International Journal of Engineering Science Invention (IJESI)
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org ||Volume 8 Issue 08 Series. III || Aug 2019 || PP 41-49

Typical Analysis for Minimization of Non-Technical Losses in Yola Electricity Distribution Company

John J. Vandu[1], Chinda Amos[2]and Bukar Musa[3]
Department of Electrical and Electronics[1, 3], National Centre for Technology Management [2]
ModibboAdamaUnivesity of Technology, Yola Nigeria[1, 2, 3]
Corresponding Author: John J. Vandu

Abstract: *The main purpose of this paper is to carry out a study on non-technical losses in Yola Electricity Distribution Company (YEDC) in three districts; Yola, Taraba and Jalingo with the aim of proposing metering especially smart metering solutions in leveraging the epidemic of huge non-technical losses being incurred by YEDC which hitherto has not been proactive in managing the menace of non-technical losses within its system, hence impacting negatively on the overall economic efficiency and general output of the DISCO. Losses have been a silent canker worm in the Nigerian electricity power sector, largely as a result of Government dominance prior to the total deregulation of the sector in 2013. Distribution system losses are broadly divided into two: Technical and Non-Technical, the negative effect of transmission and distribution losses on the quality and level of power generation, transmission and distribution cannot be over emphasized. Whereas technical losses are considered as losses due to parameters of the transmission and distribution networks, non-technical losses which are sometimes termed as commercial losses on the other hand come as a result of energy thefts, customer accounting errors, improper billing, wrongful assessment of customer loads, un-metered customers and or errors in the metering platform.*

Keywords:*NTL, Losses, YEDC, DISCO*

Date of Submission: 25-08-2019 Date of acceptance: 09-09-2019

I. Introduction

Both the historical and present day civilization of mankind are closely interwoven with energy, there is no reason to doubt, that in the nearest future, human existence will be more and more dependent upon the use and application of electrical energy. Secondly, electrical power supply is the most important commodity for national development, hence electricity generation, transmission and distribution has become a multi-billion, multi-faceted business which must pay its way.

[9]Explain that on a single bus bar of the grid for transmission, before utilization of electricity, it passes from certain phases. It is first generated, stepped up in transformer deck, passed from switch yard for transmission through power lines. Stepped down after transmission it is then distributed for utilization to the consumers. This generated, transmitted and distributed energy need to be billed as well. Usually two types of devices are mainly used for billing procedure; these are electromechanical KWh meters and Smart meters. Our energy is strained to the utmost nowadays, so using energy efficiently is a main subject of concern which needs urgent attention. That is why electricity related issues have to be dealt with great care and urgently, as far as knowledge is concerned there is no such password which cannot be cracked but best password is the one which is being cracked in a larger period of time. This is one basic reason that the whole world is shifting from analog devices to digital devices. That is also why analog electromechanical meters are being substituted by smart meters. Digital devices provide better security and controlling options. The better detection and controlling of losses is another key reason for substitution ofanalog meters with smart meters. Everything occurs for a reason, so the reason for this substitution is losses in electrical systems this statement has a far reaching implication on the problems of electrical energy availability in Nigeria. It should be noted that distribution lines are the most vulnerable to electrical energy theft, because it is the medium and low-voltage lines that connect to majority of the consumers. These lines are numerous and usually highly inter-connected. The above analysis also implies that the overall unit cost of electricity to the individual consumer will be drastically reduced, as the consumer will no longer have to pay for the non-technical losses that are prevalent in the electrical distribution network.

II. Related Literature And Motivation Works

Non-technical losses (NTL) are difficult if not impossible to detect using information that is typically collected by utility companies. In some areas, the loads are not even metered or are metered communally [14], rendering any loss calculations technical or not for that area useless. The approach used by both utility companies contacted [14], [6], [7], involves primarily field staff monitoring meters and access points in the system on a regular basis.Sometimes this involves regular meter readers receiving special training for spotting irregularities, and sometimes when high voltage and large consumption is involved it involves meter technicians making dedicated meter and transformer inspection trips.The reason that meter inspection is the main method of NTL detection is because the utilities consider electricity theft to be the major source of NTL and the majority of electricity theft cases involves meter tampering or meter destruction [14],[6], [7]. The term "meter" used in this paper refers to the watt-hour recording meters used in virtually every household to record and calculate electric bills by utility companies.

