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Non-technical loss analysis and prevention using smart meters

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ABSTRACT

In the countries such as Pakistan, for analyzing the losses and techniques in the power distribution and for mitigating, are the two active areas of research which is spread globally for increasing the accessibility of power irrespective of installing future generation equipment. As, the Technical Loss and the Non-Technical Loss are accounted by the total energy losses. They both are also referred as TL and NTLs. In terms of the non-technical losses there are major financial losses for the utility companies present in the countries that are in the developing stage. NTLs is the major cause for the additional losses and also it includes the part of damaging the network that includes the infrastructure and network reliability reduction. This paper is subjected to investigating the non-technical losses in terms of the power distribution systems. In addition to that, the consumer energy consumption information is used for analyzing the NTLs from Rawalpindi region from the different feeder source. The data of Low Voltage (LV) of the distribution network are focused more that consists of commercial, industrial, residential and agricultural consumers by the use of KWh interval data which is captured over a month using the smart meter infrastructure. The discussion of this review paper determines analysis and prevention techniques of NTLs to safeguard from the illegal use of the electricity in the distribution of electrical power system.

1. Introduction

In the electricity supply companies, the customer illegal use of electricity are the main problems and the reason for the electrical theft is due to the Non-Technical Losses (NTLs). These type of losses occur because of tampering the meter, then the illegal connections, malfunctioning of the meter, irregularities of billing and because of the bills that are not paid. The NTLs problem is faced not just by the developing countries instead it also includes the developed countries like the United States of America. Taking United States as an example for the problem of NTLs, the total annual revenue is estimated to range from 0.5% to 3.5% [1]. Bangladesh, India, Iran, and Pakistan comes under the category of developing countries, where the percentage of NTL is average, and it ranges from 10% to 15%, whereas the United States of America and the United Kingdom falls under the category of developed countries. Thus, the estimated total annual revenue is comparatively low in comparison with the developing countries [2]. The losses of worldwide transmission and Distribution (T & D) are comparatively higher than the total generation capacity of the countries such as France, Germany and UK. It is known that certain companies are known for their loss which is over US $20 billion annually, just because of the theft of electricity. On the other hand, the countries similar to India faces lose that ranges to US$9 billion annually because, of the theft of electricity [1]. The observed energy losses in Pakistan are generated as 17.5% in the year 2012–2013 and the year of 2013–2014 it is observed as 16.9% and 0.6% is accounted for the improvement of the losses.

The graph represents the line losses that Pakistan faced, which is shown in Fig. 1 [3]. There are huge range of losses suffered by the utilities because of the theft of electricity. Therefore, to save from the effects of losses, it is important to reduce the process of NTL. The power system components influences the power that is generated, distributed and transmitted including the appliances of the customer. The most difficult part of the electricity is the use of illegal electricity consumption in real time. In such cases, the parameters that are used to analyze the theft of electricity are, the economic, political, managerial and criminal aspects. Different kinds of methods are described such as the efficient management of NTLS and various electricity distribution system are proposed, because of the problem that occurred in NTLs in the form of electric utilities for securing the revenue. The use of Advanced Metering Infrastructure (AMI) can reduce the NTLs in an effective way, in which it makes the fraudulent activities complex and the detection is easy. But, in such case, the cost will be much expensive for those meters. For example, they are described in various sectors like the commercial, residential and agricultural sectors [4–6]. The fraud identification of the research studies on several data mining techniques and the prediction of it is carried out by the sector called as electricity distribution sector. They include many types like statistical

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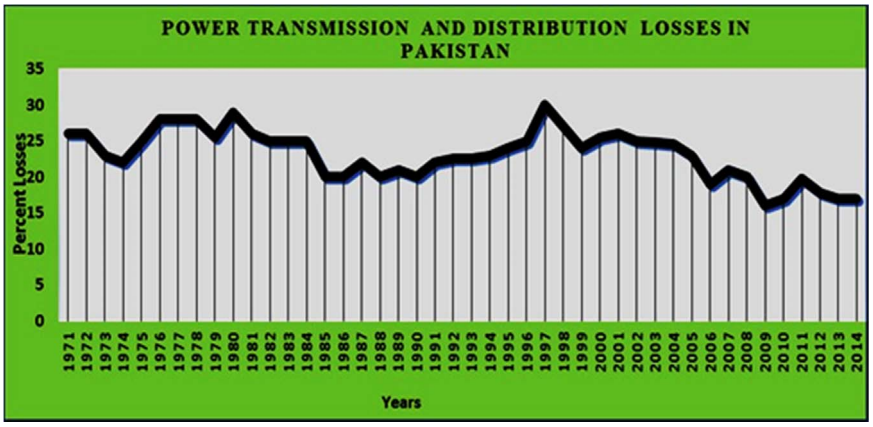

