Review Paper on Prepaid-Postpaid Energy Meter With Distorted Distribution Voltage

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Abstract*—Electricity theft is a comprehensive problem in both developing and developed countries. Although the theft causes great economic losses and reduces reliability of power grids, the problem continues to grow.This paper proposes a mathematical model of multi-featured prepaid-postpaid energy meter with distorted distribution voltage. The evidence shows that theft is increasing in most regions of the world. The financial impacts of theft are reduced income from the sale of electricity and the necessity to charge more to consumers. Electricity theft is closely related to governance indicators, with higher levels of theft in countries without effective accountability, political instability, low government effectiveness and high levels of corruption. Distorted distribution voltage is the most significant revision in the new configuration since traditional distribution voltage is directly consumable in electric powered devices and facilitates the theft.The proposed model is simulated and tested over MATLAB/ platform. The results obtained are promising and complying with the existing system.

I. INTRODUCTION

In any power system, losses of electricity, at transmission and distribution levels include technical losses and non-technical losses (NTLs) or commercial losses, both. Technical losses involve inevitable dissipation of electric energy into the equipment, losses in dielectrics, and conductors. Non-billed electricity and billed but unpaid electricity, either due to metering/ billing errors, or fraudulent behavior of consumers are the major reasons for NTLs. These NTLs enhance the costs to utilities, genuine consumers and states [1]. It is recorded that more than 20% of the electricity generated in India is lost due to rampant thefts [2]. Additionally, more than 30% of total electricity generated in India is lost due to thefts and inefficiencies in transmission and distribution[3].

These issues are quite often prevalent in Indian power distribution system. If these losses are minimized, a lot of electrical power can be saved, and thus the economy of the country will increase by increasing the revenue collection. This is partially possible using a smart energy meter. Because a smart energy meter enables the power utility company to gather electricity bills from the consumers before to its consumption except for postpaid customers. Therefore, the new smart energy meters are being placed in place of the conventional energy meters to improve the accuracy, towards the enhanced capability to control irregular billing and power theft [4]. These smart meters (SM) differ from traditional

metering systems regarding their advanced communications and processing capabilities, enabling the collection of data regarding high resolution of consumption or consumer services (e.g. automatic efficient control of appliances, demand side management) [5]. The importance of introducing SMs, along with architectural model of a conventional energy meter and SM are explained in [6].

Also, the main differences between smart and conventional power meters, highlighting the new features, methodologies, possible functionalities and applications of modern SMs are discussed in [7]. A framework for characterizing and quantifying societal benefits, attributing to smart metering is presented in [8]. Moreover, nowadays, the energy consumption data collected from the advanced metering infrastructure implemented in smart grids identifies the possible defective smart meters and abnormal consumption patterns of consumers, to prevent the NTLs [9]. Besides, various SM data applications can add efficacy in demand side management, resulting in lower peak demand and operational costs, towards maintaining system security without any new investment costs in power system [10].

Power utility companies provide the facility to recharge the smart card or electricity bill payment from a remote place on customer's request at a suitable/ requested time. Pre-billing is bound to remove the unpaid bills and problems of human error during the billing meter, to ensure proper revenue for the power utility company.

II. LITERATURE REVIEW

Joaquim L. Viegas et al. (2017, [1]), this paper is an audit of writing with an investigation on a choice of logical examinations for discovery of non-specialized misfortunes. Non-specialized misfortunes happening in the electric lattice at dimension of transmission or of conveyance have negative effect on economies, influencing utilities, paying buyers and states. The paper is worried about the lines of research sought after, the primary methods utilized and the

restrictions on ebb and flow arrangements. Likewise, a typology for the arrangement of answers for identification of non-specialized misfortunes is proposed and the sources and conceivable assault/defenselessness focuses are distinguished. The chose writing covers a wide scope of arrangements related with non-specialized misfortunes. Of the 103 chose contemplates, 6 are hypothetical, 25 propose equipment arrangements and 72 propose non-equipment arrangements. Information based arrangement models and information from utilization with high goals are separately required in about 47% and 35% of the detailed arrangements. Accessible arrangements spread a wide scope of cases, with the primary impediment discovered being the absence of a brought together arrangement, which empowers the location of a wide range of non-specialized misfortunes.

Fernando Deluno Garcia et al. (2017, [2]), thinking about the rising interest for power the world over, a few innovations have been created to give an increasingly effective and present day control framework. In this unique circumstance, the savvy matrix idea is identified with the reconciliation and the board of various power framework gadgets, meaning to give specialized, financial, social and natural advantages. Subsequently, the shrewd meter has turned out to be one of the primary components in keen lattices and it might give substantially more abilities than the traditional electromechanical and electronic vitality meters. Along these lines, this paper examines the principle contrasts among shrewd and customary power meters, indicating the new highlights, strategies and uses of present day savvy meters. In addition, this paper manages the meaning of "savvy", presenting potential functionalities and applications that can adequately affect on the comprehension of the vitality utilization, while permitting to improve control the board and vitality productivity.

