2	211.1	81.22%	60.04%	42.22%
7	POST OFFICE	500	11/0.415	470.0	411.0	363.0	337.8	295.4	260.9	67.57%	59.09%	52.18%
8	DENISE UFOT	300	11/0.415	376.0	298.0	286.0	270.3	214.2	205.6	90.09%	71.40%	68.53%
9	MAJOR OBI	500	11/0.415	638.0	513.0	285.3	458.6	368.7	205.1	91.72%	73.75%	41.02%
10	FAITH AVENUE I	500	11/0.415	411.0	363.0	238.7	295.4	260.9	171.6	59.09%	52.18%	34.31%
11	FAITH AVENUE II	300	11/0.415	398.0	299.0	203.7	286.1	214.9	146.4	95.36%	71.64%	48.80%

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12	FAITH AVENUE III	300	11/0.415	412.8	390.1	281.0	296.7	280.4	202.0	98.91%	93.47%	67.33%
13	CREEK VIEW	500	11/0.415	565.0	489.0	308.7	406.1	351.5	221.9	81.22%	70.30%	44.38%
14	WOJI NEW LAYOUT	500	11/0.415	401.0	314.0	234.0	288.2	225.7	168.2	57.65%	45.14%	33.64%
15	ELITOR III	500	11/0.415	498.0	409.0	229.0	358.0	294.0	164.6	71.59%	58.80%	32.92%
16	ENDLESS	500	11/0.415	586.0	427.0	296.0	421.2	306.9	212.8	84.24%	61.39%	42.55%
17	JERRY LANE	500	11/0.415	463.0	391.0	279.3	332.8	281.1	200.8	66.56%	56.21%	40.16%
18	WOJI STREET I	500	11/0.415	363.0	315.0	246.3	260.9	226.4	177.1	52.18%	45.28%	35.41%
19	WOJI STREET II	500	11/0.415	347.0	337.7	302.0	249.4	242.7	217.1	49.88%	48.54%	43.42%
20	AMADI ODUM	500	11/0.415	663.0	498.0	364.7	476.6	358.0	262.1	95.31%	71.59%	52.42%
21	PALACE STREET	500	11/0.415	306.0	257.0	225.0	220.0	184.7	161.7	43.99%	36.95%	32.35%
				10,002.8	**8,348.4**	**5,888.4**	**7,190.0**	**6,000.9**	**4,232.6**			

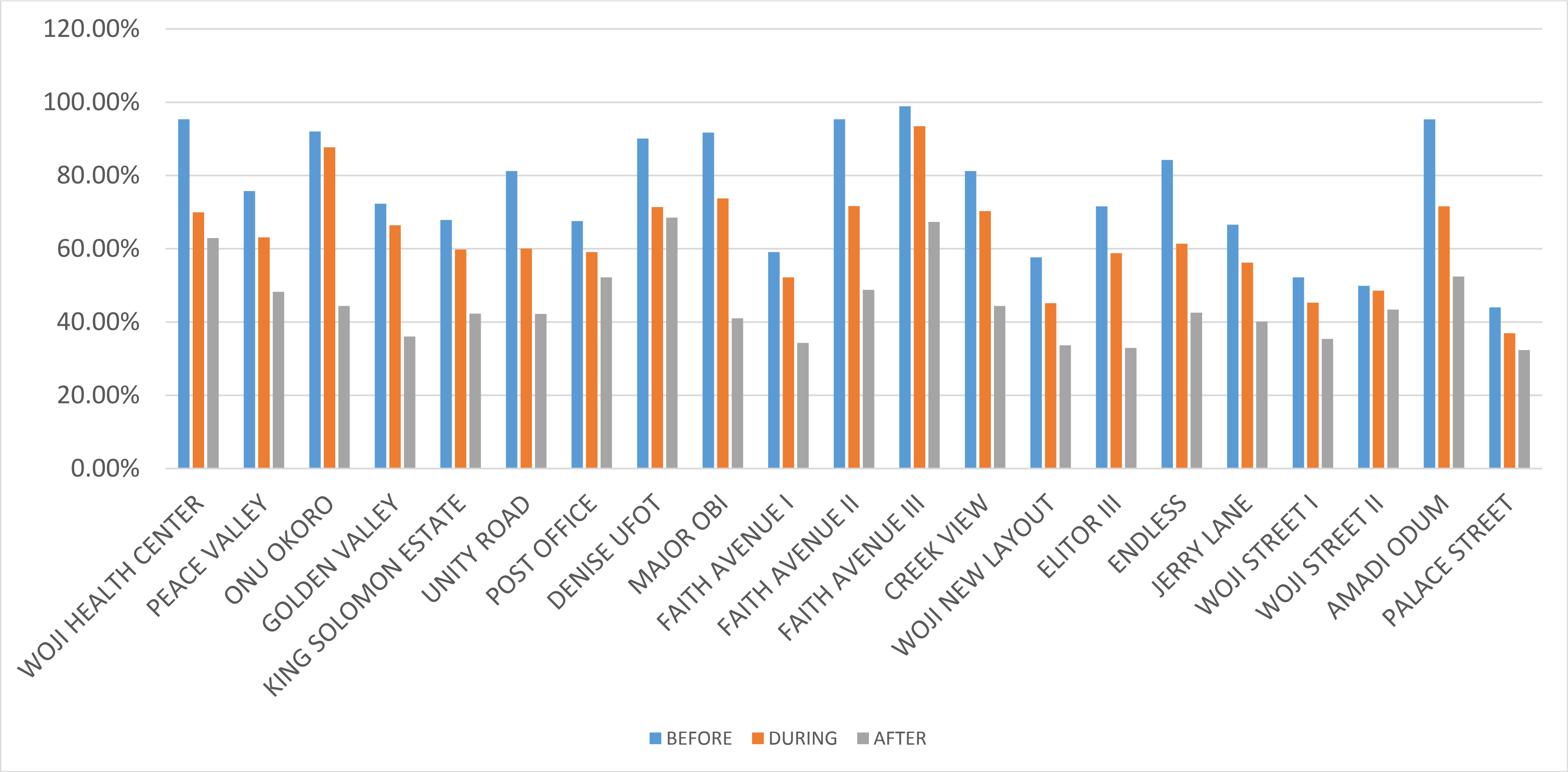

Figure 4.5b Distribution substations % loading on Obgatai 11 kv feeder

4.5.2 Voltage Drop Across the Network

The voltage dropped across the individual substations is tabulated and illustrated for both sections of the study network.

4.5.2.1 Voltage Drop Along Nvigwe 11 KV Distribution Network

Taking the distribution substations connected to the Nvigwe feeder into consideration, the result of the simulated information over the past three (3) years is tabulated in 4.5a.

Table 4.5a Voltage drop on the distribution substations on Nvigwe 11kv feeder

SNO	SUBSTATION NAME	Rating (MVA)	BEFORE	DURING	AFTER
1	ABEC SS	0.5	4.66	3.49	2.02
2	ALCON1 SS1	0.5	4.46	3.86	1.92
3	ALCON2 SS	0.5	4.44	3.71	2.59
4	AMBROSE1 SS	0.5	3.72	2.63	2.68
5	AMBROSE2 SS	0.5	3.15	2.04	1.85
6	CHIJIOKE SS	0.5	3.66	2.62	1.25
7	CIRCULAR1 SS	0.5	4.27	3.3	0.18
8	CIRCULAR2 SS	0.5	4.49	3.28	2.39
9	CIRCULAR3 SS	0.5	4.59	3.41	1.78
10	ECHENDU SS	0.5	4.1	3	2.2
11	FYNE FACE SS	0.5	4.09	2.93	1.95
12	IHEWU C SS	0.5	3.37	2.76	2.48
13	NKPALAJAH SS	0.5	3.7	2.87	2.48
14	NVIGWE1 SS	0.5	4.45	3.61	2.17
15	NVIGWE2 SS	0.5	4.25	3.2	1.85
16	ROAD1 SS	0.5	3.45	2.94	1.73
17	ROAD2 SS	0.5	3.7	2.78	2.2
18	ROAD3 SS	0.5	3.62	2.94	2.08
19	ROAD 7 SS	0.5	3.04	2.4	2.05
20	ROAD 16 SS	0.5	2.76	2.39	1.83
21	ROAD 18 SS	0.5	3.28	2.67	2.29
22	ROAD21 SS	0.5	3.59	3.01	1.77
23	ROAD 23 SS	0.5	3.11	2.62	1.83
24	ROAD26I SS	0.5	3.47	2.9	1.93
25	ROAD26II SS	0.5	3.3	2.81	1.8
26	ROAD26III SS	0.5	3.68	3.07	2.22
27	ROAD 28 SS	0.5	3.19	2.56	1.91
28	KINGSLOPE SS	0.5	3.95	3.08	1.81
29	SAMPSON C SS	0.5	4.03	2.81	1.99
30	SIMON EKE SS	0.5	3.67	3.05	1.46
31	ZACOSEM SS	0.2	4.83	4.13	3.62
			118.1	92.9	62.3

