Research on Electricity Consumption Pattern of Households

M.D Lakmali

139170T

Dissertation submitted to the Faculty of Information Technology, University of Moratuwa, Sri Lanka for the partial fulfillment of the requirements of the Master Degree of Science in Information Technology.

April 2016

Declaration

I declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any university or other institution of tertiary education. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

Name of the student : Lakmali M.D

Student Number : 139170T

Signature of the student: ..... Date: 29/04/2016

Supervised by

Name of the supervisor: Mr. Saminda Premaratne

Signature of the supervisor: ... *UOM Verified Signature* Date: 29/04/2016

Dedication

This Dissertation is dedicated to my loving parents for being part of me and encouraging me always being by my side.

Acknowledgement

First I express my heartfelt appreciation and gratitude to my supervisor Mr.Saminda Premaratne for his most valued guidance, commitment and kind support to make this research success.

My next thank goes to Prof. Asoka S Karunanda who taught us Research Methodology and Literature Review and Thesis Writing subjects which were more benefited us throughout the research work.

Also sincere appreciation is extended to Eng.Mr.Kanishka Jayasekara, Deputy General Manager (Information Technology) for his valuable opinions and encouragement given to me in this endeavor.

Special thanks go to Eng.D.K.P.U. Gunathilake, Deputy General Manager (Northern Province) and Eng.S.Gnaganeshan, Area Engineer (Jaffna) for the great effort given me to do this research in a successful manner.

It's my pleasure to thank Ms.Anusha Selvarasa (Electrical Engineer –SCADA Systems and Control Centre) for the tremendous support giving me throughout the research for the data collecting process.

It is my great pleasure to thank all the other Senior lecturers, Lecturers, Instructors, and staff members who helped us in many ways to make this research. The guidance and support received from all the members who contributed and who are contributing to this project, was vital for the success of the Research. I am grateful for their constant support and help.

Then I would like to thank my all the batch mates of the M.Sc in Information Technology batch 7 in faculty of Information Technology for their various help and support. And also other friends of the faculty as well as friends for outside who gave me support and encourage me with their best wishes.

Abstract

There is a growing tendency in the usage of electricity consumption over last two decades in Sri Lanka. The electricity sector is growing rapidly and the demand is also increasing day by day. The technology of Sri Lanka is also evolving rapidly with compares to the 60 70 decades, the demand of electricity consumption is increased. When the demand is increased the electricity network should have the facility to distribute the correct level of electricity load to the correct transformer where the houses are basically connected. So it is necessary to look at the electricity consumption pattern of households for a specific recent time period and based on that there should be a way to find the key factors of the behaviors of people which are mainly affected for the energy requirements.

Electricity consumption is on a constant rise with domestic use contributing substantially to the overall consumption. As the population of Sri Lanka growth along with the using of daily electric appliances to make the life easy, also drive to the electricity demand to higher levels. Targeting domestic electricity consumption pattern become most influential factor to make the global consumption to be lowered. This involves understanding and changing the consumer's behavior, awareness and increasing their knowledge on the subject of electricity conservation methods. In this research various factors affecting for the household electricity consumption are analyzed. And also the energy awareness, related interests and also the knowledge level is considered when trying to explain differences in household consumption patterns.

Ceylon Electricity Board is the only major utility in Sri Lanka where the electricity is generated for the whole nation. For this research, consumers from Jaffna area in Northern Province are selected for the sample data gathering. Consumers are categorized in to different consumption groups (average consumption groups) and well defined questionnaire is distributed among consumers. The consumer's consumption and billing related information is extracted from the Ceylon Electricity Board's databases. The collected data will be processed and analyze the consumption pattern and indentify the ways to increase the energy conservation habits. The classification and decision trees in data mining are used for the analysis step.

For the further work it is necessary to educate the consumers towards the use of electricity efficiently and save the energy for the future demands. For that it should start from the individual household and expand that to the whole country.