P. Loganthurai et al. (2017, [3]), the fundamental thought of the task is to modernize our charging framework utilizing GSM. The GSM is a method chips away at the standard of TDMA - time division various access and works at the recurrence of 900MHZ. The subtlety of intensity uprooted in the vitality meter is moved to the versatile utilizing GSM and it likewise demonstrates the units devoured by the heap. In the event that the quantity of units devoured by the absolute burden surpasses certain breaking point implies it will gives a notice dependent on levy and furthermore we are doing to kill ON and turn the heap by setting secret word to each heap utilizing GSM procedure. Hence with the assistance of this undertaking we can lessen the power bills.

B. Yildiz et al. (2017, [4]), this study makes use of Grounded Theory Methodology It comprises many unique methodological elements such as- developing substantive theory/ hypothesis rather than testing it, theoretical sampling, collecting and analyzing data simultaneously and most importantly (to this section), deferring literature review until the theory starts taking a shape. The later Glaser and his advocates argued for delaying the literature review in the substantive area of research until analysis is nearly over. They found ignoring literature of theory and facts on the area under study an effective strategy. They contended that delaying literature review helps the researcher generate a theory that is well grounded in the empirical data. They were of the view that postponing literature review helps in avoiding data contamination i.e., forcing data into pre-existing categories. As prescribed by the contemporary grounded theorists, though proscribed traditionally, this study carried out literature review. This chapter explains the use of literature in Grounded Theory and describes literature review strategies. It presents the literature on Indian power sector, its constituents and challenges. It then throws light on electricity theft and the role of employees in it. The chapter describes distinct perspectives on employee theft.

Sook-Chin Yip et al. (2017, [5]), grounded theory is considered to be an effective strategy for topics about which there is a paucity of knowledge. However, raised a counterargument saying, ‘but how can the paucity of knowledge be ascertained unless an initial review of literature is undertaken?’ The literature review, therefore helps in highlighting appropriate gaps in the existing knowledge providing a rationale for the study orienting the researcher and importantly, revealing how the phenomenon has been studied till date.

Not carrying out relevant literature review at an early stage can leave the researchers open to criticism, as it is not very wise to reinvent the wheel, and the researcher who is unaware of the relevant literature, runs a danger of doing the equivalent. The researchers must understand what might appear to be a totally novel idea to them in terms of a discovery in their research might simple be their own ignorance of the literature. Another conundrum exists related to substantive area of research- given that a researcher may not know what constitutes precisely the substantive area, how can he know what does not constitute area.

Vasundhara Gaur et al. (2016, [6]), the researcher cannot unlearn what he already knows therefore; it becomes impossible for him to carry out studies in his own area of expertise which appears unusual and counter-intuitive. The literature review can help the researcher in contextualizing the developing ‘sensitizing concepts and knowing how the phenomenon has been investigated to date. From the above discussion, it can be inferred that there does not exist a blanket ban on reviewing the existing literature in the Grounded Theory Methodology.

The core of the problem is not whether or not a literature review should be done- there is more or less a consensus that it should be done. The dilemma rather is - when it should be done and how extensive it should be.

It have advised cautious use of literature so that the researchers are able to maintain objectivity when undertaking the study. They further advised that the researchers should avoid developing an in-depth familiarity with the literature, because it might influence them and block their creativity. They further added that, "Also, the researcher does not want to be so steeped in the literature that he or she is constrained and even stifled by it. The contemporary Grounded Theorists appear to take a middle position- They not only acknowledge the original ethos of Grounded Theory, but also recognize the practical need of engaging with the existing literature early in the substantive area of research. Given the opposing perspectives about the role and place of literature review in grounded theory, each researcher must make an informed and logically justifiable decision regarding how and when existing literature should be used in their studies.

V. Preethi et al. (2016, [7]), in this study, prior to data collection, the existing literature on Indian power Sector, its constituents and challenges were reviewed. The review helped in identification of a business problem. To ascertain whether the phenomenon identified in the business problem had already been studied or not, further review of literature was carried out. The initial review suggested that the identified phenomenon had been researched- a) but in different contexts b) differently by different perspectives, but none painted the picture complete.

To be able to develop a holistic contextualized conceptual framework, development of a conceptual lens integrating all the major perspectives was felt important, hence, the literature review of the major perspectives on the phenomenon was carried out. Since, the purpose was to gain only a broad understanding of each perspective and not an in-depth familiarity, the literature review was intentionally kept limited. The approach of the study mirrored the suggestions outlined in the above paragraph. The coming section presents the literature review on the identified phenomenon.

