Analysis of Non-Technical Losses and its Economic Consequences on Power System

Tejinder Singh[1] and Arvind Dhingra [2]

[1]*Assistant Professor, PEC University of Technology, Chandigarh(India)*
[2]*Assistant Professor, GNDEC, Ludhiana (India)*

[1]*saggutejinder@gmail.com,* [2]*arvinddhingra@gmail.com*

***Abstract*- India faces prevalent electrical energy and peaking shortages. The Power Sector is plagued with mounting commercial losses due to various inefficiencies, colossal commercial and technical losses and increasing subsidy burden on the states. These shortages have had a very detrimental effect on the overall economic growth of the country. As total distribution system losses equals technical losses plus non-technical losses. The reasons cited for such high losses are; lack of adequate T & D capacity, too many transformation stages, improper load distribution and extensive rural electrification etc. A non-technical loss is defined as any consumed energy or service which is not billed because of measurement equipment failure or ill intentioned and fraudulent manipulation of said equipment. In order to study non technical losses which constitute a portion of the total losses in electrical power systems, the logical first step is to understand the complete picture of power systems losses. The purpose of this paper is to perform an investigation of Non Technical Losses with the help of a case study in power systems.**

Keywords: **Non Technical losses, Technical losses, Electricity theft, T&D losses, Energy meters, PSEB**

I. INTRODUCTION

Power is about the way in which electricity is generated and distributed. The way decisions about the generation and distribution of electricity are made affects us all. The term "distribution losses" refers to the difference between the amount of energy delivered to the distribution system and the amount of energy customers is billed. Distribution line losses are comprised of two types: technical and non-technical. Depending on the regulatory arrangement, losses can have adverse and varying levels of financial effects on the customers and the utility. On one extreme, if the utilities were allowed to pass on its entire loss burden to the customers, irrespective of the magnitude of loss, there would be no incentives for it to enact loss reduction measures. This may not be fair to the customers because certain operating inefficiencies of the utility that impacts the system losses could be passed on to them. On the other extreme, it would be unfair for the utility to shoulder all the responsibility of the system losses. Technical losses are naturally occurring losses (caused by actions internal to the power system) and consist mainly of power dissipation in electrical system components such as transmission lines, power transformers, measurement systems etc. Technical losses are possible to compute and control, provided the power system in question consists of known quantities of loads. Non-technical losses (NTL), on the other hand, occur as a result of theft, metering inaccuracies and unmetered energy [1]. NTLs, by contrast, relate mainly to power theft in one form or another. NTL are more difficult to measure because these losses are often unaccountable. The aim in this paper is to first compute the technical losses and then impact of non technical losses on them is shown.

II. CASE STUDY OF NTL MEASUREMENT AND ITS MINIMIZATION

The way to obtain a fairly accurate value of average load demand is to utilize the information the utilities use to calculate the electric bills. The calculation requires energy consumption accumulated up to the beginning of the time period and the consumption accumulated at the end of the time period. The accumulated consumption at the end of the period is subtracted by the accumulated consumption at the beginning of the period. The result is the total consumption during the time period in kilowatt-hours, and the portion of the bill for energy consumption is based on this number. In this work, a case study of 66 kV substation, Golewala was undertaken [2]. Golewala is situated at a distance of about 12 km from district headquarters Faridkot in Punjab state of India. It is a 66/11 kV substation. The main incoming lines of 66 kV are coming from Sadik. There are two step down transformers in the substation which step downs the 66 kV incoming voltage to 11 kV. The two transformers provide supply to various nearby villages as indicated in Table 1. The readings have been taken from the 11 kV energy meters installed at substation. The readings of whole one month have been collected. The busbar losses in terms of percentage have been calculated. After that total losses have been shown which includes sum of transmission, distribution and non technical losses. For simplicity sake, only one outgoing 11 kV feeder of Golewala has been considered for case study. Similar technique can be applied to any of the substation in Punjab to calculate the losses. The losses have been calculated by the difference of the units supplied to Golewala and units which had been consumed or billed in that particular area. The P.S.E.B. has proper record of all the incoming and outgoing units in the form of a log sheet. For this, we have to first find out the total number of consumers in that particular area and their type i.e. whether they are domestic, commercial or small power units.

TABLE 1: INCOMING AND OUTGOING FEEDERS OF SUBSTATION

S. No.	Name of feeder	Readings as on Month start	Readings as on Month end	Difference of readings	Multiplying factor of meter	Total units (kWh)
	Main-I	148908.7	146895.9	2012.8	1000	2012800
1	Saadhan wala	11259.42	11172.35	87.07	1000	87070
2	Golewala	56934.05	56417.25	516.8	1000	516800
3	Pipli	8189.91	8176.52	13.39	1000	13390
4	Rayian wala	7991.78	7136.00	855.78	500	427890
5	Rajowala	4012.82	3977.78	35.04	1000	35040
6	Sayian wala	19902.26	19854.34	47.92	1000	47920
7	Ghugyana	29125.37	28322.99	802.38	1000	802380
8	Beguwala	24414.09	24324.72	89.37	1000	89370
	Main-II	52726118	52404961	321154	2	642308
9	Dallewala	14546230	14546230	Nil	---	----
10	Hardeyale wala	14542721	14528900	13821	2	27642
11	Kabal wala	7730686	7709477	21202	2	42404
12	Burj masta	5323320	5302291	21029	2	42058
13	Nicer paper mill	2067.91	1534.53	533.38	1000	533380

