Optimization of Power Distribution System Non-technical Losses by Using SVM and AMI Methods

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***Abstract*— The distribution sector companies suffer from revenue losses because of the nontechnical losses (NTLs). NTLs mainly caused by the illegal activities of the customer. NTLs caused a chain of further losses, such as damage to the distribution infrastructure components of grid, resulting in reduced distribution grid reliability .additionally lead to economic losses .This paper explain the cause of NTLs and methods of it, history for discovering the techniques of NTLs and the economic losses , methodologies, and approaches aimed at continually optimizing in the accurate estimation and decrease of NTLs ,by using support vector machine SVM and advanced measurement infrastructure, as a solution to minimize the NTLs.**

Keywords*— Classification; nontechnical losses; distribution grid system; costumer load profiles; theft of electricity (TOE); SVM; AMI.

I. INTRODUCTION

Electricity is a backbone of the live and development of any society measured by the consumptions electrical power, it is considered as an indicator of it is socio economic situation the losses that accompaniments to the generation of electrical. power system including generation sector ,transmission sector, and distribution sector any problem in one of this sector cause a big problems, One of this problems is the financials losses which lead to decrease to the electrical power to the providers and decreased the reliability and stability of the electrical power .We can classified these losses in to technical losses (TLs) and NTLs losses, TLs are usually accompaniments of electrical components like generator , transmission lines and transformer as a result of initial resistance .this losses are possible to calculate ,detect and control by given acknowledge of the loads volumes. TOE plays a pivotal function in non- technical losses. In numerous countries the economic development is hampered by incompetent and illegal supplies of electric power because of theft of electricity .NTLs as well defined as a nonphysical losses are commercial losses, connected with the quantity of electricity not billed and not paid that billed .In some country when the electric energy funded by Governments some of companies or persons they may paid a bribes to government officials to condonation the amount of electricity that consumed by them, and that lead to a big financials losses for electric energy sector in these countries and these losses funded by public means .In this paper present a stringent study of quality for NTLs resource and their possibly of economic effects and discovering techniques of NTLs considered by many electrical power distribution companies.

A. Modules of Non-technical Loses

Nontechnical losses are primarily associated with customer management and electricity theft in which there are several of methods Consciously defraud the respective facilities. In many developing countries, distribution, and transmission Loss Calculation for a high part of nontechnical losses, which indicates that the electrical facilities management should focus on the limit nontechnical before reducing technical losses. nontechnical Includes The next activities:

- Tamper with energy meter to ensure it record less than consumption reading.
- Connecting wires on low tension lines.
- Ignoring unpaid bills by bribing readers meter and arranging false readings.
- Errors in calculating technical losses.

Unregistered load Connecting directly to the electrical low-tension line and Tamper by the registered load's meter to order to minimize the bill amount. In this case of seals are broken for the meter many scenarios can be done to stop or slow the meter reading. NTLs are defined that the losses occur out of the Transmission & distribution technical losses of the electrical energy. In the naturalist circumstances, the electrical energy which generated by power plants should be like consumed energy. The loss of energy is a comprehensive results of transmission power and distribution power. Davidson defined these energy losses can be calculated with Eq. (1)-(3) [1]:

$$E_{\ loss} = E_{delivered} - E_{sold} \quad (1)$$

$$C_{Loss} = U_{cost\ of\ electriccity} * E_{Loss} + M_{cost\ of\ maintenance} \quad (2)$$

$$C_{NTLs} = C_{Loss} - C_{Technical\ loss} \quad (3)$$

In formula (1), E_{Loss} , $E_{Delivered}$, E_{Sold} represent energy losses, delivered energy, sold energy respectively. In formula (2), C_{Loss} , $U_{cost\ of\ electriccity}$, $E_{cost\ of\ maintenance}$ represent revenue loss due to technical losses, electricity cost, maintenance cost respectively. In formula (3), C_{NTLs} , $C_{Technical\ loss}$ represent nontechnical loss, technical loss.

Technical losses are calculated by using suitable load flow Simulated studies in the MATLAB software program. Minimizing the nontechnical losses is important for corporation of electricity distribution. Since the traditional method of worked with NTLs lead to imposes expensive operation proses costs caused to use of a large human resources and onsite checking by employees of the corporation [2]. Because of that, it is necessary to make effort to Designing new and efficient technologies aimed at minimizing operation Costs of monitoring nontechnical losses activities.

B. Economic Effects of NTLs

Electricity theft in the India results in estimated annual losses4.5 billion US dollars, which is about 1.5% of the Gross

Domestic Product [3]. Problem NTLs are not just only encountered by the lower growth countries African and Asian regions, but also by the developed countries like British and America [4], [5]. frankly, high ratio of NTL activities has been reported in the multitude from developing countries in the Association of Southeast Asian Nations (ASEAN) group, which include, Indonesia, Malaysia, Myanmar, Thailand, and Vietnam [4]. In the 2004, Tenaga National Berhad (TNB). the prime electricity provider in Malaysia registered income loss of about 229 US million per year due to NTLs [6-8].