III. TECHNICAL REVISIONS

The power losses occurred in power grids are divided into two groups: Technical and nontechnical losses. The technical losses are mechanical, electrostatic and electromagnetic losses occurring in the generation, transmission, distribution and conversion of energy in electric power grids. The nontechnical losses can be defined as illegal electricity consumption or electricity theft, which is made consciously by dishonest customers. The dishonest customers use several theft techniques such as illegal connection, misreading, power meter tampering and unpaid bills [3]. The following sections describe revisions required for existing power grids to solve the theft problem by considering known and probable electricity theft techniques. The revisions should be handled as a whole and zero tolerance policy must be applied against electricity theft.

Unusable Distribution Voltage

Distribution transformers step down high transmission voltage to low distribution voltage, which is directly consumable in electric powered devices. Therefore, utility customers can use utility electricity with a power meter and there is no need for an additional power converter. The power meters have no impact on utility power quality and they are only used to protect the cost benefits of utilities and their customers. Dishonest customers can use utility electricity by tampering or bypassing the power meter [7]. These theft techniques are easy particularly from overhead lines in rural areas since theft detections, which are made by utility staff, are impossible in every time. However, dishonest customers cannot use utility electricity without power meter in the case distribution voltage is harmful or insufficient for electric powered devices and it is safely used only with the power meter.

Using an external harmonic source in electric distribution centers is a practical and efficient way to distort the distribution voltage because of the following advantages. Firstly, the harmonics can be easily cleaned by a passive harmonic filter group, which is embedded in new power meters; hence, genuine customers are not adversely affected by distorted distribution voltage. Secondly, the distortion characteristic of the distribution voltage can be controlled by changing frequency and amplitude of the harmonic voltage. Therefore, different harmonic characteristics can be used for different customer types and regions. Thirdly, there is no need to change power architecture of existing distribution grids because only distribution transformers and power meters must be changed to implement the method. Finally, the harmonic voltage source needs no extra much power since harmonic voltage with low current is enough to distort the distribution voltage. These advantages reveal that use of an external harmonic voltage source is an easy and effective recyclable way for distribution voltage distortion.

Unusable Distribution Voltage for Street Lighting

Distribution voltage of street lighting systems has same electrical characteristics with usable home voltage, so overhead street lighting lines can also be used for electricity theft. In fact, there is no power in the street lighting lines at daylight hours owing to photocell sensors.

However, dishonest customers deactivate the sensors to employ the lines for the theft, in which distribution voltage has low power quality because of overload. This theft technique also leads to street lights working during the whole day rather than only evening hours. Therefore, distribution voltage of street lighting system must be inconsumable for conventionalelectric powered devices to prevent this theft technique.

DC distribution voltage is more reliable and efficient for street lighting systems owing to improved led and power conversion technologies [8]. This is the reason why DC distribution voltage can be preferred to change traditional AC voltage of street lighting systems. Dishonest customers, who know DC voltage is insufficient for conventional electric devices, give up using street lighting lines to meet their electricity needs. DC distribution voltage of street light system can be used only with a DC/AC power converter by establishing an illegal connection. However, the use of a power converter is not a practical way to employ the lighting lines for the theft since the converters are expensive electronics equipment. Even so, this way must be considered as a risk for the theft and an effective precaution should be taken against it. Electricity consumption of street lights is generally stable and limited. If the lighting power characteristic is abnormally changed, there is a theft attempt. In these cases, the lighting energy must be automatically cut for a short time by power control center. After this short time period, if the characteristic abnormality of the lighting power continues, the time of energy cutting is gradually increased until utility staff interfere the lighting system.

IV. CONFIGURATION MODEL

The working scheme of proposed model has been visiblyclarified with the help of a block diagram shown in Fig. 1.This proposed model is a combination of three sub-models as follows

- Distribution Transform
- Energy Meter
- Power Utility

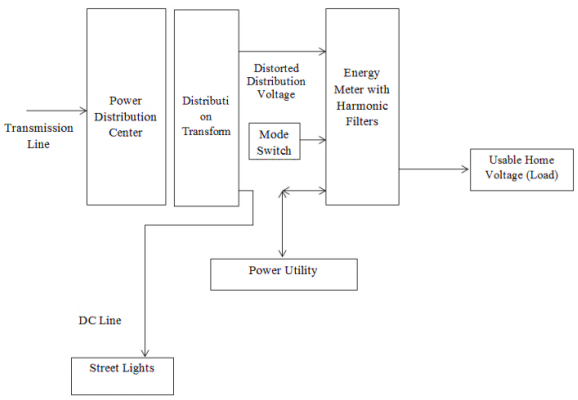

Figure 1: Block Diagram of Configuration Model

(i) Distribution Transform

The distribution voltage of the houses is distorted by an external harmonic source in the power distribution center. The power meter includes harmonic filters to eliminate harmonics of the distorted distribution voltage and provide reliable energy to domestic loads. 400 V DC voltage is utilized for the distribution voltage of street lights to make it unusable for traditional electric powered devices.