Then units consumed in each area have been calculated and have been added up. This sum has been subtracted from the actual incoming units given to that area. The difference will give the idea of transmission, distribution and non technical losses. Generally major portion of this sum is covered by nontechnical losses, because transmission and distribution losses are generally less in nature than nontechnical losses. Table 1 shows the detailed analysis of incoming and outgoing units from the main 66 kV substation.
Thus;

Total outgoing supply from T1 = 87070+ 516800+ 13390+ 427890+35040+47920+802380+89370

= 2019860 kWh

Total outgoing supply from T2 = 27642+ 42404+ 42058+ 533380

= 645484 kWh

Losses of main-I feeder = 2019860-2012800

= 7060 kWh

Percentage losses = 7060/2012800= 0.35%

Losses of main-II feeder = 645484-642308

= 3176 kWh

Percentage losses = 3176/642308 = 0.49%

Thus the busbar losses of both the feeders have been calculated in terms of percentage.

III. DETAILED ANALYSIS OF OUTGOING FEEDER AND NTL CALCULATION

As there are two main supply feeders which are supplying to 13 outgoing villages. For simplicity sake, Village no. 2 has been chosen i.e. Golewala and hence a detailed study of this village had been carried out. The total no. of customers and their type is as shown in Table 2. There are mainly three types of consumers in the region. Their total units consumed/billed have been recorded from the log sheet and the following results have been obtained.

TABLE 2: DETAILS OF BILLED UNITS

S. No.	Number of consumers	Type of consumer	Units billed
1	880	Domestic	233338
2	136	Commercial	52253
3	15	Small power	41045

Total units billed= (233338+52253+41045) kWh

= 326636 kWh

Difference = (516800- 326636) kWh

= 190164 kWh

Percentage losses= 190164/516800= **37%**

NTL are widely acknowledged by electricity distribution utilities worldwide, they are estimated to account for up to 30% revenue losses to utilities [3]. This has been nearly proved as above with the help of above case study. This result contains transmission, distribution and non technical losses. As our main problem of NTL is of great concern, these losses as shown above cannot be measured exactly. When we talk about T&D losses it also includes the theft of electricity, although it is the part of commercial loss but there is no way to segregate theft from the T&D losses. In practice we know the energy billed and we know the input energy the difference between these two is T&D loss. Obviously the theft is included in this loss. When we talk about T&D losses it also includes the theft of electricity, although it is the part of commercial loss but there is no way to segregate theft from the T&D losses. In practice we know the energy billed and we know the input energy, the difference between these two is T&D loss obviously the theft is included in this loss. Electricity theft is at the centre of focus all over the world but electricity theft in India has

a significant effect on the Indian economy, as this figure is considerably high. The loss on account of theft is reflected in ARR (*Accounting rate of return*) of the electricity company thus these costs are routinely passed on to the customers in the form of higher energy charges.

IV. APPROACHES FOR REDUCTION OF NON TECHNICAL LOSSES

When we talk about T&D losses it also includes the theft of electricity, although it is the part of commercial loss but there is no way to segregate theft from the T&D losses.
Worldwide the energy loss (and Theft) exceeds the total electricity demand of Germany, UK and France, the third, fourth, and fifth largest economies of the world. It is estimated that utilities of developed countries alone lose 500 million dollars every year by way of T & D losses. The theft of electricity is so rampant. For domestic consumer it may be on account of the small temptation resulting from allurement of the staff of the licensee or any third party agent but for the industries it is many fold as it also enables them to hide their actual production from the department of excise, sales tax, etc. who determine the production based on the actual consumption of energy. The meter inspection is the main method of NTL detection 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. The following are the various approaches [4], [5] which must be accomplished in order to reduce the non technical losses at utility and government level:

A. Approaches at the Utility Level:

i. *Metering:* Adequate metering is essential to prevent electricity theft and non-payment at the utility level.

ii. *Organisation:* Utilities should organize the functions of meter reading, billing and collection, customer accounting, and follow up.

iii. *Non-Payment:* The practice of mailing checks or paying in cash at financial facilities instead of just giving cash to the meter man can reduce the non-payment.

iv. *Elimination of Intermediaries*: In some countries utilities widely outsource the meter reading, billing, and collection through resellers. These resellers are being phased out in most areas because of past records of indiscipline.

v. *Incentive Mechanisms for Utility Staff*: In some cases where the utility staff members have more incentives to be dishonest, the companies should develop payment schemes to reward good performance in bill collection.

vi. *Working with Large Consumers*: In some countries the largest consumers were seen as business partners as well as customers by the utilities, which developed payment schedules to suit the customers to ensure payment.

vii. *Price Discounts*: In addition to regular discounts, some utilities have offered longer supply durations or guaranteed supplies for customers who were willing to pay in advance.

