SYNOPSIS

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Thesis title: **TO DEVELOP AN ANALYTICAL FRAMEWORK OF ELECTRICAL POWER CONSUMER'S BEHAVIOUR TO ASSIST IN THE IDENTIFICATION, DETECTION AND PREDICTION OF ELECTRICAL POWER LOSS**

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In India, average power losses, have been officially indicated as 23 percent of the electricity generated. However, these losses have been estimated to be as high as 50 percent in some states. With the setting up of State Regulatory Commissions [1] in the country, accurate estimation of T&D Losses has gained importance as the level of losses directly affects the sales and power purchase requirements and hence has a bearing on the determination of electricity tariff of a utility by the commission [7].

Power losses occur in the process of supplying electricity to consumers due to technical and commercial losses. The technical losses are due to power dissipated in the conductors and equipment used for transmission, transformation, sub- transmission and distribution of power. These technical losses are inherent in a system and can be reduced to an optimum level. The losses can be further sub grouped depending upon the stage of power transformation & transmission system as Transmission Losses [2] (400kV/220kV/132kV/ 66kV), as Sub transmission losses (33kV /11kV) and Distribution losses (11kV/0.4kv). The commercial losses are caused by pilferage, defective meters, and errors in meter reading and in estimating unmetered supply of energy.

Experience in many parts of the world demonstrates that it is possible to reduce the losses in a reasonably short period of time and that such investments have a high internal rate of return. A clear understanding on the magnitude of technical and commercial losses is the first step in the direction of reducing power losses. This can be achieved by putting in place a system for accurate energy accounting. This system is essentially a tool for energy management and helps in breaking down the total energy consumption into all its components [3]. It aims at accounting for energy generated and its consumption by various categories of consumers as well as, for energy required for meeting technical requirement of system elements. It also helps the utility in bringing accountability and efficiency in its working. Unmetered supply to agricultural pumps and single point connections to small domestic consumers of weaker sections of the society is one of the major reasons for commercial losses. In most states, the agricultural tariff is based on the unit horsepower (H.P.) of the motors [2]. Such

power loads get sanctioned at the low load declarations. Once the connections are released, the consumers get into the habit of increasing their connected loads, without obtaining necessary sanction, for increased loading, from the utility. Further estimation of the energy consumed in unmetered supply has a great bearing on the estimation of power losses on account of inherent errors in estimation. Most of the utilities deliberately overestimate the unmetered agricultural consumption to get higher subsidy from the State Govt. and also project reduction in losses. In other words higher the estimates of the unmetered consumption, lesser the T&D loss figure and vice versa [6]. Moreover the correct estimation of unmetered consumption by the agricultural sector greatly de- pends upon the cropping pattern, ground water level, seasonal variation, hours of operation etc. To increase the food output, almost all the State Governments show benevolence to farmers and arrange supply of electric power for irrigation to the farmers at a nominal rate, and in some States, without charges at all. In view of this, most Electricity Boards supply power to agriculture sector and claim subsidy from the State Govt. based on energy consumption. Since the energy supplied to the agriculture sector is a generous gesture by the State Govt., all the electricity boards have eliminated energy meters for agriculture sector services. The absence of energy meters provides ample opportunities to SEBs to estimate average consumption in agriculture sector at a much higher value than the actual. In the absence of energy meters, most of the SEBs resort to fudging consumption figures to include not only the under estimated T&D Losses but also energy theft from their system. The extent of fudging is more in the States where agricultural activity is high. The benefit derived by these boards is not only the extent of subsidy from the respective States but also self-praise by showing much less T&D losses. Further the boards are ignoring the inefficiency in operating the distribution system by blaming the agricultural supply for all ills and raising the tariff of other consumers. Most of the methods being employed by SEBs for estimating the unmetered energy consumption are as follows: (1) Load factor based estimation. (2) Estimation based on feeder wise theoretical calculation of losses. (3) Estimation based on readings of meters installed at all the Distribution Transformers located on a feeder. However, none of these methods provide correct estimation of unmetered consumption [5].

