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# Analysis of Non-Technical Electrical Power Losses and their economic Impact on Pakistan

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**Abstract**: The electricity produced in electric power station does not extend to consumers who make imbursement because of output losses and organizational liabilities. When the losses above 16% specify that there existence of an inclusive electric power stealing in the country. The frequency above 40% indicates an identical extensive economic and social problematic reserve for the country. According to NEPRA (National Electric Power Regulatory Authority) the government losses more than 89 billion Pakistani rupees per year due to electricity theft and illegal approaches. Two types of electricity losses have been detected during electric power transmission and distribution. These losses included losses in transmission and distribution to end consumers. The highest transmission (technical) and distribution (non-technical) losses percentage value over the past decades were 30.41 1n 1998 while the lowest was 16.23 in 2010. Transmission losses are due to dissipated in the conductors, cables and equipment used for transmission lines, distribution lines, and transformer and substation transmission lines. The normal technical or transmission losses are 22.5% and directly depend on the electric power network infrastructure. The other losses are distribution (non-technical) in power systems that cannot be projected or calculated earlier. The bulk of these losses triggered by electricity theft, poor maintenance, bill calculation and accounting mistakes. But in Pakistan transmission and distribution losses are more than the normal losses because the electric power network is not upgraded since a decades that's why technical and non-technical losses are more than normal. This paper presents the comparative analysis of non-technical electricity losses and implausible consequence on the economy of Pakistan. This research also find out the illegal approaches electricity usage and its socio-economic possessions were investigated.

**Keywords:** Electricity losses, electricity network, on-technical losses, method and techniques, comparative analysis

## 1. INTRODUCTION

Electric power systems has a large and complex electrical network all over the world. The electrical power reaches to the consumers through the composite network included transmission lines, transformers, distribution lines, small grid stations, overhead lines, cables and other equipment. In fact, the electric power generated by the power station does not match with the electric power distributed to the end consumers and some percentage of power units usually lost by the distribution network. The difference between electric power transmission and distribution losses are known as electrical power losses. In last decade, the highest percentage of transmission and distribution losses were 30.41% in 1998, whereas the lowest was 16.23% reported in 2010 (Chauhan 2015). The main reason for transmission losses is due to the poor and unmanaged electrical power network. In addition, power dissipation in the conductors, cables and equipment is also a major reason of losses. The normal transmission losses are 22.5% which directly depend on the standards adopted to establish electric power network infrastructure (Depuru, 2011).

The distribution losses ratio is more than the transmission losses because the electricity distribution sector is considered as a weakest link in the entire electrical power infrastructure9Farooq, 2016) (Nagi, and Mohammad, 2008). According to NEPRA (National Electric Power Regulatory Authority)report in 2012 the distribution losses are approximately 50% while the transmission losses are 17 % between transmission and distribution (Power Generation Policy 2015), (Navani, *et al.,* 2012). In this research paper an analysis of Non-technical electricity losses in Pakistan has been presented. Furthermore, the electric power theft techniques has been reviewed and discussed as a major non-technical losses. The rest of the paper is structured into six sections. The energy theft and losses have been reviewed and discussed in section one. Various techniques and methods of electricity thieving demonstrated in section two. The section three have been comprised with comparative analysis of theft ratio and losses and section four represents the discussion about theft and its possible consequences. Finally a conclusion has been drawn in section five.

## 2. ELECTRICAL POWER LOSSES

Two types of electrical power losses occurred during the generation, transmission and distribution of electricity from its sources of generation station to distribution point **(Fig. 1).**

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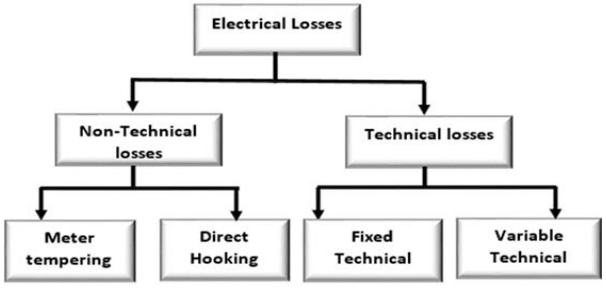


**Fig 1. Electrical power losses in electric power System**

These losses are called technical and non-technical losses. The **(Fig. 2)** shows the infrastructure of electricity distribution and transmission from source to distribution points (Kumar, *et al.,* 2017). Where various losses occurred due to different reason such as length wires, transformer heating, grid station distribution and meter tempering and modification (Jiguparmar in transmission and distribution, 2013).