Table of Contents

List of Figures

List of Tables

Definitions, Acronyms and Abbreviations

DDR1	Distribution Division Region 01
DDR2	Distribution Division Region 02
DDR3	Distribution Division Region 03
DDR4	Distribution Division Region 04
CEB	Ceylon Electricity Board
GUI	Graphical User Interface

Chapter 1

Introduction

1.1 Background and Motivation

Household electricity consumption in the country significantly increased in the last two decades due to two major reasons, expansion of rural electricity distribution programs and dramatic increase of types of energy consuming equipments in use and the pattern of using those equipments.

Sri Lanka's Energy Balance shows that the domestic sector accounts are for one third of the national electricity consumption. Therefore it is timely that the proper energy conservation programmers are introduced in this sector for the process of energy management at a national level. Introducing such energy conservation programs is very important to understand the domestic energy consumption pattern in order to identify the attitudes and behaviors of the people that lead to waste or save energy.

Ceylon Electricity board is one of the major utility in Sri Lanka which is generating electricity for the whole nation. By looking at their statistics for last ten years, we can clearly see the demand for the electricity is increased and the growth of the new consumers for this electricity network is also increased by analyzing the total customer growth per year. So it is necessary to build up the habits of the people towards energy saving for save the energy for our future generation. The background of the research is based on this concept.

This research is aiming to identify the electricity consumption pattern in houses in Northern area .The reason behind to identify that area is, the electrification is done recently (By Uthuru Wasanthaya Program) and it is necessary to identify the behaviors pattern of people to minimize losses. And also to identify where there is a need to do some energy conservation programs to them to make the best out of appliances and the effective use of energy.

1.2 Electricity Consumption in Sri Lanka

Ceylon Electricity Board is a corporate body established under the Act of Parliament No.17 of 1969.It is the national institution charged with the responsibility of generating, transmitting and distributing electrical energy to reach all categories of consumers nationwide. It consists of 4 Distribution divisions (DDR1, DDR2, DDR3,

DDR4), 12 provincial offices, more than 60 area offices and 200+ consumer service centers island wide.They have nearly 5.5 million of customer base and the annual turnover is more than 200 billion Sri Lankan Rupees and the current electrification level is more than 90% and they are planning to make that 100% of electrification within next couple of years.

Ceylon Electricity Board published Statistical Analysis Reports which summarize the reports such as

- Electricity Generation Statistics
- Electricity Sales by Province
- Electricity sales by Tariff
- No of consumers account by Province
- No Of Consumer Accounts by Tariff
- Revenue from electricity sales
- Details of power complexes and the current capacity

The data extracted from Ceylon Electricity Board's Statistical Analysis reports the consumption of the electricity can be analyze in different ways.

Total Electricity Sales from 2005 to 2013 and the domestic sector (domestic tariff category) contribution is shown below (Data extracted by statistical analysis reports from 2004 to 2013)

Year	Total Sales in GWh (Million MWh)	Domestic Sales in GWh(Million MWh)	The percentage of domestic sector for the total sales
2004	6667	2166	32.49
2005	7255	2403	33.12
2006	7832	2579	32.93
2007	8246	2728	32.84
2008	8417	2757	32.76
2009	8441	2883	34.16
2010	9268	3138	33.86
2011	10023	3379	33.71
2012	10474	3522	33.63
2013	10621	3488	32.84
Total	87274	31199	33.23

Table 1: Total Electricity Consumption from 2004 to 2013 and the Domestic Consumption

Total Electricity Sales and the Domestic Electricity Sales

Year	Total Consumer accounts	Increase No of accounts	Increase Percentage	Domestic Accounts	Increase amount	Increase percentage	Domestic Contribution
2004	3206892			2823654			
2005	3396047	189155	5.9	2988223	164569	5.8	88
2006	3636242	240195	7.1	3203049	214826	6	88.1
2007	3866987	230745	5.8	3409440	206391	5.5	88.2
2008	4088900	221913	5.7	3608347	198907	5.5	88.2
2009	4280168	191268	4.7	3781674	173327	4.8	88.4
2010	4480423	200255	4.7	3958829	177155	4.7	88.4
2011	4717448	237025	5.3	4165738	206909	5.2	88.3
2012	4979862	262414	5.6	4391445	225707	5.4	88.2
2013	5210761	230899	4.6	4589929	198848	4.5	88.1