[13], narrates in 'Evaluation of Electric Energy Losses in Southern Governorates of Jordan Distribution Electric System" that quite a large proportion of electrical energy loss stems as a disagreement between the amount of acquired electrical energy by electricity distribution companies which are recorded at the first day of every month and the amount of sold electrical energy which have been consumed by customers these are taken from the energy meters in (watt-hour) of customers every month consumption.

[11]while describing ''an intelligent system for detection of non-technical losses inTenagaNasionalBerhad (TNB) Malaysias low voltage Distribution network" said that the impacts of NTL are enormous both on the consumer and the supply companies, these includes but not limited to financial and economic consequences but the socio- political stability aspects too, however, the financial influences are the most adverse effects for many distribution companies, because it involves sharp reduction in their profits thereby leading to shortage of funds for future expansion and meaningful investment for an improved electrical power distribution system and hence its capacity and the need for measures to be taken to deal decisively with all forms of the power system losses.

1. Problem Formulation

Given the attitude of Nigerians towards Public Property, whatever the quantity of electrical energy that is generated, if proper control is not pursued and maintained, there can hardly be a time when She would get out of Her Electrical Energy crisis, hence a deliberate metering policy is required to be put in place both on the grid and at the distribution level where the actual power is dispensed and utilized. In general, the outcome of the study should determine whether or not the introduction of compulsory metering policy is essential for enhancing efficiency of electricity supply within the Yola Electricity Distribution Company by considering these two types of losses in electrical power system: these are technical loss and non-technical loss.

2. Losses Due To Electricity Theft

All of the utilities and sources contacted by the authors agree that the dominant Component of NTL is electricity theft and non-payment by Consumers [9]. Electricity theft is defined as a deliberate attempt by consumer or consumers to reduce or eliminate the amount of money he or she owes the utility for electric energy already consumed or to be consumed as the case may be, this could range from tampering with the meter to create false consumption information used in billings or to make unauthorized connections to the power supply. The table 1 below show number of cases found on meter tempering among high and low voltage consumers' inYEDC between January, 2015 and January, 2016

TABLE 1: HIGH VOLTAGE CONSUMERS (JANUARY, 2015 TO JANUARY, 2016)

S/No.	Type of violation	Number of cases recorded
1	Tampering with TTB seals	NA
2	Breaking of control wires	3
3	Tampering with meter seals	4
4	Shorting of control wires	4
5	Breaking of voltage taps	2
6	Tampering with meter	15
7	Direct connections	5
8	Switching of control wires	3

Source: [15]

4.1TECHNICAL LOSSES

Technical losses could be defined according to [2]as those which are caused by actions internal to the power system and consist mainly of power loss/dissipation in electrical system components which include the transmission lines, power transformers, Distribution networks, measurement systems, etc. Technical losses can easily be controlled and computed as long as the power system quantities consist of defined electrical units [5].The distortion of electrical load quantities caused by NTL could however distort the computations of the technical losses primarily caused by prevailing electrical loads, thereby rendering any result indecisive. A common example of such losses is the power loss caused by resistance of transmission lines.

4.2NON-TECHNICAL LOSSES

Non-technical loss (NTL), on the other hand is defined as that which is caused by actions outside to the power system, or are caused by loads and conditions that the technical losses computation failed to take intoaccount [1]. NTL are more difficult to measure because they are frequently not taken into consideration by the system operators thereby having no defined information. The most probable causes of NTL are:

i. Errors in accounting and record keeping that distort technical information (estimated billing)
ii. Non-payment by customers
iii. Electricity theft (by-passing of meters, illegal connections) etc.
iv. Errors in technical loss computations (wrongful assessment of customer load)
v. Lack of taking into cognizance increases in system losses due to equipment deterioration over time, but are usually disregarded in all calculations.

The most prominent forms of NTL are electricity theft and non-payment, which are considered to account for most, if not all, of NTL in electrical power systems. It is estimated that electricity stealing/theft in Nigeria costs billions of naira each year [9] and it is this whoopee sum along with the author's metering experience that has prompted this research work on Electricity Energy theft which translate to non-technical losses (NTL). The paper therefore is aimed at carrying out an academic research into the assorted types/nature of non-technical losses in power systems generally.

