NEDCo NETWORK STUDIES, 2011

NEDCo NETWORK STUDIES REPORT

INTRODUCTION

The present network has grown beyond the level where manual calculations are used to compute voltage levels and current flows in the network. Due to the complexity of the network the computation of branch current or loading , voltages, and losses cannot be done satisfactory without the application of high personal computers and dedicated software applications. There are several network analysis software that are available for the study of power system networks, such software , depending on the size of the network require large array of data for successful network study. Data such as conductor type and size for various sections of lines, pole top design arrangements, transformer ratings, voltage levels, earthing methods, vector groups, short circuit impedance, tap positions etc; were all required to make accurate models of the network components for the study.

Therefore, upon 90% successful completion of the medium voltage network data capture in the NEDCo, it was time for the network studies to begin as all the relevant information for creating computer models for the various components became available. The computer models for sub-transmission lines, cables, transformers, capacitors and loads were quickly developed with the help of industry standard software SKM Power Tool®. The computerized load flow analysis was done with SKM Power Tool ® at peak load and off peak load conditions. About 2,600 transformers were modelled and analyzed. The NEDCo MV network was analysed in its totality without load aggregation to ensure that the errors are minimal; since the main objectives were to determine the loading voltages and losses of each branch of the network.

OBJECTIVES OF THE STUDY

The objectives of the study are

1. To determine the equipment loadings and voltage levels at the 34.5 and 11.5 kV buses.
2. To determine the loss in the MV network branches as a result of the loading conditions.
3. To compute the technical losses on the network.

METHODOLOGY

The computer models for transmission lines, cables, transformers were quickly developed with the help of industry standard software SKM Power Tool®. The computerized load flow analysis was done with SKM Power Tool®. SKM Power Tool® was chosen for its flexibility of use and speed of convergence.

About 2,600 distribution transformers and the interconnected lines were modelled and analyzed. The NEDCo MV network was analyzed in its totality without load aggregation to ensure that the errors are minimal. The results of computer runs were compared with the measured values at the various substation buses. The measured values were obtained from electronic data loggers UMG 503 mounted on the various buses and feeders. The loggers measure and store system parameters at intervals of 30mins. System parameters such as phase voltage phase current, power factor, active, reactive, Harmonics, and apparent powers were logged. These measured values are compared with the simulated values to determine the correctness of the models chosen for the study (see tables 1 and 2). The total active coincidental load measured in the NEDCo is 123MW.

LOAD FLOW

Power flow studies in general are used to determine the voltages, currents, active and reactive power flows in a given power system. This reveals branch /equipment loadings determined from load flow studies. The results of power-flow studies are very important in the evaluation, control, and planning of an electric network.

The load-flow analysis provides a comprehensive description of the system including its state and the power flow at each network bus.

In this study, the primary objective is to determine the loading of the various sections of the network and to determine technical losses associated with the flow of power in the network. In addition to knowing the loading of the various components such as Transformers and conductors, the results of the studies are to reveal the weak points of the system by highlighting the components that have violated the planning criteria. The method used for the flow analysis is the well-known Newton-Raphson iterations.

Table 1 Comparison of some measured and simulated voltages

No.	Bus Name	Measured Voltage in kV	Simulated Voltage, kV	Error	% error
1	Sunyani 34.5kV @T1	32.80	32.77	0.03	0.09
2	Sunyani 34kV @T2	29.9	28.58	1.32	4.41
3	Berekum 34.5kV	29.5	29.29	0.21	0.71
4	Mim 34.5kV	33.49	33.88	-0.39	-1.16
5	Techiman 34.5kV@T1		34.3	0.6	1.73
6	Wenchi	11	10.6	0.4	3.63
7	Tamale 34.5kV@T1	34.5	32.3	2.2	6.37
8	Bolgatanga	34.3	32.2	2.1	6.12
10	Sawla	36.4	34.4	2	5.49
11	Wa	33.5	31.2	2.3	6.86

Table 2 Comparison of some measured and simulated loads

No.	Feeder ID/Name	Measured load in MW	Simulated Load, in MW	Error	% error
1	Sunyani	36.9	37.4	-0.50	-1.36
2	Techiman	18.8	18.6	0.20	1.06
3	Tamale	24.8	25.2	-0.40	-1.61
4	Upper East	9.9	10.6	-0.70	-7.07
6	Sawla	7.2	7.9	-0.70	-9.72

Errors

The voltage and results of the studies were compared to measured values at some selected substations. The percentage errors shown in tables 1 and 2 suggest fairly accurate model of the network.

Input Data

Conductor data

The line is made up of conductors. The conductors may be of different shape, types, and sizes. The basic data of the lines are the conductor data. Such as:

a. Type (eg AAC,AAAC, ACSR, Cu,)
b. Area Size. – Conductors are also selected by Area.
c. AC Resistance/km

The intrinsic properties of the conductor such the DC resistance/km, AC resistance/km, internal inductance/km etc were compiled.

When the conductor is framed, the circuit parameters of the line are then calculated based on the conductor data and the choice of the model which is also dependent on the length of the given line. The distances between conductors for 11kV and 34.5kV lines were all entered for triangular, Horizontal and vertical framings.