The Table 4.5a is shown in figure 4.6a as a chart for detailed analysis

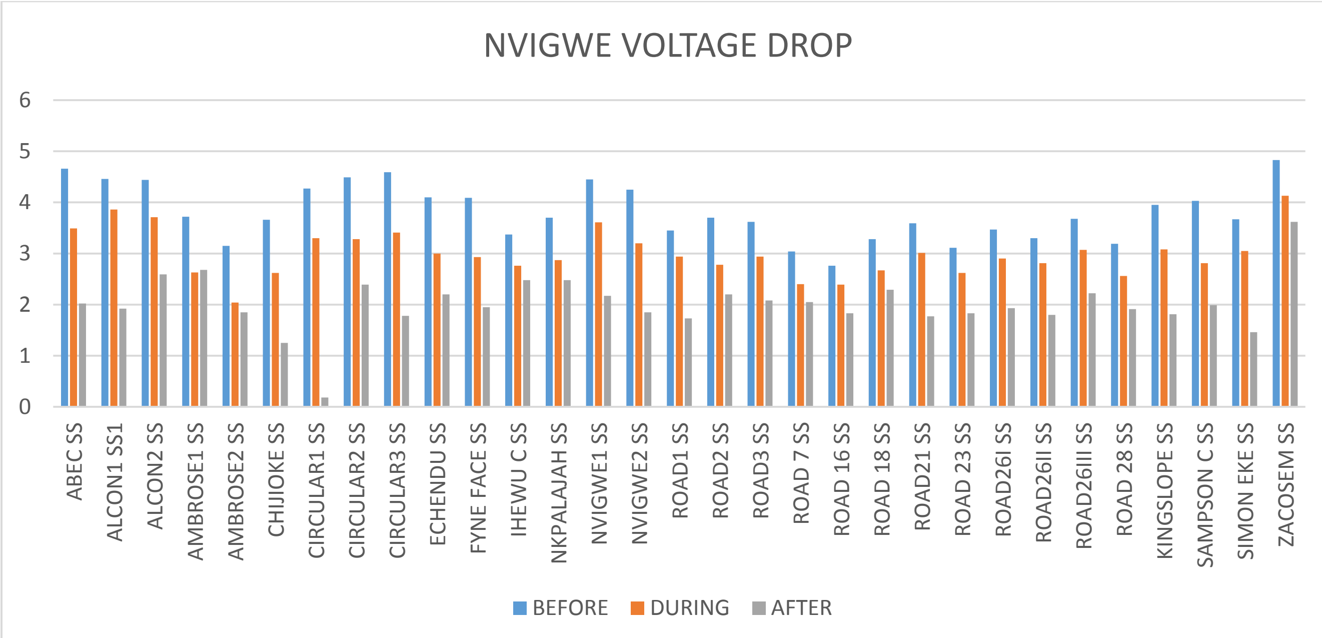

Figure 4.6a Voltage drop across the Nvigwe 11kv distribution network (in percentage)

Voltage drop is a function of a conductor's size, route length and load carried, as it is measured per km and increases with distance it covers and the magnitude of current it conveys. This was seen in the load flow analysis results illustrated by the chart tagged figure 4.6. Both feeders utilizing same 150mm^2 Aluminum conductor have varying voltage drops, Nvigwe 11kv line possesses the longest route length (10km) and the heaviest load, which indicates the highest voltage drop of 4.83% on Zacosem 200KVA 11/0.415 kv substation before the metering process began, which further reduced to a value of 3.62% of the nominal bus voltage after the process, while ABEC 500KVA 11/0.415 kv substation also had a 2.64% reduction in voltage drop due to the decrease in load over the years. Nvigwe being the feeder with the most reduced feeder load was able to decline from a total of 118.1% to 62.3%, giving a 55.8% fall in the voltage drop felt across its substations.

4.5.2.2 Voltage Drop Along Ogbatai 11 KV Distribution Network

The distribution substation network connected to the Ogbatai 11 kv network also experiences voltage drops, which are expressed in table 4.5b and displayed in figure 4.6b

Table 4.5b Voltage drop on the distribution substations on Ogbatai 11kv feeder

SNO	SUBSTATION NAME	Rating (MVA)	BEFORE	DURING	AFTER
1	AMADI ODUM SS	0.5	4.17	3.01	2.12
2	CREEK VIEW SS	0.5	3.53	2.96	1.79
3	DENIS UFORT SS	0.5	4.1	3.09	2.84
4	ELITOR III SS	0.5	3.1	2.46	1.32
5	ENDLESS SS	0.5	3.85	2.66	1.75
6	FAITH AVE.1 SS	0.5	2.61	2.22	1.4
7	FAITH AVE.2 SS	0.3	4.28	3.07	1.99
8	FAITH AVE.3 SS	0.3	4.45	4.04	2.77
9	GOLDEN VALLEY SS	0.5	2.9	2.61	1.42
10	JERRY LANE SS	0.5	2.76	2.28	1.59
11	KSE SS	0.5	2.94	2.5	1.71
12	MAJOR OBI SS	0.5	3.97	3.05	1.67
13	ONU OKORO SS	0.5	3.98	3.65	1.81
14	PALACE STR SS	0.5	1.96	1.58	1.32
15	PEACE VALLEY SS	0.5	3.15	2.57	1.91
16	POST OFFICE SS	0.5	2.93	2.46	2.15
17	UNITY RD SS	0.5	3.68	2.59	1.73
18	WHC SS	0.3	4.2	2.92	2.6
19	WOJI NEW LAYOUT SS	0.5	2.48	1.88	1.35
20	WOJI STR.1 SS	0.5	2.35	1.95	1.46
21	WOJI STR.2 SS	0.5	2.24	2.09	1.79
			69.6	**55.6**	**38.5**

The Table 4.5b is illustrated in figure 4.6b for easier analysis.