The council of electricity in the state of Andhra (India) that is vertically owned by the government power integrated facility which serving about 13 million users. Afforded from high and the financial losses increase in the ninth decade of the last century, was appending up to 0.8$ US billions by 1998 because of NTLs [9]. A rough copy from world bank[9] [10] report shown achievements of the facilities in the regions of sub-Saharan. The median advantage in that area presents tremendous inefficiencies. Just 52% of the energy generated is billed compared to the amount of energy injected into the grid for which it is billed, but rest bills are not paid because of the low rate of bills collection by employees [10]. The variation in achievement is large, with the huge inefficiencies Nigeria for example the facility can capture just 25% of owed revenues. Other research has presented those concealed costs of distribution sector losses in Sub Saharan in Africa are generally more than 0.6% of gross domestic product and this amount may reached to 1.6% of gross domestic product in other countries [9] [10].

II. History of Discovering the Techniques for NTLs

Discovering of NTLs it is not new area of researches. It will occupy more than decades of research to discover the variety and notable methodologies for diagnosing theft of electricity to same extent. Procedures of the protection from TOE came in to being in the 1899, Association of Edison Illuminating Corporation (AEIC) showed that electrical power theft was an early interest, and it might be even more pivotal in the close future, AEIC constitute a committee, the recommendations of this committee was incorporated several improvements such as structure of energy meter which designed and support to reduce curiosity tampered with inner mechanism [19]. GE company I 70S in 1969 and Schlumberger J5S in 1983 are the new meters which having properties proposed through AEIC [19]. technological up alternative and gradation led to develop energy meters and that led to rising energy industry in the end 19th century.

III. Detection of Electicity Theft

A. *Detect theft by Support Vector Machine(SVM) and Genetic Algorithm (GA-SVM)*

SVM is the supervised machine learning method which is used to classifications the data. Mainly aim of using SVM is to classify the invisible data strictly decreasing classification error using function of decision. This can be done by training the SVM on the training data and directly thereafter using it to predict the output group of the invisible data, as shown in Fig.1.In the end of 1960s V.N Vapnik introduced the SVMs [12]. the theory of Statistics learning is the basis of the SVM. The SVM mainly employ for regression and classification SVM classifies customers loads profile to detection of fraud cases suspects. The different steps used in SVM classifier are [13]:

- Data pre-processing.
- Data normalization.
- Choice of appropriate kernels.
- Choose modeling parameters.
- Train and test the classifier.

Genetic Algorithm- Support Vector Machine. In this method it proposed a hybrid converging for analysis of non-technical losses by using the AG-SVM. In this method depend on using the historical data from distribution company. future extraction process was used for load profiles in synchronization with SVM. firstly, customer consumption patterns are extracted by using the techniques of mining data Which exemplifies the loads profile of the customers [8]. It supposed when a theft case occurs, the load profile will be affected by these abnormalities and show it as default.

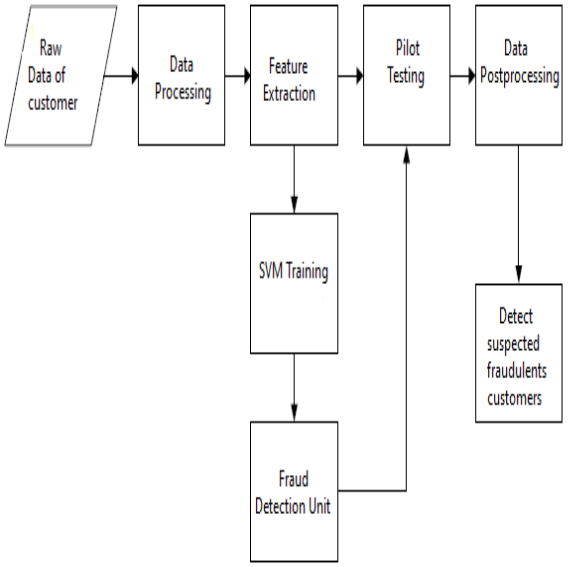

Fig. 1. Detecting Fraudulent Electricity Customers by using GA-SVM

The structure acting with the historical information data for 256,780 customers through a duration of time about 26 months thereafter customer selection and filtrate features can be taken from dataset for classifier of SVM. It noted that a hit rate of 23% is carried out when the onsite scanning it is performed through the distribution company on the overall number of clients shortlisted by fraud detections models.