Table 2: Total Electricity Sales and the Domestic Electricity Sales

Figure 1 shows total energy sales in Jaffna area and the domestic contribution for the sales, here we can see considerable amount of sales are from domestic account holders and hence it is timely requirement to analyze electricity consumption pattern of domestic consumers both qualitative and quantitative manner. Figure 2 shows the total consumer base from 2004 to 2013 and the total domestic consumer contribution for that. We can see the height numbers of consumers are from domestic sector. Figure 3 shows the total consumer growth in Jaffna area from 2005 to 2015.we can see after July 2012 the number of consumers has increased rapidly. Figure 4 shows total KWh units consumed by consumers in Jaffna area. On the other way the total energy is consumed by Jaffna area. Figure 5 shows how the electricity demand prediction in future, here we can see the demand is increasing every year. As a result, there should have proper mechanisms to save energy for future needs.

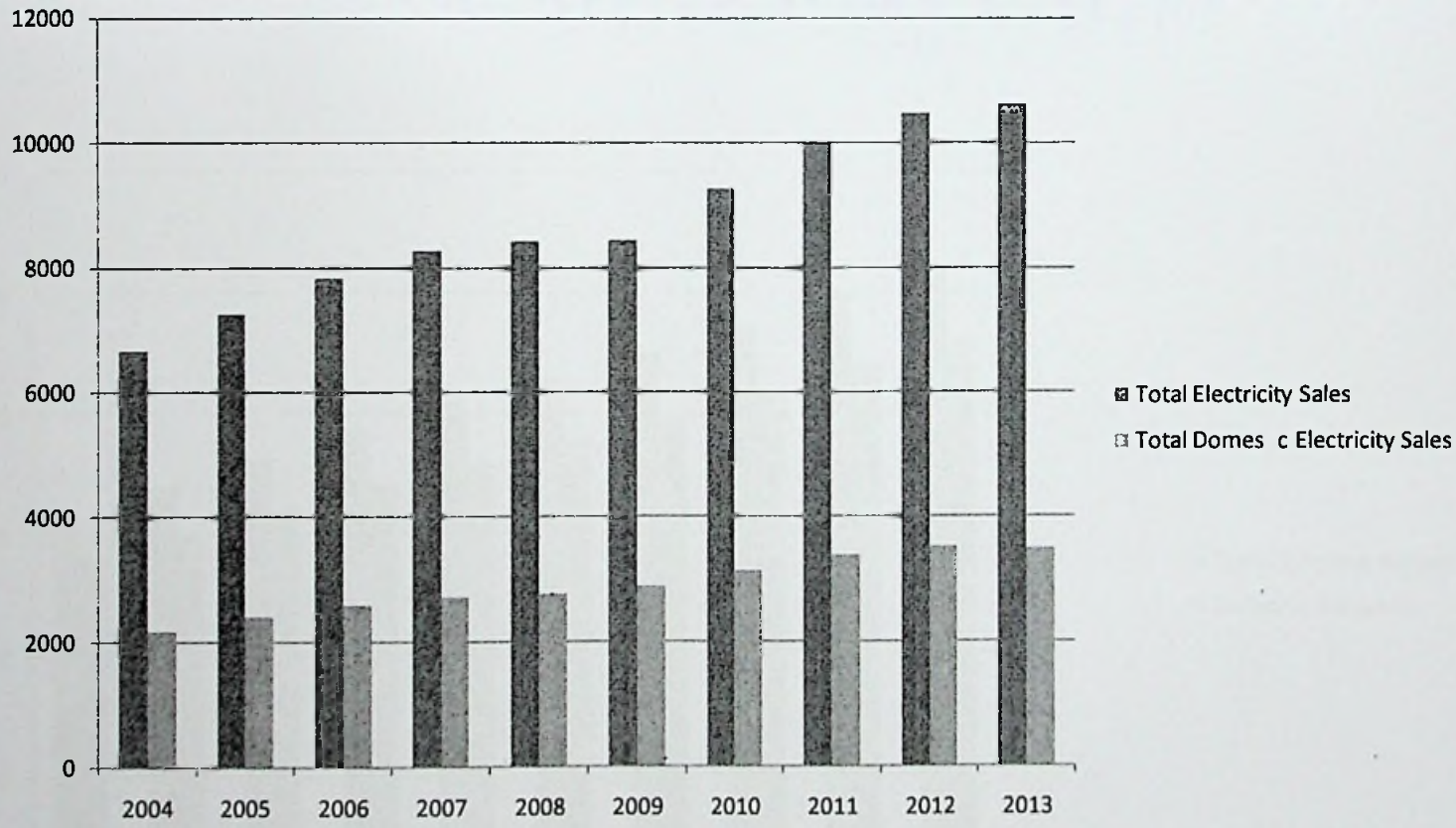


Figure 1: Total Energy Sales in Jaffna Area in GWh

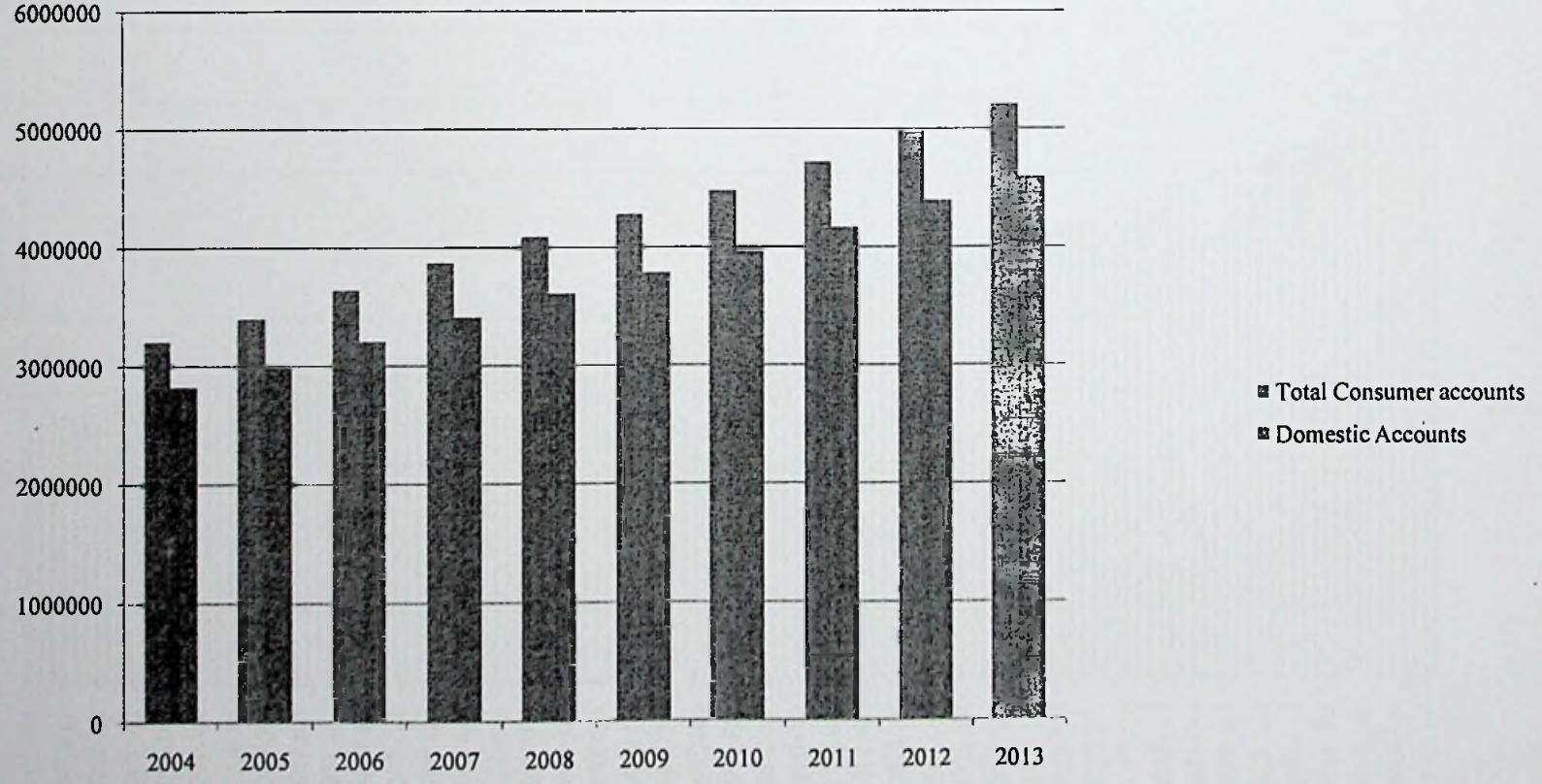


Figure 2 :Total consumers and total domestic consumer accounts in Sri Lanka from 2004 to 2013