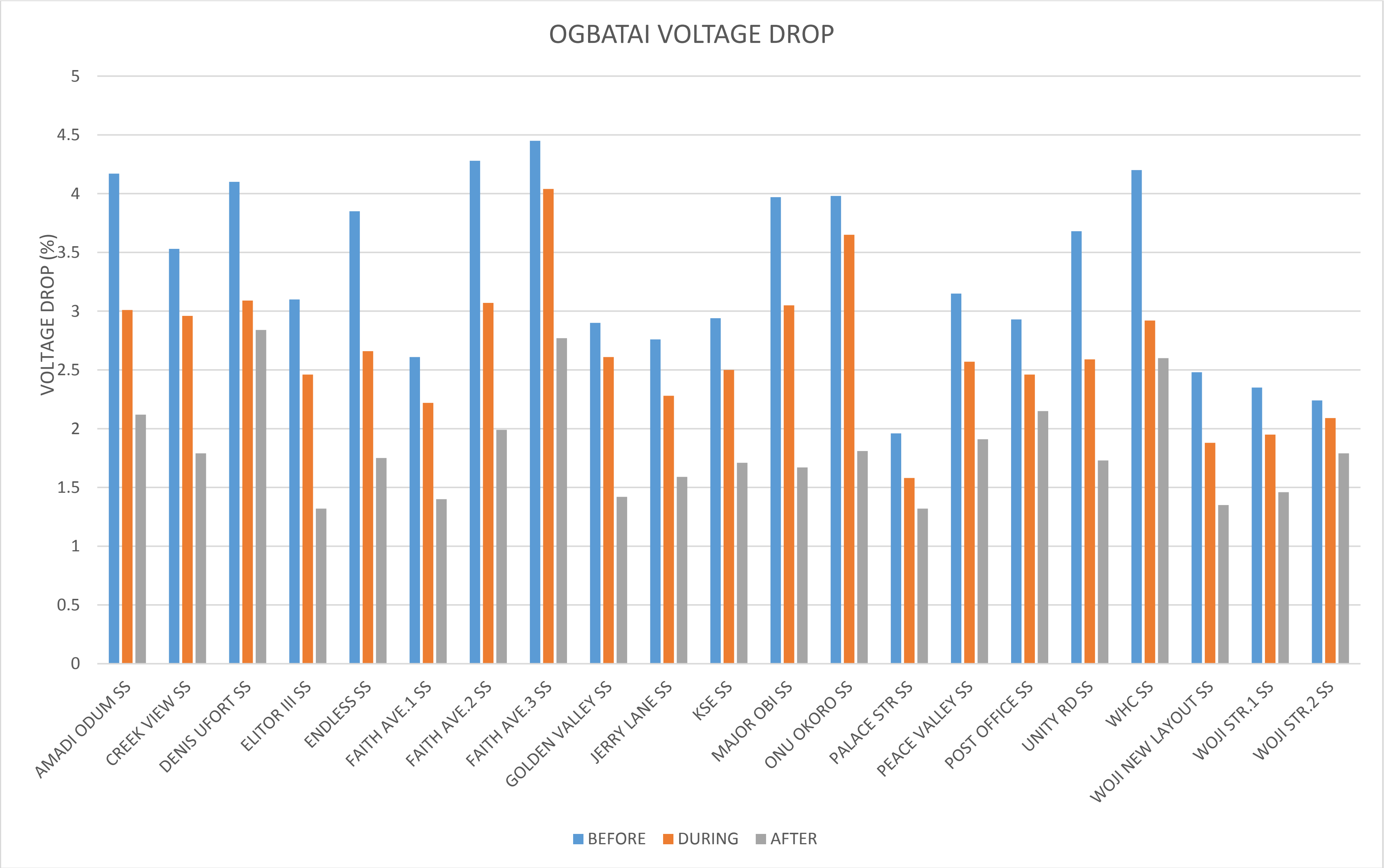

Figure 4.6b Voltage drop on the Ogbatai 11kv distribution network (in percentage)

The Ogbatai 11kv line with a route length of 8.65 km had a total voltage drop on its entire individual substation decrease from 69.63 % to 38.49 % of the nominal bus voltage. Figure 4.6b indicates that after metering the Ogbatai 11 kv feeder, Faith avenue 3 Substation which had largest voltage drop changed from 4.45% to 4.04 % and finally to 2.77% before, during and after metering the feeder. There were major improvements in the distribution network performance; which is seen as the rise in the amount of voltage intercepted along each bus as the feeder loading was reduced, which is due to the effect of energy management by newly metered customers on these feeders.

4.5.3 Power Loss across the Distribution Network

The individual substations tend to lose power as the load flows through the network, hence the simulated values for both the real and imaginary power are recorded for both sections of the network.

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4.5.3.1 Power Loss across the Nvigwe 11KV Distribution Network

Table 4.6a Power Losses on the Nvigwe 11KV feeder substations

			BEFORE		DURING		AFTER	
SNO	SUBSTATION NAME	Rating (MVA)	kW Losses	kvar Losses	kW Losses	kvar Losses	kW Losses	kvar Losses
1	ABEC SS	0.5	16.832	25.248	9.466	14.199	3.164	4.746
2	ALCON1 SS1	0.5	16.459	24.688	12.333	18.5	2.871	4.307
3	ALCON2 SS	0.5	16.329	24.494	11.445	17.168	5.216	7.824
4	AMBROSE1 SS	0.5	10.747	16.121	5.39	8.084	5.581	8.371
5	AMBROSE2 SS	0.5	7.685	11.528	3.237	4.856	2.656	3.984
6	CHIJIOKE SS	0.5	10.398	15.597	5.322	7.983	1.224	1.836
7	CIRCULAR1 SS	0.5	14.143	21.214	8.429	12.643	0.026	0.039
8	CIRCULAR2 SS	0.5	15.614	23.421	8.323	12.484	4.441	6.661
9	CIRCULAR3 SS	0.5	16.27	24.405	9.007	13.51	2.468	3.702
10	ECHENDU SS	0.5	13.945	20.917	7.46	11.19	3.761	5.641
11	FYNE FACE SS	0.5	12.933	19.399	6.653	9.98	2.953	4.429
12	IHEWU C SS	0.5	9.456	14.183	6.337	9.506	4.792	7.188
13	NKPALAJAH SS	0.5	10.594	15.892	6.413	9.619	4.773	7.159
14	NVIGWE1 SS	0.5	15.364	23.047	10.126	15.189	3.653	5.48
15	NVIGWE2 SS	0.5	13.999	20.999	7.927	11.89	2.656	3.984
16	ROAD1 SS	0.5	9.252	13.878	6.7	10.049	2.327	3.49
17	ROAD2 SS	0.5	10.633	15.95	6.007	9.01	3.77	5.655
18	ROAD3 SS	0.5	10.186	15.279	6.728	10.092	3.355	5.032
19	ROAD 7 SS	0.5	7.682	11.524	4.812	7.218	3.262	4.893
20	ROAD 16 SS	0.5	5.916	8.874	4.425	6.637	2.606	3.909
21	ROAD 18 SS	0.5	8.335	12.503	5.557	8.336	4.092	6.138
22	ROAD21 SS	0.5	10.683	16.024	7.512	11.268	2.432	3.648
23	ROAD 23 SS	0.5	7.488	11.231	5.337	8.006	2.605	3.907
24	ROAD26I SS	0.5	9.322	13.983	6.53	9.795	2.904	4.356
25	ROAD26II SS	0.5	8.466	12.699	6.142	9.213	2.51	3.765
26	ROAD26III SS	0.5	10.52	15.781	7.312	10.968	3.831	5.747
27	ROAD 28 SS	0.5	7.886	11.829	5.08	7.62	2.837	4.256
28	KINGSLOPE SS	0.5	12.086	18.129	7.368	11.051	2.554	3.832

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SNO	SUBSTATION NAME	Rating (MVA)	BEFORE kW Losses	BEFORE kvar Losses	DURING kW Losses	DURING kvar Losses	AFTER kW Losses	AFTER kvar Losses
29	SAMPSON C SS	0.5	12.559	18.838	6.114	9.171	3.077	4.616
30	SIMON EKE SS	0.5	11.176	16.763	7.756	11.633	1.658	2.486
31	ZACOSEM SS	0.2	7.211	10.817	5.291	7.937	4.058	6.087
			350.2	**525.3**	**216.5**	**324.8**	**98.1**	**147.2**

A graphical illustration of the power loss across the network is shown in figure 4.7a