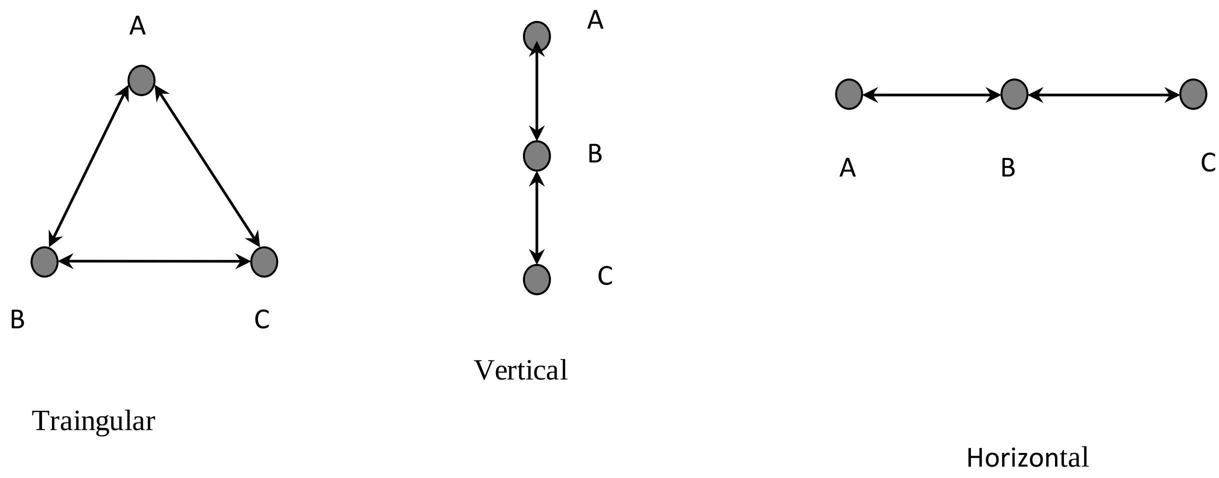

Fig 1. Types of line framing

Table 3 Line framing dimensions

Framing	Triangular			Horizontal			Vertical		
Distance (mm)	AB	BC	CA	AB	BC	CA	AB	BC	CA
11kV	660	660	660	660	660	1320	660	660	1320
34.5kV	1200	1200	1200	1200	1200	2400	1200	1200	2400

Transformer Data

The transformer data that were inputted into the software are Primary and secondary voltages, rated power, percentage impedance voltage, connection type, earthing method and tap position. These data were collected for the various transformers found on the NEDCo network today. Where the name plate data were not found, typical values were assumed. The following typical values were assumed. Every effort was made to ensure that tap positions of the various transformers reflect those found in the field.

Table 4: Typical transformer ratings and parameters

No.	Rated Power, KVA	Iron losses , Po	Copper losses , Ps	% impedance Voltage	Connection Methods
1	50	0.16	1.05	4.3	D/Y-g
2	100	0.29	1.8	4.3	D/Y-g
3	160	0.34	2	4.3	D/Y-g
4	200	0.43	3	4.3	D/Y-g
5	315	0.56	4.4	4.3	D/Y-g
6	400	0.66	4.4	4.3	D/Y-g
7	500	0.83	6.5	4.3	D/Y-g

Results

Three reports were generated from the analysis, namely equipment loading, critical reports and losses report:

Equipment loading reports

The loading of about 2,600 transformers and all the feeders and lines in the NEDCo was reported. The full equipment loading report for the Networks is contained in the crystal report generated by the software.

Critical reports

The critical reports show the violations of planning criteria such as voltage, and loading limits. The marginal and critical loading limits for transformers were set at 90% and 100%. The full critical report for the Networks is contained in the crystal report generated by the software.

Table 5: Report criteria for system components

item	Component	Marginal	Critical
	Lines	85	100
	Cables	85	100
	Transformers	90	100
	Buses	85	100

Table 6: Report criteria for voltages

Item	Parameter	Marginal	Critical
1	Overvoltage	110	>110
2	Undervoltage	90	<90

Losses report

The losses were reported for the various sections of lines, cables and transformers. The total NEDCo losses were also reported. The total loss on the HV networks for the NEDCo is 6,674 kW representing 5.4 %. The full losses report for the Networks is contained in the crystal report generated by the software.

This 5.4% represents the losses in the 34.5kV and 11kV network. The losses in the 20kV and 30kV networks are not included since the flow did not include these models. Further Studies will be performed to determine the losses on this special scheme.

As there were no accurate and sufficient information about the LV network, it was necessary to make certain assumptions to enable an approximate estimation of the LV losses to be made. Even though this approach may not give accurate results as against collecting field data across the LV network, we think that this approach is economical and will at least give us a good estimated separation point to start with.

The LV losses estimation was done with the following Assumptions:

1. The distribution transformers are 100KVA each.
2. Each transformer has two outgoing feeders
3. Each outgoing feeder has a feeder length of 1km
4. Each feeder conductor is of type AAAC and size of 100sq. km
5. The load is concentrated at the end of the feeder for worst case condition.
6. Each transformer was 50% loaded.

These assumptions were modelled in the software for one transformer and the result was multiplied by the number of transformers. The total estimated losses for the NEDCo operational Area LV network is 5,040 KW.

Total Technical Losses

The total technical losses for the NEDCo Area is the sum of the HV losses and the LV losses(6,674KW+ 5,040 KW) and amounts to 11,714 KW. This represents a technical loss of 9.8%. It should however be noted that, the losses does not include that on the shield wire network.