B. Approaches at the Government Level

i. *Broader Focus for Stabilization:* Urging governments to reduce subsidies and implement effective privatization to stabilize and organize the energy market.

ii. *Legal Framework and Exit Policies and Practices:* Changing legal concepts of property, property rights, financial laws and regulations, enterprise laws, banking and trade reforms. The financial chaos is cited as a major reason of the continuation of non-payment problems.

iii. Government agencies and departments should be urged to manage their budgets and their energy consumption, in order to reduce the strain placed on utilities and the power systems.

iv. Legal reform, more clarity in the current laws for most countries, as well as the enforcement of the rule of law are required to provide utilities with the option of disconnecting non-paying customers.

V. TECHNIQUES OF ELECTRICITY THEFT

There are plenty of techniques adopted by fraudulent users for the theft of electricity. As In this paper main emphasis has been given on the field study. Thus the various techniques used for theft are discussed below:

1. *Direct connection to the power grid:* Since the meters and equipment in this section are in the 220 V system, where customers are mostly residential and small businesses, a direct connection to the power grid is much easier than the high-voltage system. Well, at least safer, a pair of rubber gloves could be all the necessary protection and a ladder and knife all the necessary tools, as opposed to climbing up HV lines. This is by far the most common method of electricity theft.

2. *Using alternate neutral lines:* The single-phase system often has only one wire going into a house, the “hot” line. Neutral is usually grounded (electrically connected to the earth) and is sometimes provided by the foundation of the house to be more generic. So if a person could manage to use a small transformer and use that as the “neutral”, the meter that uses the very same neutral source would read the incoming voltage

lower than it really is, resulting in a reduced unit count.

3. *Phase-to-phase connection:* This is similar to using an alternate neutral line, except that the system voltage becomes the phase-to-phase voltage, at 240 or 380 volts.

4. *Meter tampering/breaking seal:* This is basically the same thing that happens to the HV meters.

5. *Other methods of electricity theft include:* Tapping off a nearby paying consumer, damage done to meter enclosures, and using magnets to slow down the spinning discs in the meter housing.

VI. SUGGESTIONS TO MINIMIZE NON TECHNICAL LOSSES

In important information provided under RTI Act by Central Electricity Authority regarding transmission loss it was reported that in 2004-05 the transmission losses were to the tune of 175534.96 million units. If we multiply the cost per unit as Rs 2, then the total loss in financial term will Rs 35000 crores (Approx.) [6]. This is only one year figure. If we add 10 years transmission loss it will be enough money to build Delhi like metros in all major cities of India, enough money to build roads to take village kids to nearby town schools, enough money to build hospitals to take care our elderly people. The people who use ACs but do not pay for its use, they have factories but in connivance with electrical board people do not keen to pay as per their use. The reason for the significant amount of non-payment is political and economic changes and the response of the governments and the public to those changes. Payment default at the consumer end resulted in T & D companies defaulting on their dues to the generating companies, which in turn accumulate unpaid debts to energy suppliers, banks, and employees.Total distribution system losses equals technical losses plus non-technical losses [7]. Following are the non-technical strategies by which non-technical losses can be minimized or mitigated:

1. Upgrading of electricity meters to meet standard accuracy must be conducted to support reduction of non-technical losses thru statistical analysis

2. Integrated billing system and prepaid energy meters are the choices which need to be accomplished by the utilities in order to reduce the non technical loss reduction

3. Smart card technology can play an important role in minimizing the theft of energy.

4. Technical training to the operating personnel must be given plus enhancing employees loyalty will be there to eliminate pilferage in the distribution system

5. Statistical monitoring of energy consumption per sector, per class and geographical set-up must be employed and statistical evaluation of meter readings must be done

6. Statistical analysis of electricity meter readings must be done so that sample data from electricity meters can be analyzed statistically over time to estimate significant deviation from usual meter readings. This will help the operating personnel to keep track the energy usage of its consumers and will have a benchmark in case significant meter reading deviation especially at the totalizing meters is observed.

VII. CONCLUSIONS

The measurement of NTL and its effects on electrical power systems as a whole using existing analytical tools would be possible only if information about the NTL loads themselves is available to the analyst. Accurately estimating losses in distribution systems is becoming increasingly important, as regulatory thinking shifts from input-based to output-based methods. Also private companies become more involved in the distribution segment of the electricity industry. Thus this need is particularly important in developing countries, where total losses are generally high, especially prior to the incorporation of the private sector. With the help of case study of one village, the total NTLs have been calculated. Thus it has been concluded that it is very difficult 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 these two is T&D loss obviously the theft is included in this loss but there is no way to segregate theft from the T&D losses. It is clear that reducing non-technical losses will ensure that the cost of electricity to the supplier will be reduced, as less electricity will be used from the power generating company.

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