4.3TECHNICAL LOSS CALCULATION

Technical losses in power systems mean power losses incurred by physical properties in the resistance of transmission lines. The average power loss in a distribution line can be expressed as [10]

$$P_l = P_s - P_{ld} \quad (1)$$

Where:

P_s = The average power that the source is injecting into the distribution line, and

P_{ld} = is the power consumed by the load at the other end of the distribution line.

This is a simple enough calculation, except that power and current are both time dependent functions and that energy and not power is the quantity that gets translated into Naira. Energy is power accumulated over time, i.e.

$$W_{lss} = \int_{x_1}^{x_2} P_{loss}\ (t)dt \quad (2)$$

Where$X_1$and X_2 are the starting and ending points of the time interval being evaluated. As a result, we need a fairly accurate description of P_{loss} as a function of time to make a reliable prediction of energy loss (W_{lss}). Whereby, power in a single-phase case, with sinusoidal current and voltage can be represented by

$$P_{1-\Phi} = V \quad I \quad COS\theta \quad (3)$$

With P, V and I being the average power, rms voltage and current of the element in question, respectively. The term cosθis the power factor of the element in questionwhileθ is the phase angle difference between the voltage and the current waveforms and (1-Φ) is the single phase element. From the above therefore, it can be summarized that the information needed to calculate the average power loss sampled at an instant of time on a transmission line or an arbitrary chosen element on the power system should be one of the following sets (all variables are single phase, rms values and average power):

1) Voltage across the element, resistance, or $P = V^2/R$ (4)
2) Current and resistance, or$P = I^2 R$ (5)
3) Voltage, current and phase difference between the two, or P=VIcosθ (6)

These sets of data and choice of calculations are the options that any researcher could wish to obtain for computing power losses in a load-flow analysis. But in order to improve the voltage (V) and the current (I) or both rms values, the voltage must be known at two ends of the element that is compute a numerical value, at all times or as averages, which implies the terminals that supply the consumer loads must be monitored throughout using some of the most latest Automatic Metering Infrastructure (AMI) meters that could store and compute average and instantaneous values that the load-flow analyst is interested in. The information about the power sources and loads listed above are needed to ascertain all expected losses in the power system using load-flow analysis software, also by reducing both technical and non-technical losses the efficiency of electrical power system will be increased [8]. The actual losses are the difference between outgoing energy recorded by the source (e.g., at a substation) and energy consumed by the consumers, which can be obtained on the monthly bills. The illogical differences between predicted losses and actual losses would produce the total area covered by the non-technical losses in that power system.

4.4ANALYSIS OF NON-TECHNICAL LOSSES

NTLs, by contrast, relate mainly to power theft in one form or another. They are related to the customer management process and can include a number of means of consciously defrauding the utility concerned. By default, the electrical energy generated should equal the energy registered as consumed. However, in reality, the situation is different because loses occur as an integral result of energy transmission and distribution. The total energy losses within the electrical system generally, is referred to as 'energy losses' and can be related with the following equations: [4].

i. Energy Losses

$$E_{Loss} = E_{Delivered} - E_{Sold} \quad (7)$$

ii. Revenue Loss due to technical losses

$$C_{Com\ Loss} = U_{ElectCostXEloss} + M_{Maintenance\ Cost} \quad (8)$$

iii. Non-technical Loss

$$C_{NTL} = C_{ComLoss} - C_{Technical\ Loss} \quad (9)$$

Where, $U_{Elect\ cost}$=Unit cost of electricity

The information about the power sources and loads are needed to determine expected losses in the power system using load-flow analysis software. The actual losses are the difference between outgoing energy recorded by the source (e.g., at a substation) and energy consumed by the consumers, which is shown on the bills. The discrepancy between expected losses and actual losses could yield the extent of non-technical losses in that system. Technical losses would be calculated using the available data flow studies. The various specifications of different parameters of transmission line, transmission line resistance and reactance values will be taken from 11KV transmission lines datasheet [12].