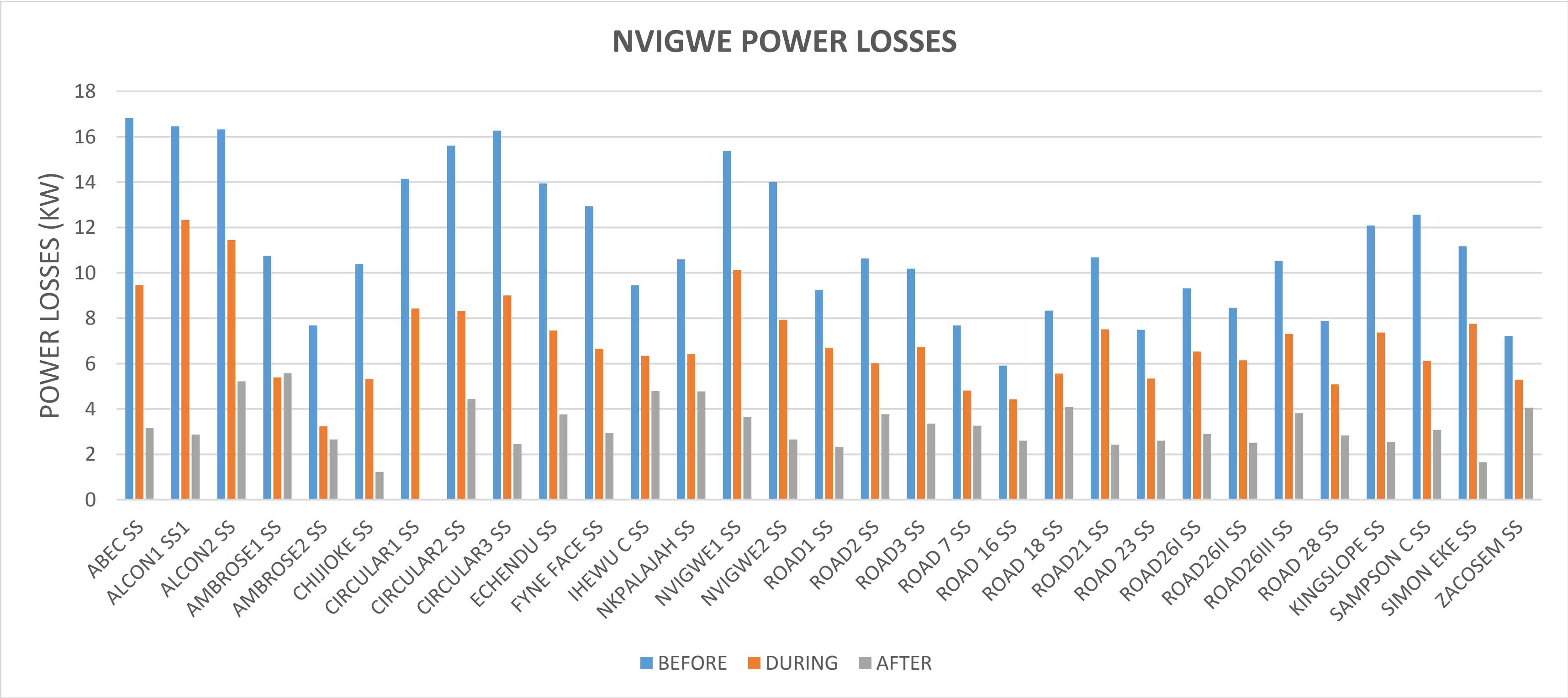

Figure 4.7a Power Loss across the Nvigwe 11kv feeder substations

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The power loss report displayed in figure 4.7a, shows a drastic reduction in the KW power losses with some substations like ABEC 500kva 11/0.415kv drooping by 13.64 kw, which is about an 81.2% change, while Circular I 500kva 11/0.415 kv substation had loss value as low as 0.026 kw from its initial 14.1 kw. The network showed a tremendous improvement in the in the aspect of power losses, from a total of 350.2 kw to 98.1 kw.

4.5.3.2 Power Loss Across the Ogbatai 11KV Distribution Network

Table 4.6b Power Losses on the Ogbatai11kv Feeder Substations

			BEFORE		DURING		AFTER	
SNO	SUBSTATION NAME	Rating (MVA)	kW Losses	kvar Losses	kW Losses	kvar Losses	kW Losses	kvar Losses
1	AMADI ODUM SS	0.5	13.491	20.237	7.043	10.564	3.5	5.25
2	CREEK VIEW SS	0.5	9.686	14.53	6.784	10.177	2.495	3.743
3	DENIS UFORT SS	0.5	7.812	11.717	4.45	6.675	3.764	5.646
4	ELITOR III SS	0.5	7.468	11.202	4.708	7.062	1.364	2.046
5	ENDLESS SS	0.5	11.497	17.245	5.497	8.246	2.395	3.592
6	FAITH AVE.1 SS	0.5	5.279	7.918	3.82	5.73	1.515	2.273
7	FAITH AVE.2 SS	0.3	8.512	12.768	4.382	6.573	1.856	2.784
8	FAITH AVE.3 SS	0.3	9.186	13.779	7.585	11.378	3.574	5.36
9	GOLDEN VALLEY SS	0.5	7.007	10.51	5.673	8.51	1.577	2.366
10	JERRY LANE SS	0.5	5.923	8.885	4.043	6.065	1.962	2.943
11	KSE SS	0.5	6.689	10.033	4.874	7.311	2.265	3.398
12	MAJOR OBI SS	0.5	13.046	19.569	7.737	11.606	2.173	3.26
13	ONU OKORO SS	0.5	13.131	19.697	11.053	16.58	2.55	3.825
14	PALACE STR SS	0.5	2.979	4.469	1.934	2.902	1.365	2.048
15	PEACE VALLEY SS	0.5	7.722	11.583	5.119	7.679	2.847	4.271
16	POST OFFICE SS	0.5	7.16	10.74	5.023	7.534	3.599	5.399
17	UNITY RD SS	0.5	10.497	15.745	5.2	7.799	2.341	3.511
18	WHC SS	0.3	8.77	13.155	4.26	6.39	3.147	4.72
19	WOJI NEW LAYOUT SS	0.5	4.79	7.185	2.749	4.124	1.425	2.137
20	WOJI STR.1 SS	0.5	4.284	6.426	2.955	4.432	1.65	2.476
21	WOJI STR.2 SS	0.5	3.907	5.86	3.404	5.107	2.494	3.741

SNO	SUBSTATION NAME	Rating (MVA)	BEFORE kW Losses	BEFORE kvar Losses	DURING kW Losses	DURING kvar Losses	AFTER kW Losses	AFTER kvar Losses
			168.8	253.3	108.3	162.4	49.9	74.8