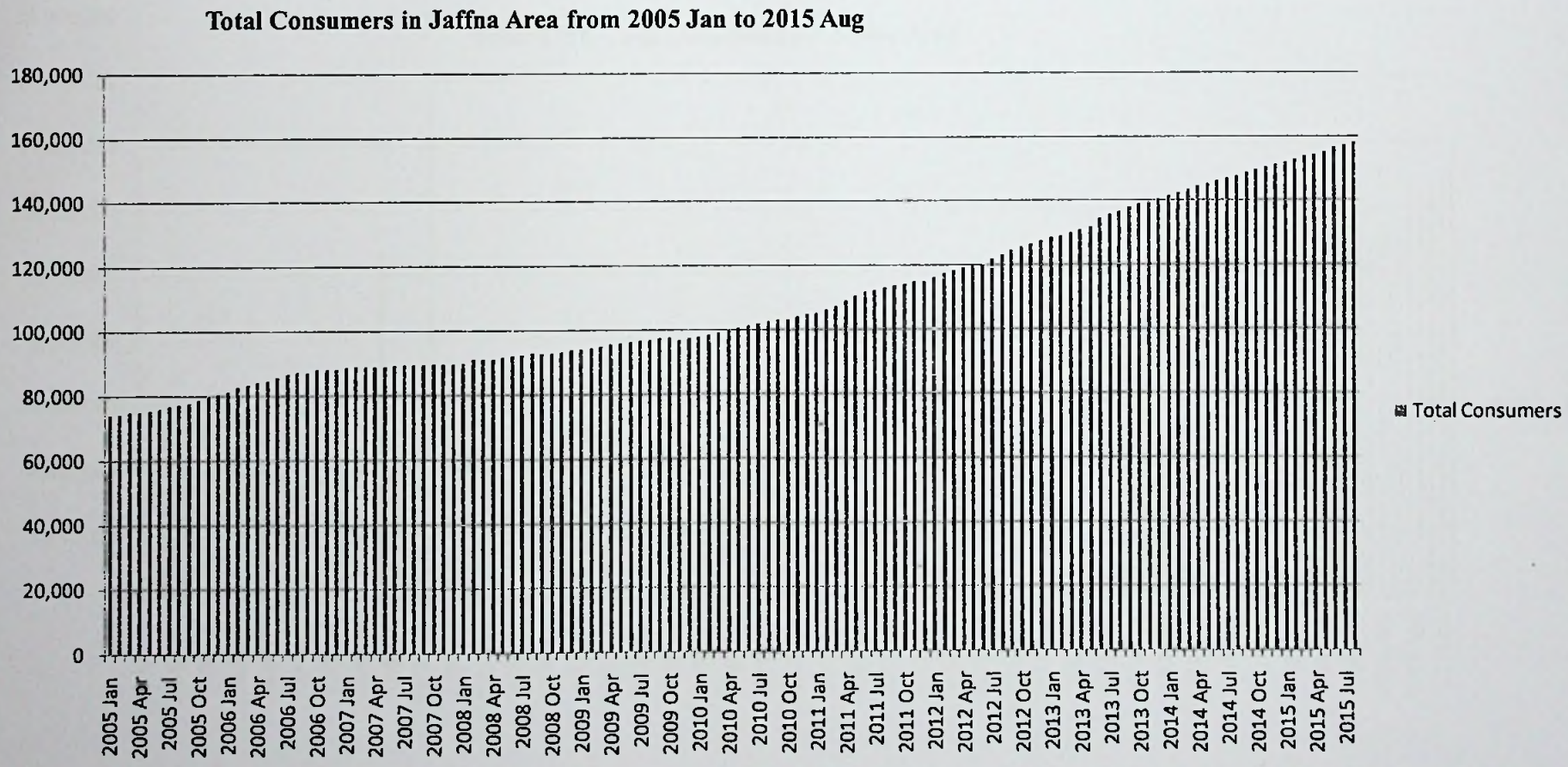


Figure 3: Total Consumer Growth in Jaffna Area from 2005 to 2015