3. DATA COLLECTION

The major basis of the evaluation is on the collected grid data as well as data received from YEDC which was used for billing its consumers within the same period, for each of the three districts of Jimeta-Yola and Numan of Adamawa State as well as Jalingo of TarabaState were selected. Data was collected from Yola-TCN and YEDC on the metering status of the area under study. Selection was for all categories of supply connections, namely: commercial and residential as well as single and three phases. The total electrical energy supplied to all of the selected districts/consumers for the period being investigated has been collected from the authorities of YEDC.The most relevant measuring tools for physical measurement of electrical quantities are: The Clamp-On meter, Multi-Testers and Insulation Resistance Tester (Megger) as well as a 100/5A Check meteretc.

4. ANALITICAL RESULTS AND DISCUSSION

The procedure below explains the method adopted in carrying out the research work.

1. Data collection from TCNYola and YEDC.
2. Analyse incoming and outgoing electrical energy from feeders of transformers T_1 (Yola, Numan) and T_2(Jalingo)
3. Analyse customer population profile for YEDC and details of billed units.
4. Determine the total units billed by YEDC and compare with the total energy received from TCN transformer T_1 and T_2.
5. Calculate the difference between the outgoing units from (T_1 and T_2) and the billed units by YEDC), then determine the commercial losses.
6. If the difference between the outgoing units of $T_1$and T_2 is not significant, then go back to 2 else proceed to 7
7. Calculate the non-technical loss obtained in the system and stop

TABLE 2: INCOMING AND OUTGOING FEEDERS OF SUBSTATION

S/No	Name of Feeder	Readings as on 1/12/2016	Readings as on 31/12/2016	Difference of readings	Multiplier factor	TotalUnits (MWH)
1	T1Yola	488,723.40	502,719.00	13, 995.60	1	13, 995.60
2	Jimeta	191,757.00	196,818.00	5,061.00	1	5,061.00
3	Jambutu	78,026.30	82,409.80	4,383.50	1	4,383.50
4	Yola Town	124,787.00	128,396.00	3,609.00	1	3,609.00
5	Numan	61,586.00	63,166.00	1,580.00	1	1,580.00
6	T2Jalingo	231, 049.00	237,264.00	6,215.00	1	6,215
7	Mutum-Biyu	79,077.00	80,689.00	1,612.00	1	1,612.00
8	Zing	21,859.00	22,507.00	648.00	1	648.00
9	Govt. House	39,286.00	40,799.00	1,513.00	1	1,513.00

10	Jalingo	90,512.00	93,269.00	2,757.00	1	2,757.00

Source: [16]

From table 2 above:
Total outgoing supply from T_1 = 5061 + 4383.5 + 3609 + 1580 = 14633.50 MWH
Total outgoing units from $T_1$and T_2 = 21163.5MWH
Total outgoing supply from T_2 = 1612 + 648 + 1513 + 2757 = 6530.00 MWH
Losses of T_1Yola feeder = 14633500 – 13995600 = 637900 KWh
Percentage loss = 637900/13995600 = 4.6%
Losses of T_2Jalingofeeder =6530000 – 6215000 = 135000 KWh
Percentage loss = 135000/6215000 = 2.2%
Therefore, the bus bar losses for the two main feeders have been calculated in percentage. Details of YEDC Customer Population Profile viz-a-viz their metering status is shown below.

TABLE 3: CUSTOMER POPULATION PROFILE

S/No	Business Unit	1Φ Metered	3Φ Metered	MD Metered.	Un-Metered Population	Total Compliance	% of Non-
1	Yola	6179	5760	151719780	33236	60	
2	Numan	4102	2800	906 7910	15718	50	
3	Jalingo	4850	4196	123510600	20881	51	
Total	1513112756	3658	38290	69835	55		

Source: [15]

6.1 DETAILED ANALYSIS OF OUTGOING FEEDERS

There are only three main types of consumers on this feeder. Their total units consumed and billed have been recorded from their monthly billing sheet and the results in the table below were obtained.