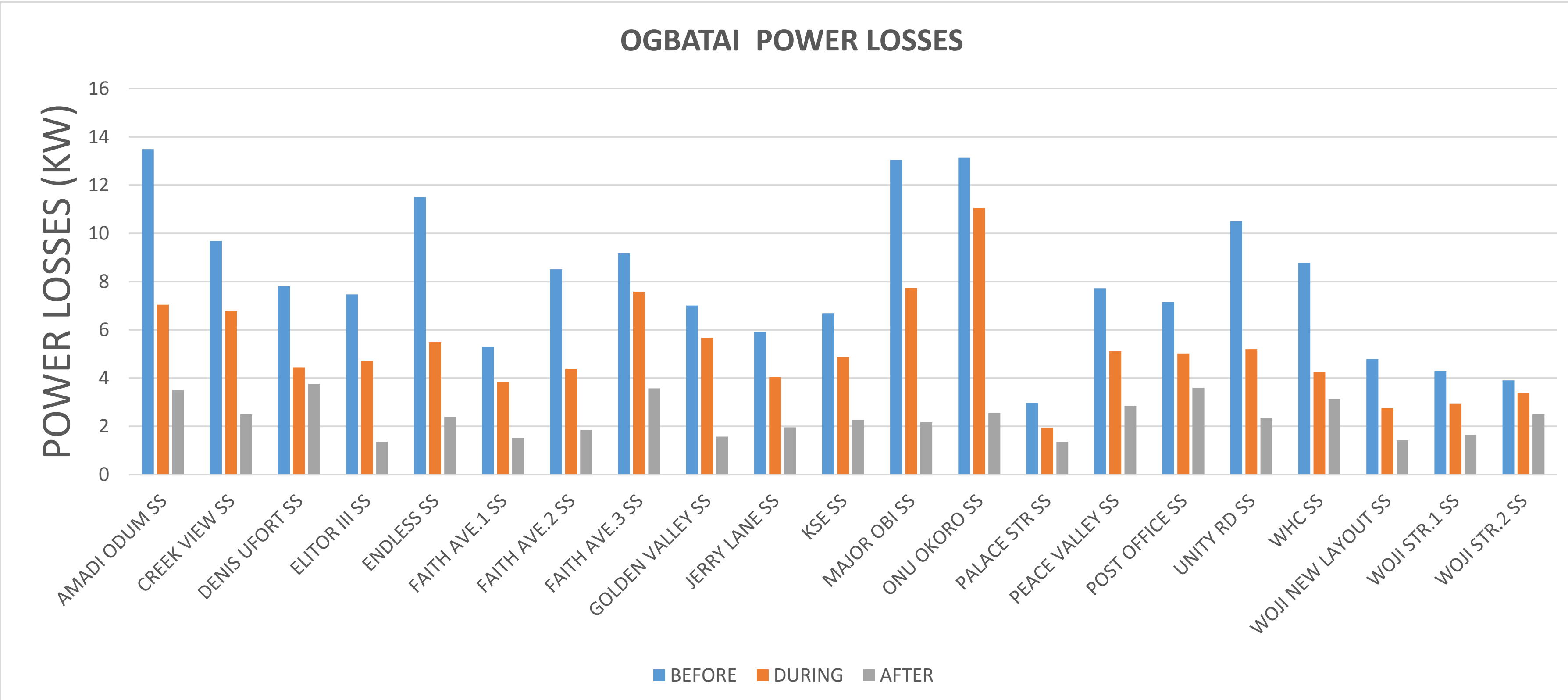

Figure 4.7b Power Loss Across the Ogbatai 11kv feeder substations

Ogbatai 11 kv distribution network also had a steep reduction in power loss value, from a total of 168.8kw before the metering process began, to a new lower value of 49.9 kw, which is a 70.3 % decline in the power lost due to a corresponding drop in the load measured at the distribution substation customer end. Substation like Amadi Odum, Endless, Major Obi and Onu Okoro which had the highest power loss values ranging from 11.5kw to 13.49 kW in 2016, had a decrease in power loss in 2018 after the metering process to a range of 2.17kw to 3.5kw.

The source 1 x 15MVA 33/11kv injection substation was also relieved as its real power losses dropped from 141kw to 39.2kw, while its reactive power changed from 2617kvar to 729kvar within this time period.

4.6 System Network Improvement Model

Taking a look at the entire study area data and simulation reports collected on the network, it was noticed that both feeders have critically overloaded distribution substation transformers even after the metering process, a total of six (6) distribution substations three (3) number substations on each 11 kv network; namely Woji Health Center, Denis Ufort, Faith Avenue 3 on the ogbatai network and Alcon 2, Zacosem and Ambrose I substations on the Nvigwe network. Two of the substations would be upgraded from 500kva to 750kva, while the decommissioned 500 kva substations would be used to de-load the other two (2) critically overloaded 300kva substations and a new 500kva substation would be purchased to upgrade the critically overloaded 200kva substation, to allow future load demand.

Hence all transformers of critical status are to be upgraded and the decommission transformers relocated to areas requiring their capacity or saved as spares. The new network is modelled using ETAP, and the upgraded network is simulated to see the effect of the distribution substation upgrade. The simulation window is illustrated in figure 4.8 a and b.

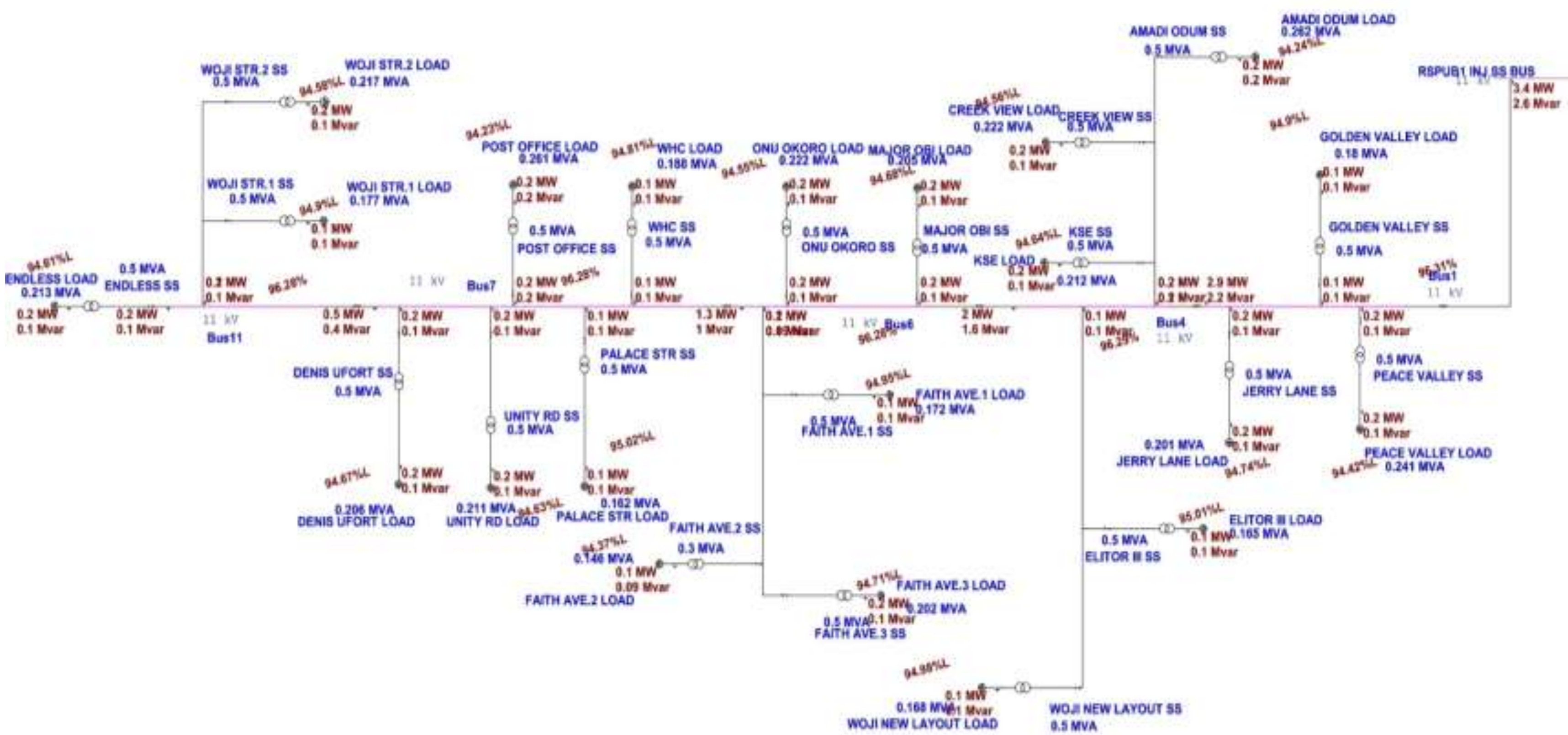

Figure 4.8a Load flow result screen after Upgrade of Ogbatai11kv distribution network