Fig. 1. Total power system losses including (transmission and distribution) in Pakistan [3].

methods [48], Decision Tress [49], Artificial Neural Networks (ANNs) [50], and then the Knowledge Discovery in the Database. By getting all of these the load profiling is one of the most widely used pattern of electricity and the customer over a period of time demand its pattern. At the same time, the system called as e-metering will be used for implementing the processing of the data, and will detect the abnormal activities that are present at the load profile. Thus, it will indicate the electricity theft. To identify the energy consumption of a customer, a smart meter is used for this process, which produces additional information when compared with the conventional energy meter. The approach for grouping of illegal consumption and the process of estimation will be based on the smart meter is proposed [51–56].

2. Power system losses

The losses of electric power system will be affecting the utilities and it can be categorized into two types:

(1) The technical losses
(2) The Non-technical losses

The difference between the quantity of the energy delivered and the quantity of the energy recorded is defined as the power losses, and they are sold to the customers.

$$P_{LOSSES} = P_{DELIVERED} - P_{SOLD} \quad (1)$$

The amount of energy can be represented as P_{Loss} and the amount of energy delivered can be expected as $P_{Delivered}$. Whereas, the amount of energy either recorded or sold will be determined as P_{Sold}.

2.1. Technical losses

It mainly consists of power dissipation in terms of electrical system components. The components will be described as the transformers, transmission and the distribution lines, and energy system's measurement unit. But, at the same time the losses are in technical terms and are being calculated during the phases of design and construction. Their power transmission and distribution networks are also mentioned. The values of the technical losses will be known by the utilities [7–9].

2.2. Non-technical losses

The actions of external are caused by the Non-technical losses and then these actions are follows: power system's external actions, mainly the theft of electricity, customer non-payment regards to the errors in the meter reading and in maintaining the record. The NTL activities are contributed and the factors can be shown in [10–13], and it can be categorized into the following forms:

1. Line diversion is unauthorized: stealing by means of bypassing the meters or the other way of making an illegal connections [13].
2. Line tapping is unauthorized: meters will be tampering and so the lower rates of the consumption will be recorded by the meters [11].
3. The lack of quality and the meter reading will be inaccurate [13].
4. Electricity bill of the customer are not accurate [10].
5. The techniques are poor for the poor revenue collection [12].
6. With the help of the internal employees, the bill can be arranged and the irregularities can be sorted, like the lower bills [12].
7. The non-metered supplies are not accurate when estimated. For example, rail traction and public lighting [12].
8. Faulty meters cause loss [10].
9. Non-payment of electricity bills [12].
10. The protective equipment, cables, conductors and the switchgear becomes loss if the equipment are damaged [11].

The electrical distribution business will help in the form of detecting the NTL, and it is said to be the very important task; because in Spain, represents the percentage of fraud based on the form of energy and in respect with the total NTLs. The NTLs is about 35–45%. There are so many fraud for the works and researches and they are from the literature.

The researched based on fraud and for the detection of NTL are present in various fields [56–65]. But, the researches that are based on the detection of NTLs in the power utilities is less though, the percentage of the NTLs is comparatively greater [66–70]. The research works are generally based on theory and the types of detection techniques used are less. The electrical companies adopt to the current methodology in terms of the NTLs detection. It is basically divided into two kinds. They are listed below:

(1) The primary type is based on the making of situ inspections for the wanted users, which is selected from the earlier zone.
(2) The secondary type is based on the user's study and it contains the null consumption at a certain point.

The primary issue that is faced in the primary alternative is that, it wants vast numbers of the inspectors, which results to high cost. The secondary alternative contains the problem of possibly detecting the users only with the null consumption. But, for the customers who have non-null consumption will be quite low when compared with their consumption. In recent days, the techniques of the data mining [71,72] will be applied to one or more fields and then the power utility will be considered as an industry, where it meets its success [73–78].