TABLE 4: DETAILS OF BILLED UNITS

S/No	Number of consumers	Type of Consumers	Units Billed
1	66177	Domestic	23053100
2	3523	Commercial	7012000
3	135	Small Power	5946300

Source: [15]
Total units billed = 23053100 + 7012000 + 5946300 = 36011400 KWh
Difference = (36011400 – 21163500) KWh = 14847900 KWh
Percentage losses = 14847900/36011400 = 0.412 = 41.2%

6.2 DETAILED ANALYSIS OF METERED AND UN-METERED CUSTOMERS

Yola feeder which includes Jimeta, Jambutu and Yola Town is used here as case study for non-technical loss calculation whereas:-
Total metered customers from table 3 above= 13,456
Total un-metered customers from the same table = 19,780
Difference between metered and un-metered customers =6324
Therefore % of metered Customers = 6324/19780 = 32%
Also % of un-metered Customers = 6324/13456 =47%
Total Mega Watts consumed in Yola for the month of December, 2016 = 13053.5MWh
Unit Consumed by metered Customers in Yola =32% of 13053.5MWh =4177.12MWh
Estimated bill of un-metered Customers in Yola = 47% of 13053.5MWh = 6135.15MWh
Non-Technical loss = 21% of 13053.5MWh = 2741.24MWh
Note: From the above it can be deduced that there is a loss of 21% of customers not accounted for; hence it can be counted as non-technical losses and is being added to the un-metered customers during billing. There is non-technical loss of 21% due to electricity theft.

6.3CALCULATION OF POWER LOSS

The incurred active and reactive power loss in transmission lines is calculated. The average power loss in a transmission line can be expressed as [3], (all variables are single phase, rms values and average power).

$P = V^2/R,$ (10)

As V=1R (11)

Therefore, $P=1^2R$ (12)
Also $P= VICOS\theta$ (13)
P = Load demand X Power factor
$P = KVA \times Cos\ \theta$ (14)

TABLE 5: POWER LOSS PROFILE

S/No	Residential	Commercial	Loss with NTL	Net P.U Losses
1	26.24	59.8	29.15	0.0265
2	24.6	64.4	27.6	0.0251
3	41	75.69	45.15	0.040
4	33.06	75.69	36.81	0.0335
5	21.25	82.8	24.06	0.0219
6	32.34	93.84	36.66	0.0333
7	59.76	104.4	60.85	0.0553
8	55.5	123	62.25	0.0566
9	79	177.1	88.9	0.0808
10	51.46	180.95	60.37	0.0549
11	42.5	196.35	51.65	0.047
12	46.17	204.05	55.83	0.0551
13	24	211.75	33.15	0.0301
14	51	231	61.8	0.0562
15	39.6	231	49.95	0.0454
16	46.61	246	57.38	0.0521
17	67.5	205	77.7	0.0706
18	71	143.5	79.25	0.0720
19	94.9	117.45	102.88	0.0935
20	118.5	81	125.7	0.1142
21	138.25	77.35	146.05	0.132
22	65.6	64.4	70.16	0.0638
23	61.32	59.15	65.46	0.0595
24	59.15	54.6	62.9	0.0571

Figure 1 expresses the losses incurred during the day within 24hours by residential and commercial consumers. Between (8 – 17) hours, there is much loss by commercial consumers due to lack of proper accounting of the energy consumed. So also the residential consumers uses between (17 – 21) hours to incurre losses as well. All these happened because of estimated billing and by passing of meters.