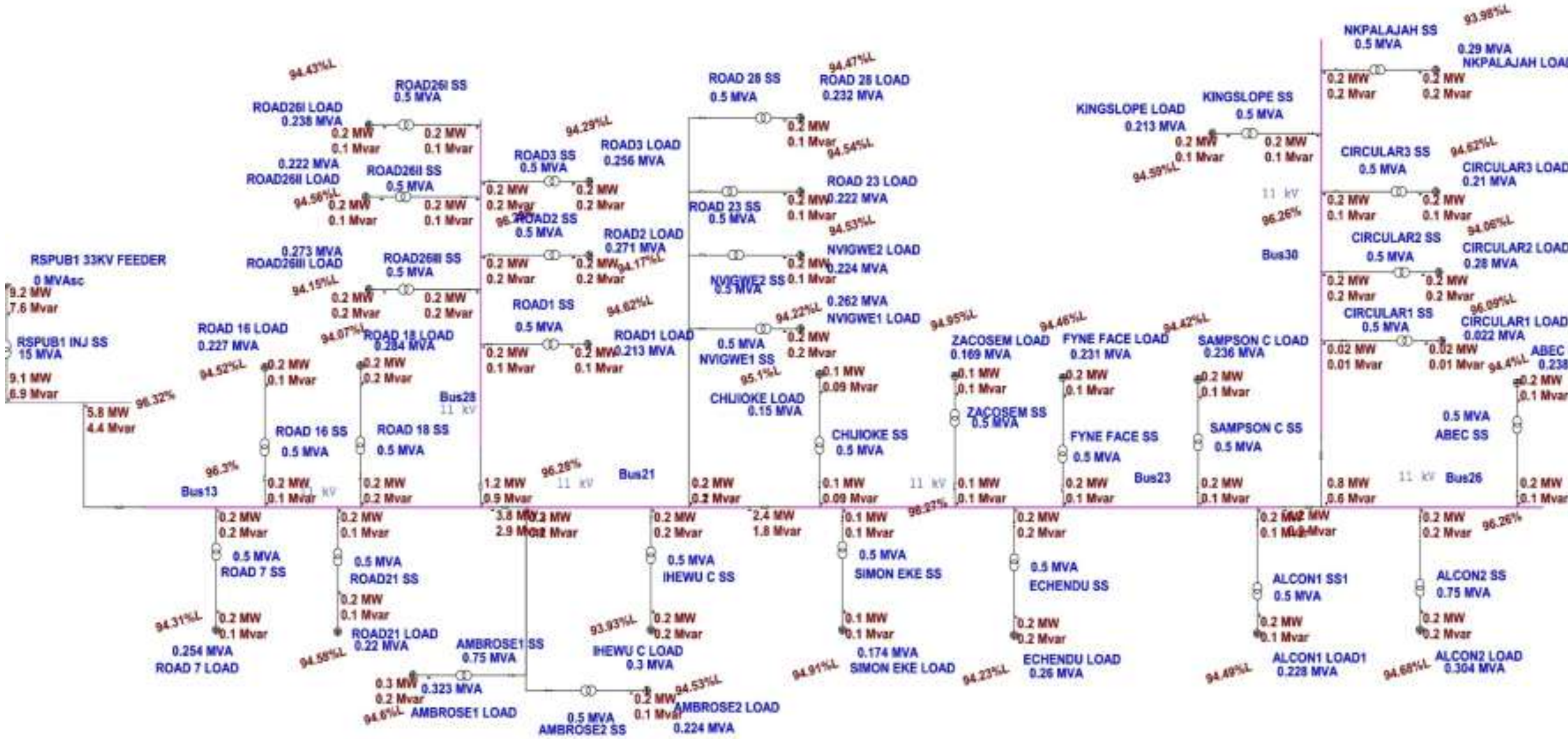

Figure 4.8b Load flow result screen after Upgrade of Nvigwe11kv distribution network

The load flow analysis after upgrading the network yielded voltage magnitudes of 96.32%, 96.31% and 96.30% as compared to the present magnitudes of 96.03%, 92.21 % and 94.43 % on the injection substation bus bar, Nvigwe and Ogbatai 11kv feeder network respectively. The major changed distribution substations data on both networks are detailed in table 4.7a and 4.7b.

Table 4.7a Simulation results for Upgraded Nvigwe 11 kv distribution network

S/N	DISTRIBUTION SUBSTATION	RATING (KV)	PRESENT CAPACITY (KVA)	UPGRADE CAPACITY (KVA)	% LOADING		% VOLT DROP		PRESENT		UPGRADE	
					PRESENT	UPGRADE	PRESENT	UPGRADE	kW Losses	kvar Losses	kW Losses	kvar Losses
1	ALCON II	11/0.415	500	750	60.86%	40.40%	2.59	1.58	5.22	7.82	2.93	4.40
2	ZACOZEN	11/0.415	200	500	84.54%	33.60%	3.62	1.32	4.06	6.09	1.35	2.03
3	AMBROSE I	11/0.415	500	750	64.60%	42.90%	2.68	1.68	5.58	8.37	3.31	4.96
			1,200.0	**2,000.0**	**2.1**	**1.2**	**8.9**	**4.6**	**14.9**	**22.3**	**7.6**	**11.4**

Table 4.7b Simulation results for Upgraded Network on Ogbatai 11 kv distribution network

S/N	DISTRIBUTION SUBSTATION	RATING (KV)	PRESENT CAPACITY (KVA)	UPGRADE CAPACITY (KVA)	% LOADING		% VOLT DROP		PRESENT		UPGRADE	
					PRESENT	UPGRADE	PRESENT	UPGRADE	kW Losses	kvar Losses	kW Losses	kvar Losses
1	WOJI HEALTH CNT.	11/0.415	300	500	62.94%	37.50%	2.6	1.47	3.147	4.72	1.681	2.521
2	DENISE UFOT	11/0.415	300	500	68.53%	40.90%	2.84	1.61	3.764	5.646	2.006	3.01
3	FAITH AVENUE III	11/0.415	300	500	67.33%	40.20%	2.77	1.58	3.574	5.36	1.936	2.904
			900.0	**1,500.0**	**2.0**	**1.2**	**8.2**	**4.7**	**10.5**	**15.7**	**5.6**	**8.4**

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The tabulated simulation results of the load flow across each network, showing substation loading and voltage drop is shown in figure 4.9 a to 4.10 b respectively.