$$\frac{T\&D\ Losses = (Energy\ Input\ to\ feeder\ (Kwh) - Billed\ Energy\ to\ Comsumer\ (Kwh)}{Energy\ Input\ kwh \times 100}$$

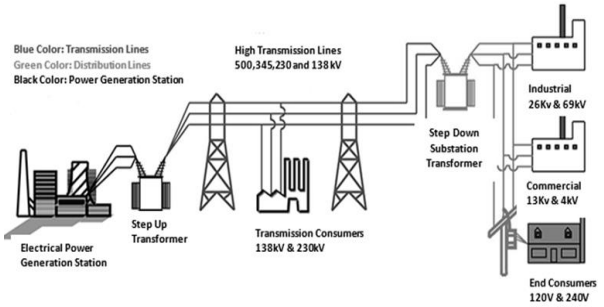


**Fig 2.Generation and Distribution infrastructure of electricity**

## 3. NON-TECHNICAL LOSSES

Non-technical losses are occurred at distribution points such as meter tempering, unregistered connection, direct hooking system, and meter connection bypassing and meter modifications (Selvam, *et al.,* 2016). Furthermore, NTLs occurred due to the consumer malpractices and not accountable by electric power supply companies until the responsible person do not visit the remote site (Onat, 2010). The **(Fig. 3)** described the non-technical losses classification.

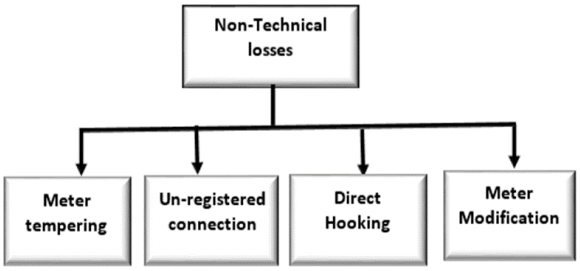


**Fig 3.Non-technical power losses of electrical power system**

### 3.1 Meter tempering.

Meter tempering is type of electricity theft where imposters manipulate the meter reading on electromechanical meter device. Meter reading shows the actual energy consumption utilized by electricity consumers but due to this electricity theft method the concrete meter reading cannot be recorded by meter readers. This is an easy way and technique to manipulate the electromechanical meter devices to hide the actual meter reading.

### 3.2 Un-registered connection.

Unregistered connection is thieving technique where consumers does not have registration of their meter device to respective electric power supply company. This theft technique is undetectable until the personal of respective company visit the remote places (Saikiran1, 2014).

### 3.3 Direct hooking.

Direct hooking from the main line of high transmission line (HTL) is a common used method, 80% of worldwide electricity stealing is by direct tapping from the HTL. The consumers tap wires on HTL from a point ahead of the electricity meter and acquires the electricity without using electricity meter panel. So the meter system cannot measure the power consumption of that particular consumer. (Depuru, *et al.,* 2011), (Hussain. *et al.,* 2016). **(Fig. 4)** shows the direct hooking method.

**Fig 4. Direct hooking system**

### 3.4 Meter Modification.

There are number of methods of electricity meter modification such as inserting external materials into the meter, penetrating holes in the electro-mechanical meter. Furthermore, the electromechanical meters can be tempered by putting a highly viscous fluid, directional changes of meter, exchanging the incoming and outgoing terminals by wiretapping, resetting meter reading, destruct the rotating density of coil by meter screws and using solid neodymium magnets for the disruption of disk (Zhan, *et al.,* 2016),(Hussain. *et al.,* 2016).

#### 3.4.1 Inverse meter Reading

Inverse meter reading is thieving technique where intruder reverse the actual meter reading by opening the

protective shield cover of electricity meter (Sultana, *et al.,* 2016). After inversion of the protective shield of metering system. The meter have been wrapped again smartly that nobody can judged about reading inversion until electricity meter cannot examine practically in laboratory. Fig.5 illustrated the theft method (Gaur and Gupta, 2016), (Hussain, *et al.,* 2016). **(Fig. 5).**

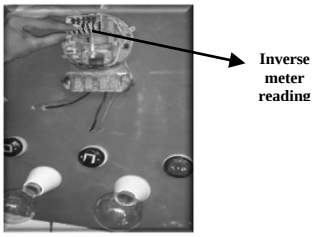


**Fig 5. Inverse Meter Reading Method**

### 3.4.2 Magnet material on rotating disk

Magnet material is used to stop the rotating disk of electricity meter. The imposter put the magnet material on the upper surface of rotating disk which create an obstacle in the free movement of rotating disk. A slower moving disk measure less amount of energy consumption as compare to its normal state. The **(Fig. 6)** shows magnet material on rotating disk of electricity meter (Hussain, *et al.,* 2016).