Figure 2 shows power components configuration of the power distribution center. Power distribution center includes a conventional transformer and power converters. The transformer steps down high transmission voltage to low distribution voltage to provide usable energy for residential areas. The AC/DC converter is utilized to produce 400 V DC, which is the suitable voltage level for DC distribution grids. The DC voltage is employed to supply street lights and the DC/AC inverter. The DC/AC inverter is serially connected to the distribution line of houses to distort its voltage characteristics with harmonics.

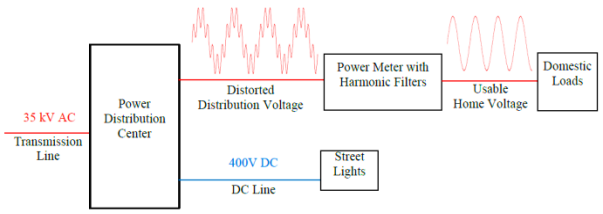

Figure 2:Use of distorted distribution voltage in an electric power grid

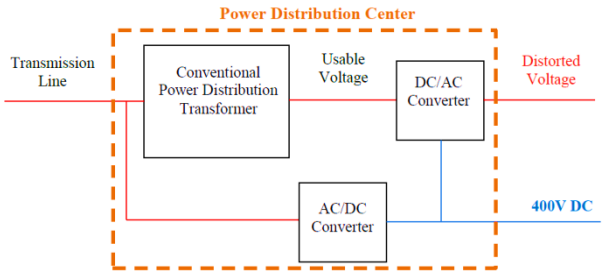

Figure 3:Power components configuration of the power distribution center

(ii) EnergyMeter

This proposed energy meter basically operates in two modes, i.e., prepaid and postpaid modes [4]. For this purpose, here mode switch is utilized for choosing either prepaid or postpaid mode. Due to this feature, the consumer has the freedom to choose prepaid or postpaid mode as per their requirement. This energy meter consists of following components:

Sensors:Inthisproposedmodel,voltageandcurrentsensors are utilized to quantify the voltage and current from the power supply.

Power Factor Model: MATLAB® simulated model of

power factor block is presented in Fig. 2. It receives voltage and current from the power supply and calculates active, reactive and apparent power, and hence calculates the power factor to be transferred to the smart card.

***Latching Relay*:** A latching relay is an interconnecting link between the consumer's load and power utility supply. The opening and shutting off this relay depend on the balance or time present in the smart card [15]. In the event of prepaid mode, if the smart card has sufficient balance, it remains shut and keeps the power supply continuous to the consumer's load. When the smart card runs out of balance, it opens and detaches the load from the supply. At the point when the smart card has insufficient time, it operates and detaches the load from the supply. Consequently, notwithstanding when the energy meter gets the voltage supply, it does not reach the consumer's load as the latching relay remains open due to the absence of balance or time in the smart card. Since the latching relay also consumes some amount of electrical energy, it has been included in the computations made by the meter and smart card.

DC Power Supply: The DC power supply unit gives the operationalvoltageof5voltsfortheMicrocontrollerunit, Buzzer and LCD display etc. Circuit diagram of DC power supply is shown in Fig.4.

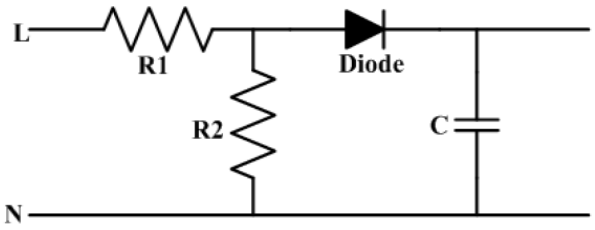

Fig. 4 DC Power supply

(iii) Power UtilityCompany

This proposed energy meter transfers the data to the power utility company through wireless communication at stored by power utility company at each instant. Utility company always monitors the energy meter remotely.

V. CONCLUSION

This paper displays a model of prepaid/ postpaid energy meter with technical revisions required to prevent electricity theft and presents a new electric distribution grid model including the revisions. This is an effort towards enhancing the revenue collection for the scheduled supply and revisions are determined by considering widely used electricity theft technics and included appropriate technological solutions against the theft technics. In the new model, inconsumable distribution voltage has a key role since consumable distribution voltage facilitates the theft and better efficiency in the measurement of rated load, power factor, output voltage, output current and system behavior. It is efficient for monitoring and controlling of energy consumption.

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