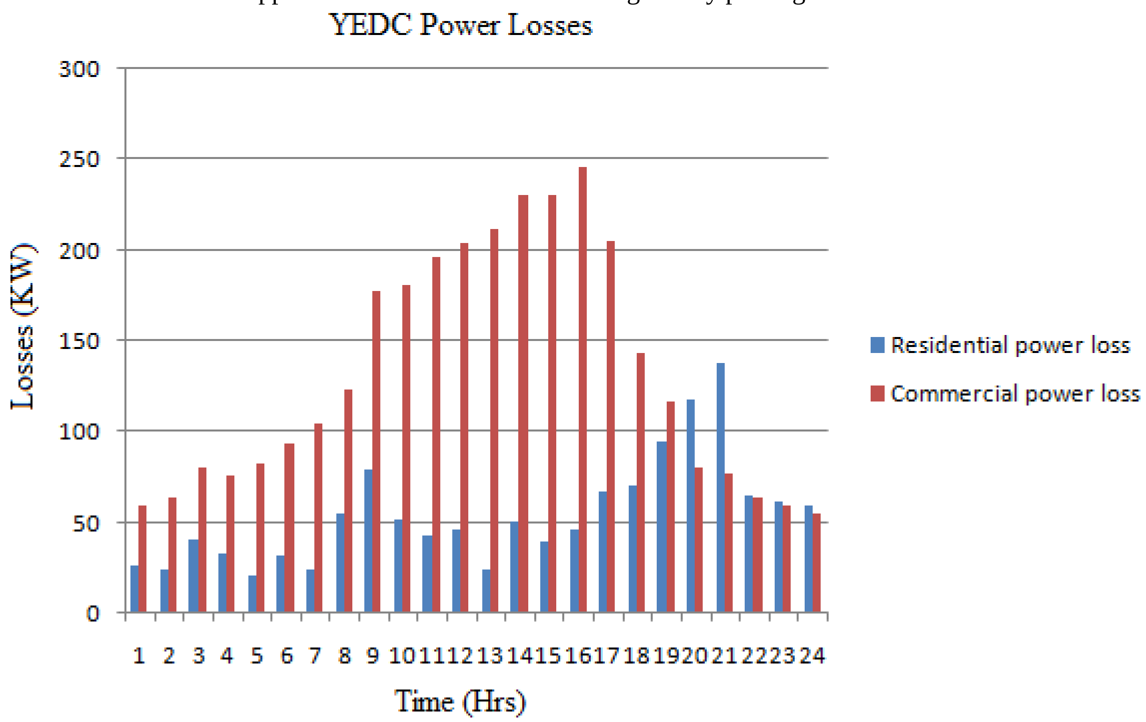

Figure 1: Power losses

Figure 2 below shows where Power losses with NTL, and are obtained by adding the extra loss to power loss on load demand.

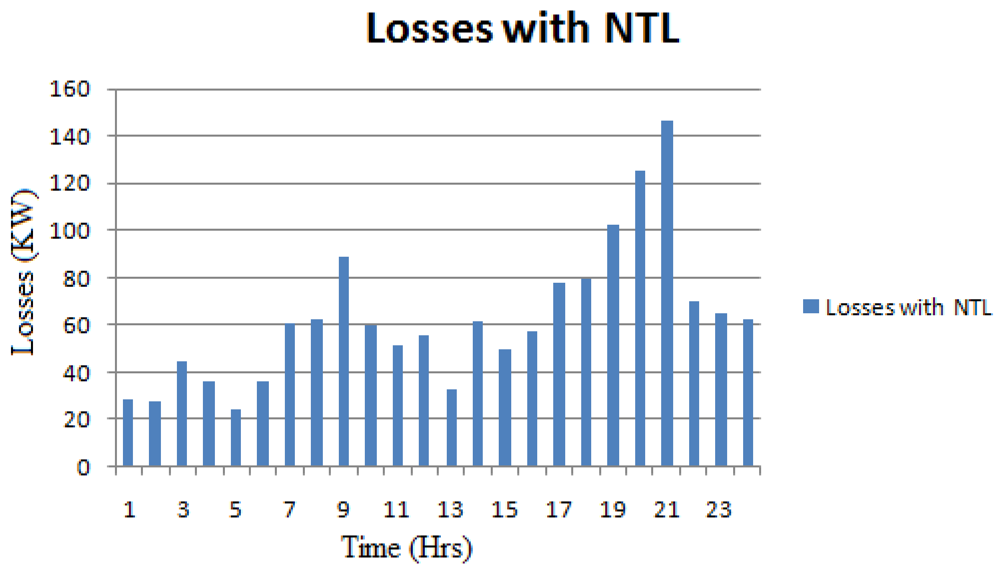

Figure 2: Power Losses with NTL

4.4COMPARISON OF LOSSES

With the addition of NTL to one of the loads, the overall system losses will increase. This large increase is only due to small addition i.e. only 3% load. The two losses are compared with the help of waveform shown in figure 3 below. The average demand for that same time period is the total energy consumption divided by the length of time period in seconds. This information is always available for metered loads, because it is what the DISCO's (YEDC) revenues are based on.