4.6.1 Transformer Loading after Upgrade

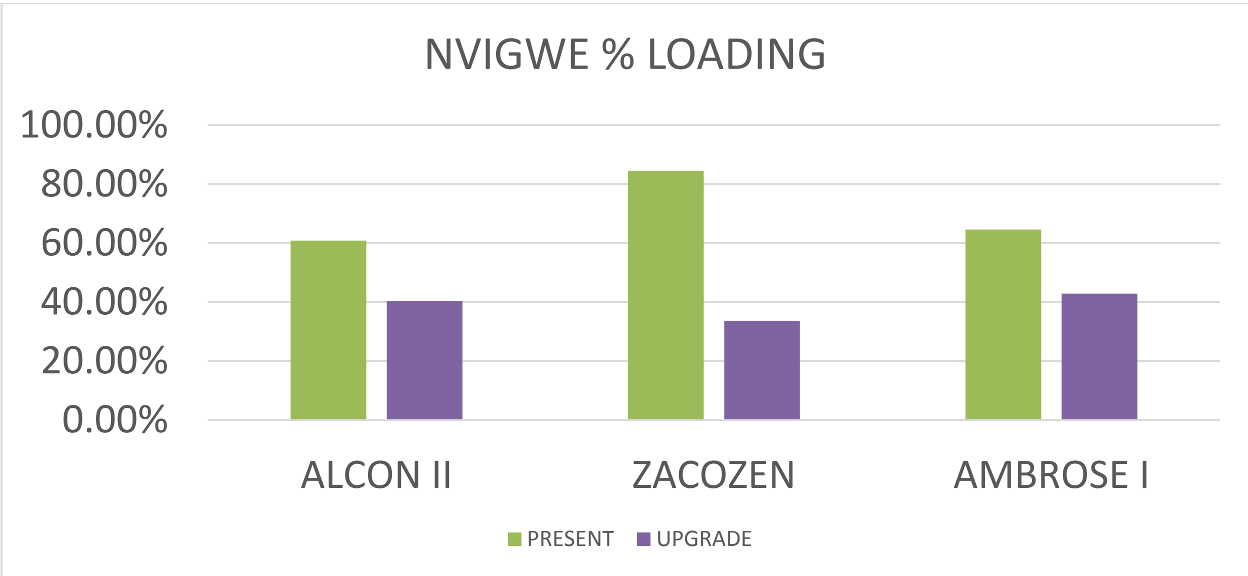

Figure 4.9 a Percentage Loading of the Nvigwe critically overloaded substations

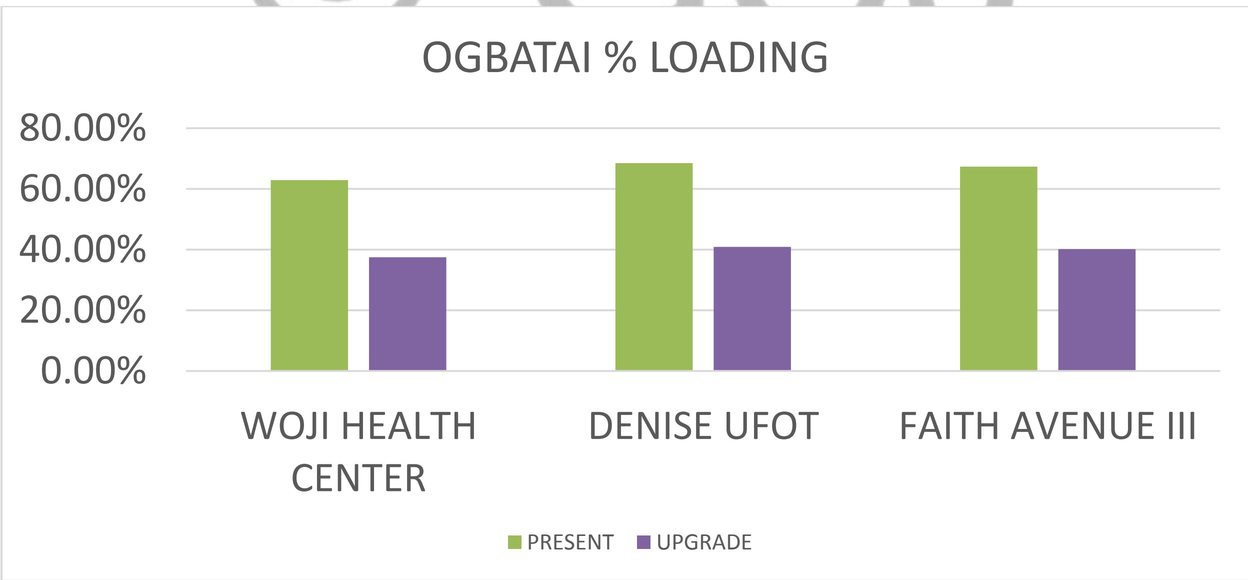

Figure 4.9b Percentage Loading of the Ogbatai critically overloaded substations

The upgrade has yielded vast improvements on the network as it has reduced the loading percentage of these substations and opened more room for growth and expansion. On the Nvigwe network, Zacosem substation with an initial loading of 84.54% would be reduced to 33.60%, and Alcon II from 60.86% to 40.40%, a reduction of 50.94% and 20.46% respectively.

While on the Ogbatai Network, Denis Ufort substation loading dropped to 40.90% from the initial 68.53% after being upgraded from a 300kva transformer to a 500kva transformer, also Woji Health Center and Faith Avenue III substations experienced this drop in substation loading after similar upgrade.

4.6.2 Substation Voltage Drops after Upgrade

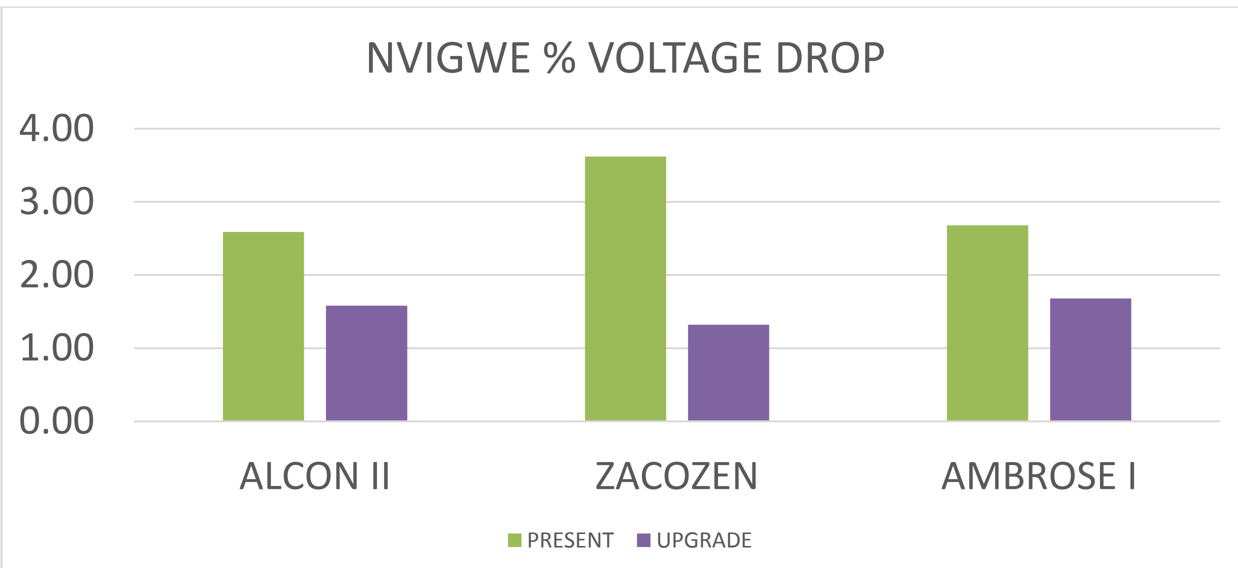

Figure 4.10a Voltage drop on the Nvigwe critically overloaded substations

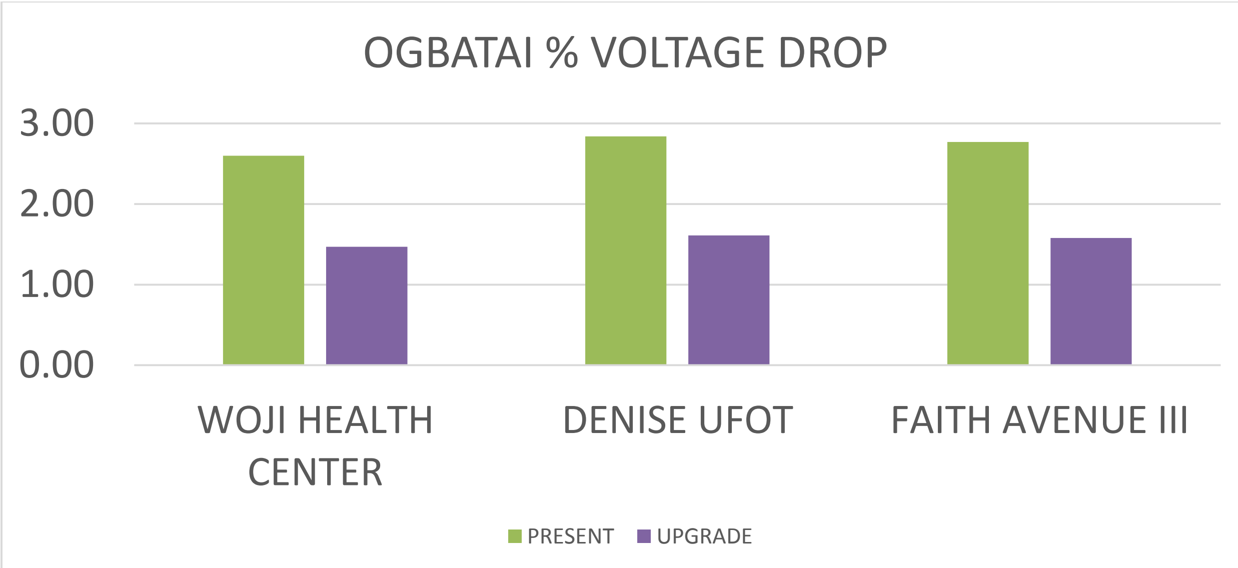

Figure 4.10b Voltage drop on the Ogbatai critically overloaded substations

Also, a reduction in the voltage dropped along the 11kv distribution network and substation transformers from stage to stage. Hence it can be said that the upgrade on the system actually improved the efficiency and performance of the feeders, taking the Nvigwe feeder substations in particular which had the highest substation voltage drop reduction of 2.30%, i.e from 3.62 % to 1.32 %, and a total voltage drop on all the substations of 55.1% as compared to the initial 62.3%.