Data mining is employed to meet the above challenges in this research. Data mining is defined as “a process of discovering various models, summaries and derived values from a given collection of data.” Several data mining studies on fraud identification and detection in electricity businesses are already researched, including rough sets, decision trees, Artificial Neural Network (ANN), statistical-based outlier detection, and wavelet-based feature extraction and multiple classifiers. In addition to this, data mining techniques are also been used in the other types of businesses including telecommunications, insurance, risk management, and credit card provision. Most of these studies used data mining techniques by directly applying them to customer databases as inputs. In each context, data mining has been examined as a tool that enables the detection and prediction of fraud. All of these applications employed data mining techniques to expose of fraud directly from their customer databases. The approach adopted for the present research is slightly different in terms of its exposure of fraud from time-series models derived from a load profiling module [8].

- Main Objectives

It was the need to deal more efficaciously with unmetered power losses activities that motivated the present study. Specifically, the intention has been to use the knowledge gathered from customers' load profiles to detect significant behavioural deviations that signal such activities. The unmetered power losses that has been observed in many countries is a significant concern. It is important, therefore, to be able to identify and predict possible unmetered power losses activity by means of analysing the data normally made available through Customer Information and Billing Systems [19]. Such analysis focuses on customers' behaviour changes by identifying significant deviations in their load consumption patterns made apparent through load profiling and data-mining techniques. The aim of the present research is to propose and develop a framework of analysis to be applied to customers' behaviour so as to aid the identification, detection and prediction of unmetered power losses activity. This is to be achieved by pursuing significant deviations in their load consumption revealed by data mining techniques. The resulting identification framework for unmetered power losses analysis that has been developed here will significantly benefit both the electricity supply utilities and their customers [20].

More specifically, the present study pursues the following objectives in its development and application of load behaviour profiling and data-mining techniques. To investigate whether abnormalities and irregularities of customers' behaviour that signal unmetered power losses activity can be identified, detected, and predicted through the proposed analytical Frame work by investigating and monitoring significant deviations in customers' load consumption. The proposed analytical framework using advanced data-mining techniques, including Extreme Learning Machine (ELM) [9], Online Sequential ELM (OS-ELM) [10], and Support Vector Machine (SVM) [13], and applying two activation functions, namely sigmoid and radial basis function (RBF) nodes. To experiment with and produce the flow processes of the proposed analytical framework using MGVCL commercial customers' load consumption data to comprise the training data and testing data for three comprehensive analyses: feature selection process, classification analysis, and prediction analysis.

Unmetered power losses activity is considered to be a serious problem for many electrical utilities worldwide. Not only does it affect a company's profitability and credibility, but it also increases the cost of electricity to customers. Therefore, the need to minimize the extent and impact this problem is crucial for both the utilities, including MGVCL Gujarat that is the focus here, and their customers. The analysis and the results of the research reported in this thesis show the effectiveness and significance of identifying, detecting, and predicting unmetered power losses activity through the proposed analytical framework.

Chapter 1: Introduction of power losses in India, Main factor of power losses and types of power losses. The commercial losses are caused by pilferage, defective meters, and errors in meter reading and in estimating unmetered supply of energy. Purposed data mining techniques and significant benefits.

Chapter 2: Customers load profile study and load profile approached. Load profile and data mining techniques, different types of clustering, electrical power losses and fraud detection techniques.

Chapter 3: Data pre-processing analysis, feature selection analysis, detection analysis, classification analysis and prediction analysis.

Chapter 4: Unmetered power losses analysis framework, data pre-processing and data normalization. Load profiles for customers of summer, winter and monsoon. Detection analysis, Key Algorithms for Customer Behaviour Classification and Prediction (ELM, OS-ELM and SVM).

Chapter 5: Classification of electricity customer behaviour using Extreme Learning Machine (ELM), Online Sequential Extreme Learning Machine (OS-ELM), and Support Vector Machine (SVM). Result analysis and comparison for ELM, OS-ELM and SVM.

Chapter 6: Presents the main finding of the thesis and makes few suggesting for further researches work in this field.

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