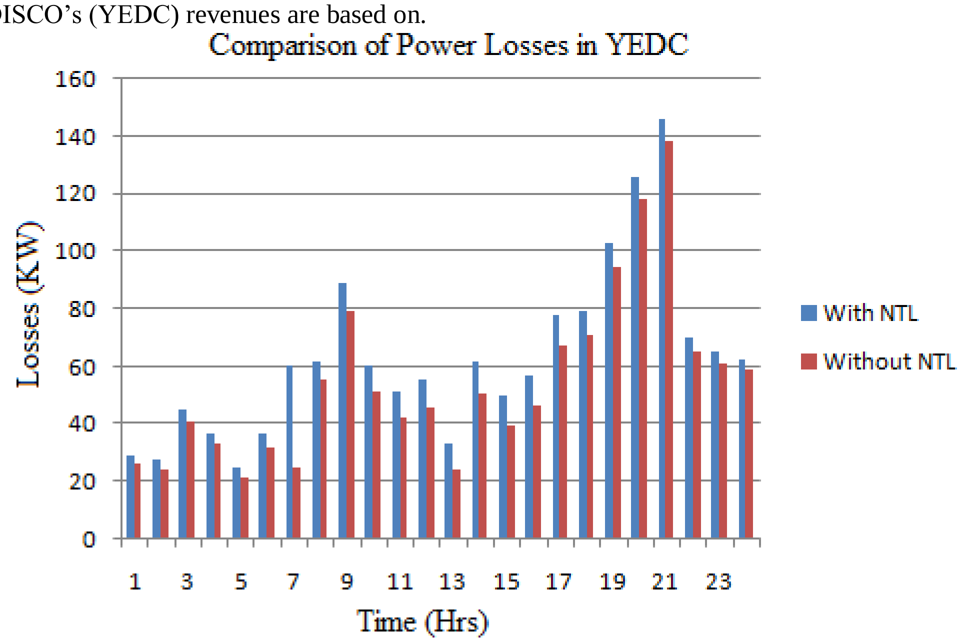

Figure 3: Comparison of Power Losses

The increase in load demand and the increase in distribution losses are not the same levels. This is caused by the power factor contribution of the NTL load. Indeed, the losses increased at a greater rate than the loads. The average loss here is computed by averaging the overall loss increase for each hour. The average loss here is computed by averaging the overall loss increase for each hour. Figure 4: show the per unit increase in losses.

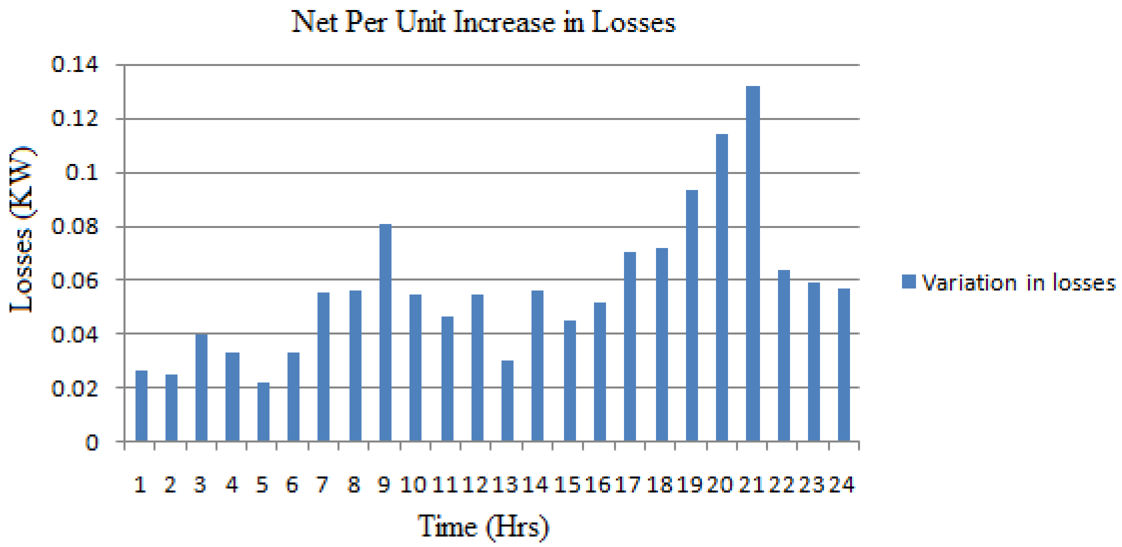

Figure 4: Per Unit Increase in Losses

III. Conclusion

The load profiles of simple industrial area and residential area were considered. The power factor contributions chosen here are negative because the NTL load is assumed to be inductive. All the simulation results have been shown in the form of bar diagrams clearly. The readings of one full month have been taken. Then a case study of Yola and Jalingowerecarried out to determine the extent of non-technical losses in that area. The total units supplied and total units billed have been thoroughly measured for one full month. Then their difference is used to determine the extent of non-technical losses in that area which was found to 2741.24MWh.