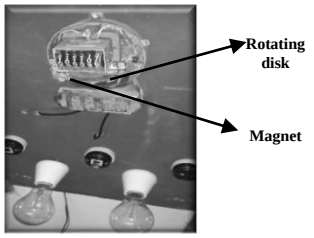


**Fig 6.Magnet on Rotating Plate Method**

### 3.4.3 Directional Changes

This is another common electricity theft technique where the intruders changed the direction of energy meter from its actual position. The directional change of electricity meter slowdown the speed of rotating disk. The slow speed of rotating disk measure less amount of energy (Hussain. *et al.,* 2016). The **(Fig.7)** shows directional changes method.

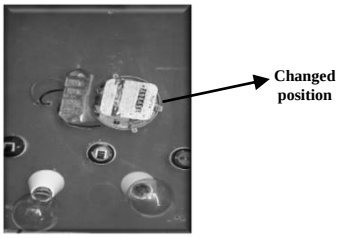


**Fig7. Changed direction of electricity meter**

### 3.4.4 Wires Tapping

The electricity distribution via electricity meter panel is combination of the neutral and load wires. The neutral and load wires must be connected to electrical panel board of meter for the proper measurement of electricity consumption and the free movement of meter rotating disk is necessary to measure the proper electricity consumption. When the imposter tapped and swapped the wires of electrical panel board and connected the neutral conductor with external devices to acquire the neutral earthing. The free movement of rotating disk will be disturb and the slow rotating disk causes less energy measurement (Hussain. *et al.,* 2016). **(Fig. 8).**

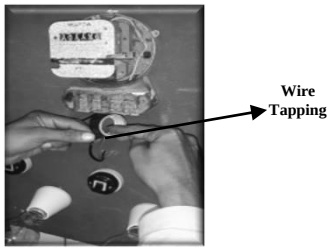


**Fig. 8. Tapping Wire Method**

## 4. COMPARATIVE ANALYSIS OF CONSUMED UNITS RATIO AND LOSSES

In this section the comparative analysis have been carried out by using different electricity thieving techniques used by imposters to hide the actual consumption. The paper shows the result of the theft ratio and losses encountered by various consumers (Hussain. *et al.,* 2016). The Monthly/yearly non-technical losses and theft ratio can be calculated by Equation 2 and 3 respectively.

$$A): CU = \ Consumed\ Units$$
$$B): TR = \ Traiff\ Rate$$
$$C): Tr = \ Theft\ Ratio$$
$$D): Lm = \ Losses\ in\ month$$
$$E): Ly = \ Losses\ in\ year$$
$$F): TL = \ Total\ Losses$$

Equation.2 used to find out the power theft ratio

$$G): Trs = \frac{CU \times TR}{100}$$
$$30units = \frac{200 \times 15}{100} \text{ Eq.2}$$

Equation 3. Used to find out the non-technical

$$H): TL = TR \times \ Trs$$
$$I): Lm = TR \times \ Days$$
$$Losses\ per\ month = 15 \times \ 30 = 450$$
$$J): Ly = Lm \times \ Months$$
$$Losses\ per\ year = 450 \times \ 12 = 5400 \quad \text{Eq.3}$$

### 4.1 Bypassing Electricity Meter Connection

Through conducting a survey in different locations, the results shows that 10 to 13 percent consumers

committed bypassing electricity meter connection technique to save the money illegally. Seven consumers have been randomly selected to obtain the electricity consumption pattern and losses in PKR per year. The tariff rate has been scheduled by government of Pakistan, when consumer will consumed 158 to280 units the tariff will be 15 rupees per unit. When units will be more than 300, the tariff per unit will be 14 rupees set by NEPRA, however; government subsidized rate at 10 rupees per unit. The **(Table 1)** summarized the facts.