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B. *Advanced Measurement Infrastructure (AMI)*

The metering reading system and metering system are the mostly faulty in the sub-distribution system. Since Billing system are slow, traditional, costly, inaccurate, less reliable, and discrete, automate Billing system reducing previously problems. Energy billing system error due to error in each phase of energy bill like human error, electromechanical meter error, an error occurred while processing paid invoices, and

the solution of this problem is advanced metering infrastructure (AMI). AMI can supply readings of consumption of the electrical power which are hard to impact with basic fraud and theft detection mechanisms. In Fig. 3., distribution of energy shown by using advanced metering infrastructure method. The smart power meter connected to distribution grid and reading of the consumption power in the customers side is collected at information data center during different type of communication network such as radio mesh or PLC. This collected data are analyze through various specified software depend on static rigging disclose modules. The required decision is executed dependent on the results of the analyzed data. The AMI can solve the unpaid bills problems, adding to the service such as remote check and prepaid billing.

IV. Suggestions to Reduce NTLs

The following suggestions that may be effective for Reduce nontechnical losses:

- Statistical monitoring of electricity consumption should be used for each sector, for each category and geographic setting.
- Readings of meter should be undergone static evaluation.
- To reduce theft, smart meters and smart grid should be used in tandem.
- Online prepaid power meters and Integrated billing system are one of the best choices that can be followed to achieve effective results.
- Loyalty learning meetings and technical training for the employees and operating personnel of power utility companies to develop the loyalty as well as technical knowledge.
- Educate customers about the rigorous laws that can be used Against them if discovered while stealing electricity.
- The companies should be providing a incentives for staff which discover theft in electricity. This action led to supporting onsite regular check-up mechanism.

V. Conclusion

We explained, in this paper the sources of NTLs, the method that diagnosis NTLs and consequences on the economic and social for the countries. There is no set method can be dependent on and consider it a best way to detect NTLs. Prepaid power meter gain large popularity between the customers and electrical distribution firms, but until now some efforts should be made with a view make prepaid power meters more customers convenient. However, development in the technologies with best statistical approaches and computational can support to produce more striking and efficient techniques during after time of years.

With the growth of the economy, increasing generation power is not the suitable solution in order to meet the energy demands, It is noted that the large proportions of the generation power resources such as coal It is in stage of extinct. The construction price of modern electric power units is relatively high with the cost of equipment to reduce losses. In order to develop the economy, it is necessary for electrical power firms to focus on nontechnical loss minimization rather than only minimizing technical losses, Because of the specific evaluate of nontechnical losses is answerable for predicting the factual amount of energy that should be generated in the future in order to meet this demands. Reducing NTLs secure that the electricity cost for customers will be minimized and thus will be Improving the best performance of the distribution grid.

VI. Future Work

Non-technical losses in all their forms are among the real and fundamental problems of energy distribution companies. There are many options that can be adopted to reduce these losses, which include monitoring consumers by special programs as well as smart meters and pre-paid meters. Prepaid meters are considered one of the successful methods must be adopted by distribution companies to reducing the gap between Produced energy in the production sector and energy consumed in the distribution sector. Where offers can be made to encourage consumers to acquire this type of meters, as well as making facilities for meter charging operations with units that maintain the consumer's electric energy.

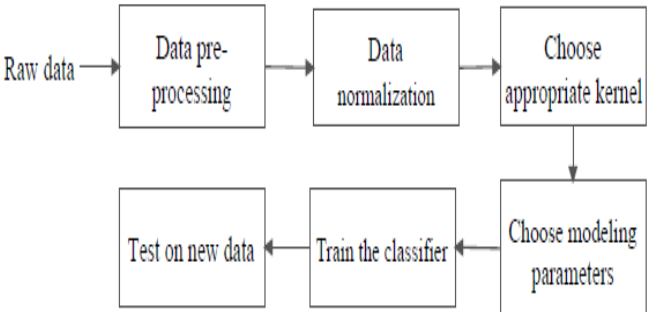

Fig. 2. SVM Classification Process

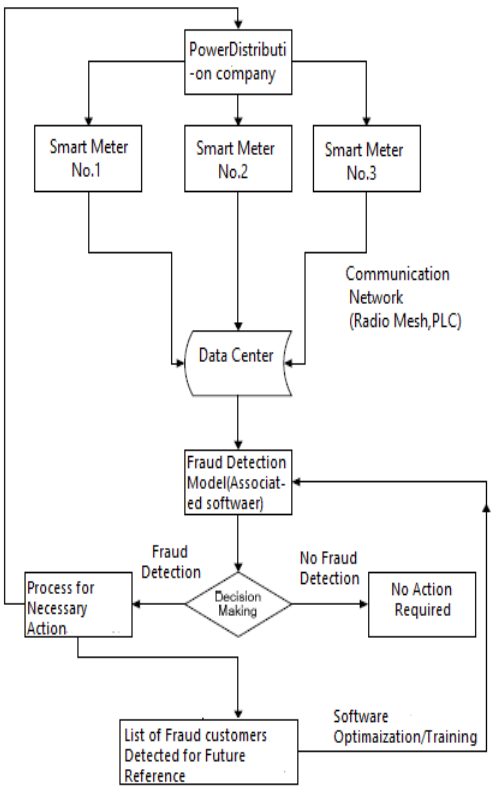

Fig. 3. Distribution Grid using AMI methodology

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