Therefore, it has been concluded that it is nearly impossible to find the exact amount of non-technical losses in a system because we know the energy billed and we know the input energy the difference between the these two is T and D loss where obviously the theft is included in this loss but there is no way to segregate theft from the T and D losses. The following are some of the techniques which urgently need to be accomplished by DISCOs to minimize non-technical losses:

i. Device deliberate methods to reduce non-technical losses primarily based on detection by using modern techniques example use of modern AMI infrastructures, meter reading employees and statistical analysis of customer information.
ii. Facilitating time-varying calculations of system losses.
iii. The DISCO (YEDC) must decide whether the costs of accurately measuring NTL be worth the returns it would invest in the form of recovering the NTL costs that were not recovered by the processes already in place.
iv. Reducing the economic and social turbulences and political and economic situations in all of its areas of franchise.

References

[1]. Charles A. Gross, (1986) “Power System Analysis” (Second Edition), John Willey and sons, New York, , PP 255 – 298 and PP 304 – 322.

[2]. Davidson I.E. and Manhire B. (2002). “Technical Loss Computation and Economic Dispatch Model for T&D Ssystems in a Deregulated Electricity Supply Industry’, Power Engineering Journal, 16, (2), 55-60.

[3]. Dan Suriyamongkol (2002). “Non Technical Losses in Electrical Power Systems” A Report Presented to Ohio University, November 2002.

[4]. Depuru S., Wang L., Devabhaktuni V. and Gudi N. “Measures and setbacks for controlling Electricity Theft”. IEEE North American power symposium-NAPS, 2010.

[5]. Fourie J. W. and Calmeyer J. E. (2004), “A Statistical Method to Minimize Electrical Energy Losses in a Local Electrical Distribution Network”, 7th AFRICON Conference in Africa, Vol 2, PP 667 – 673, 15th – 17th Sep, 2004.

[6]. Internal Annual Report, (2000),”Provincial Energy Authority of Thailand Department of Power Economics”, pp. 20 – 54.

[7]. Internal Annual Report, (2001), “Provincial Energy Authority of Thailand Department of Power Economics”, pp. 24 – 60

[8]. Julio R. A, (2012) "Improving the Efficiency of Power Distribution Systems through Technical and Non-Technical Losses Reduction," Transmission and Distribution Conference and Exposition (T&D), 2012 IEEE PES, pp 1 – 8

[9]. Maninderpal Singh andVarunSandujaEr. (2015). “Minimizing Electricity Theft by Internet of Things”, International Journal of Advanced Research in Computer and Communication Engineering, 4, (8), 326-329

[10]. Mohammad H. Alzoubi (2005). “Economic Consequencies and Solutions of Non-Technical Losses” A Presentation Report at Yarmouk University in Electrical Power Department, April, 2005.

[11]. Nizar A.H. et al, (2006). "Load profiling Non-Technical Loss Activities in a power utility", proceedings of the 1st International power and Energy Conference (PECON), Nov; 28-29.

[12]. Punjab State Electricity Board (PSEB). "T & D Losses in Punjab", Retrieved June 16, 2016, from: punjabgovt.nic.in/WHATSNEW/DCRFINAL/Industries/PSEB.htm.

[13]. Refou et al, (2015), Evaluation of Electric Energy Losses in Southern Governorates of Jordan Distribution Electric System, International Journal of Energy Engineering Vol 2(5), 9

[14]. World Bank Technical Paper (1999), Energy Sector Unit, Europe and Central Asia Region, Non-Payment in the Electricity Sector in Eastern Europe and the Former Soviet Union, The World Bank, June 1999; No. 423. pp. 3-33.

[15]. YEDC, (2016). Annual Technical Report.

[16]. Yola, TCN (2016). Monthly Reports of Grid Meter Reading.

John J. Vandu" Typical Analysis for Minimization of Non-Technical Losses in Yola Electricity Distribution Company"International Journal of Engineering Science Invention (IJESI), Vol. 08, No. 08, 2019, PP 41-49