**Table 1. Theft ratio and losses percentage per consumer using meter bypassing theft technique**

| Consumers | Consumed Units | Tariff Rate | Theft Ratio | Per Month Losses | Per Year Losses |
|---|---|---|---|---|---|
| 1 | 200 | 15 | 15 | 450 | 5400 |
| 2 | 285 | 15 | 20 | 855 | 10260 |
| 3 | 300 | 10 | 30 | 900 | 10800 |
| 4 | 400 | 10 | 35 | 1400 | 16800 |
| 5 | 450 | 10 | 40 | 1800 | 21600 |
| 6 | 500 | 10 | 52 | 2600 | 31200 |

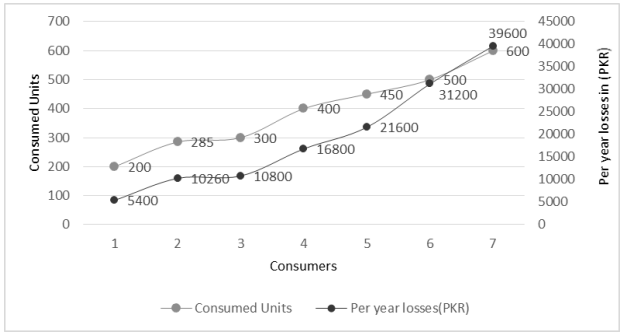


**Fig 9. Year wise losses variation by bypassing theft technique**

The **(Fig. 9)** shows the results of the electricity theft committed by various consumers with different ratio. A consumer consumed 200 units and has been thieving 30 units by the percentage of 15. Hence consumer will have been encounter 450 rupees losses per month and 5400 rupees per year respectively by using this technique. Similarly other consumer did the same thieving technique with different theft ratio. In doing so, they will encounter total 0.09606 million PKR losses per year by consuming different units of electricity respectively.

## 4.2 Direct Hooking (Kunda) from Line

The **(Fig.10)** represent the losses and consumed unit's ratio of direct hooking technique done by imposters to hide the actual consumption. Ten consumers' data have been acquired to measure the consumed units ratio and losses during electricity consumption. They encounter losses by direct hooking are 0.169855 million PKR per year.

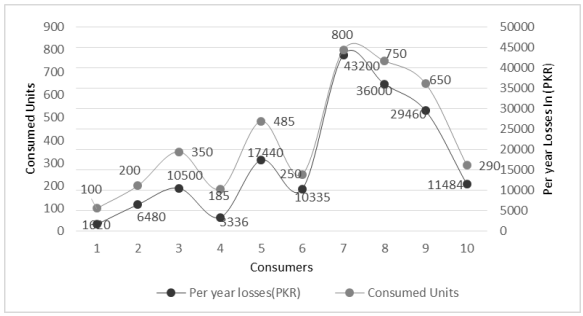


**Fig10. Year wise losses variation by direct hooking theft technique**

## 4.3 Reverse Meter Counter

**(Fig. 11)** represent the losses and consumed units ratio of reverse meter counter technique frequently committed by the domestic consumers within their homes. Here seven consumer have been selected randomly to identify the per year losses and consumed units ratio. The noticed losses by this technique is 0.13566 million PKR per year.

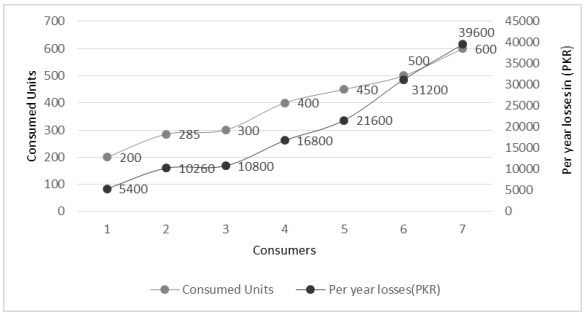


**Fig 11.Year wise losses variation by reverse meter counter technique**

## 4.4 Use of Magnets

This is the common thieving technique structured by consumers. The theft ratio and losses are more as compare to other thieving techniques. The ten domestic consumers data have been collected to detect the consumed unit ratio and total losses. Figure 12 shows the consumed units ratio and per year losses simultaneously.

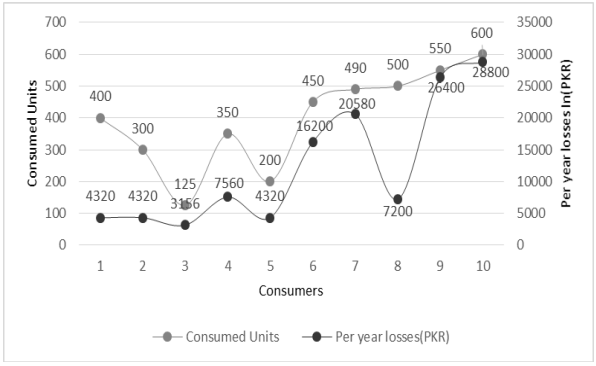


**Fig 12. Year wise losses variation by magnets theft technique**

The total losses come across from different multiple consumers during the whole year and the theft and consumed units ratio of each consumer is different from the other. The sum of one year losses observed by this theft technique is 0.12285600 million PKR.