Whereas the simulation of the Ogbatai 11kv Network after the upgrade indicated the largest voltage drop reduction of 1.19% on Denis Ufort and Faith Avenue III substation, while Woji Health Center voltage drop went from 2.6% to 1.47%. The total voltage drop value reduced from 38.5% to 33.8%.

The upgrade would allow an efficient network, by reduced losses, voltage drops and distribution substation transformer loadings, hence the network is well loaded with a maximum transformer loading of 59.95% on the Nvigwe side and 52.40% on the Ogbatai end, hence an average of 56.02% loading on the entire system.

5. CONCLUSION

The study has vividly illustrated that the reduction in feeder load goes a long way to improve our system performance by increasing the amount of useful load available and severely reducing the losses along the system, else the feeder has to be split into smaller networks. Also, the upgrade of network equipment can go a long way to improve efficiency and allow future demand. It was noticed that the injection substation was overloaded, but with the deployment of mass metering, the load consumed was driven low by customer's energy utilization awareness, as they are directly responsible for the load they use, which in turn results in energy they consume over time. With further investigation, it was also noticed that the route length of the feeders also plays a vital role in the amount of power loss as it travels along conductors to the customers. Improvements, constant monitoring and diagnostics of this distribution line elements and replacement of aged and not reliable equipment can further improve system performance. Analysis like those provided in this thesis will become of great significant as customers are becoming more sensitive to supply interruptions.

REFERENCES

Abeba, D. T. (2016). *Study of Distributed Generation in Improving Power System Reliability*. School of Electrical and Computer Engineering Addis Ababa University Ethiopia.

Abdelhay A. Sallam, Om P. Malik, Electric Distribution Systems, Hoboken, N.J Wiley-IEEE Press, February 2011, Print ISBN:9780470276822 |Online ISBN:9780470943854 |DOI:10.1002/9780470943854

Adegboye B. A. (2010) Analysis of feeder's outages on the distribution system of Zaria town. Faculty of Engineering, University of Maiduguri, Nigeria. Arid Zone *Journal of Engineering, Technology and Environment*. 7, 1-13.

Adriel, P. T. (2017). *Modeling aggregate loads in power system 19th Royal Institute of Technology School of Electrical Engineering.*

Aida, K. Azah, M., Moha, W., & Ahmad, I. (2013). *Optimal sizing and placement of distributed generation in distribution system considering losses.* University Kebangsaan, Malaysia.

Alam, J. (2015). *Tower flow solution for micro grids with distributed slack bus Department of Electric/Electronics Engineering,* Brac University, Dhaka: Bangladesh, India.

Asha, N., Tamizharasi, P., & Deepalashmi, U. (2014). Energy saving using bifurcation of distribution transformer Department of Electrical and Electronic Engineering Adhiparasakthi Engineering College Tamihadum, India, *International Journal of Innovation Research in Advanced Engineering, 1*(2), 2-10

Behailu, A. (2013). Designing of an Improved Distribution Substation to mitigate the power reliability of Bishoftu City Defence University, College of Engineering, and Department of Electrical Power Engineering Ethiopia.

Charlangsut, A., Rugthaicharvencheep, N., & Auchariyamet, S. (2012). Heuristic optimization techniques for network configuration in distribution system. World Academy of science, Engineering and Technology, *International Journal of Electrical and Computer Engineering, 6*(4).

Cruz, S.M (2014). Load Flow Analysis of Multi-Converter Transmission System, Electrical Engineering Department Drexel University.

Dan, Z. (2007). Electric Distribution Reliability Analysis Considering Time-varying load, weather conditions and reconfiguration with distributed generation. Virginia State University, USA.

Ewesor, P., 2010. Practical Electrical Systems Installation Work & Practice. Benin City: Petvirgin Partners, 1 Agbonoga Street, Eyean, Benin City

Gerardo, G. (2016). *Analysis of Power distribution system using a multicore environment,* Universidad De Malaga, Bacelona. Spain.

Jairath, A. K. (2015). *Load Flow Study of a Power Distribution System.* Amity School of Engineering and Technology, Amity University.

Jaya C. K., Sunitha R. & Abraham T. M. (2017). Reliability Analysis of 11kV Feeder a Case Study. Electrical Engineering, Department National Institute of Technology Calicut, India. jayarajasree@gmail.com.

Kanungo, S. (2013). *Modelling of loads in Power Flow Analysis*. Department of Electrical Engineering, National Institute of Technology, Rouyakela: Odisha, India.

Kipkirui, K.S. (2014). *Load Flow Study Electrical and Information Engineering*, Department University of Nairobi.

Kirtley, J. (2011). *Introduction of Load Flow Study* available: http://ocw.mit.edu/courses/electrical.engineering-and-computer-science/

Luis, G. G. S. (2016) Analysis of power distribution system using a multicore environment, Universidad De Malaga, Bacelona, Spain. PhD thesis.

A. C. Ohajianya, O. E. Abumere, I. O. Owate, E. Osarolube (2014), Erratic Power Supply in Nigeria: Causes And Solutions, *international Journal of Engineering Science Invention, www.ijesi.org Volume 3 Issue 7‖ July 2014 ‖ PP.51-55, ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726.*

J. Y. Oricha, G. A. Olarinoye, Analysis of Interrelated Factors Affecting Efficiency and Stability of Power Supply in Nigeria, International Journal of Energy Engineering, p-ISSN: 2163-1891, e-ISSN: 2163-1905, 2012; 2(1): 1-8, doi:10.5923 /j.ijee.20120201.01, Copyright © 2012 Scientific & Academic Publishing.

Pansini, A. J. (2005). *Guide to Electrical Power Distribution Systems* 6th edition, C. R. C. Press.

Patil, B. N. & Kiran, M. M. (2013). Distribution business analysis of 11KV feeders Electrical and Electronics Engineering Department, Angadi, Institute of Technology and Management Belgaum, India. *International Journal of Engineering Sciences & Research Technology*

Pritam, C. (2013). *Load Flow Analysis of Radia Distribution Networks.* Electrical and Instrumentation Engineering Department, Thapar University.

Priyesh, K., & Somir, F. (2016). *Analysis of Network reconfiguration technique for loss reduction in distribution system* Department of Electrical Engineering SGI, Gurgaon: India.

Reza, S. Azah, M., & Hussain, S. (2012). *Heuristic optimization techniques to determine optimal capacitor*, Department of Electrical and Systems Engineering University Kabagsaan: Malaysia.

Salwa, M., Sobhannul, A., & Hosan, A. (2013). Reverse Load Flow Analysis Electrical and Electronic Engineering Department Brac University, Dhaka: Banglashesh India.

Smaraji, G. (2009). A new Technique for load flow analysis of Radial Distribution Networks. *International Journal of Electrical and Technology, 1,* 75-81.

Tanuj, M., & Shisodia, Y. S. (2012). *A survey of Optimal Capacitor Placement Techniques on Distribution Lines to Reduce Losses,* Department of Electrical Engineering, YIY, 2Jaipur: India.

Wikipedia (2017). Electrical power network (online) available: http://en.wikipedia.org/wiki/electrical-power-network.

http//:www.powerelectricalblog.com, 2018. Retrieved on 12th July, 2019.