### 4.5 Directional Changes

It is also common thieving method in Pakistan because it is very easy method to steal the electricity without any physical modification in metering system. Approximately more than 40% domestic consumers structured this method. Fourteen consumers have been selected to find out the consumed units ratio and losses. The theft and losses were vary according to consumed units by various consumers. **(Fig. 13)** demonstrated consumed units ratio and total losses due to directional changes theft technique. The amount is 0.250548 million PKR occurred during the period of one year.

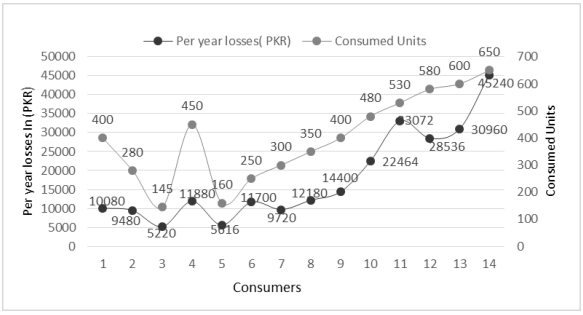


**Fig 13. Year wise losses variation by directional changes theft technique**

### 4.6 Wires Tapping

**(Fig. 14)** demonstrated the losses and consumed unit's ratio of various consumers. Six consumers have been selected to find out the consumed units and losses. The six consumers detected losses are 0.0068430 million PKR per year by the wires tapping technique.

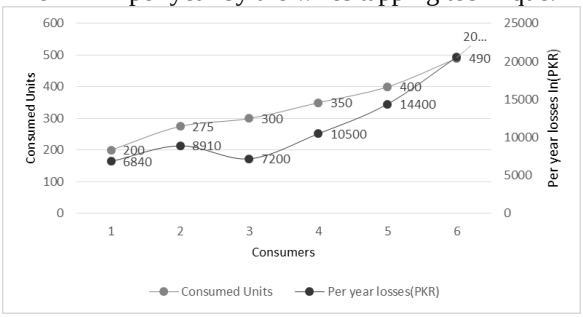


**Fig14. Per year losses variation by using tapping wires technique**

## 5. DISCUSSION

Pakistan's economy losses are around 89.89 billion rupees per year due to electricity thieving at various level and furthermore country face severe crisis because of electricity theft, unpaid bills, unregistered meter and inefficient electric power load management. The research paper is self-explanatory to the structured thieving techniques and methods of electricity in Pakistan. The section two describe the practical demonstrated of the electricity thieving techniques, methods and losses. Which are well-known to domestic consumers and sometime electricity meter readers, employed by electric power companies. These are very common and ease techniques in electromechanical and digital energy meter because these energy meter does not have any real time communication system to intimate the imposter malpractices. In Pakistan millions of electromechanical energy meters have been deployed by the government since decades but now the government started to install smart meters in some regions of country by the assistance of USAID program to minimize the electricity losses and theft. Section three of this paper exhibit the survey results which shows monthly and yearly losses due to various thieving method and techniques. To find out the minimum losses per consumer, theft ratio, consumed units and distinguish the theft category, one to fourteen consumers have been selected randomly for statistical analysis.

## 6. CONCLUSION

Electricity thieving is social crime which cause a strange un-schedule electricity breakdowns in a country. The Pakistan's economy losses are 89.89billion rupees per year due to electricity theft. Furthermore, the government of Pakistan subsidize the electric power distribution companies to improve the existing electricity infrastructure and overcome the non-technical losses from the distribution lines. However the electric power companies cannot reached the consumers places where occurrence of electricity theft is continuous practice. In addition the government took some serious actions to prevent the electricity load-shedding by extended the weekly holidays, banned neon light boards and launch campaign against the electricity theft but still the occurrence of electricity theft is more as compare to previous years. The government and electric power distribution companies only focused on the installation of new power plants instead of identification and prevention of the theft at non-technical sector of electricity infrastructure. In this research, a comprehensive survey has been completed, to identify the electricity theft techniques and losses encounter by different consumers. The different consumers used the different theft methods to hide the illegal usage of electricity at their homes due to many reasons such as un-schedule breakdowns, false billing from power companies, strange shortfall between power supply and demand, absence of punishment, bribe culture, improper check and balance. Furthermore, heavy deployment of conventional metering systems which does not have anti-theft solutions for power

stealing. To prevent the power theft at no-technical sites the smart metering systems can be an appropriate solution because smart metering system has bidirectional communication mechanism between electric power companies and consumers sites to control the power theft at consumer premises.

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