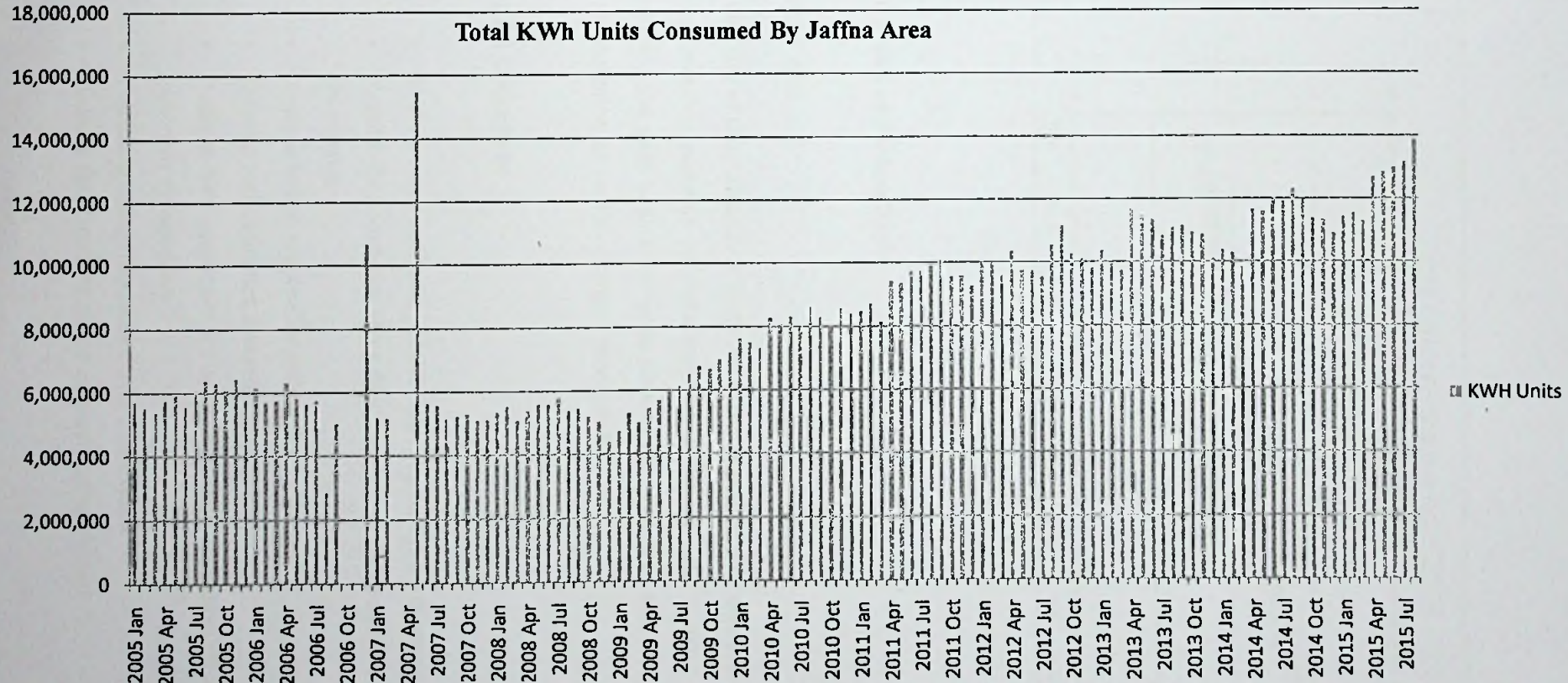


Figure 4 : Total KWH Units consumed by Jaffna area

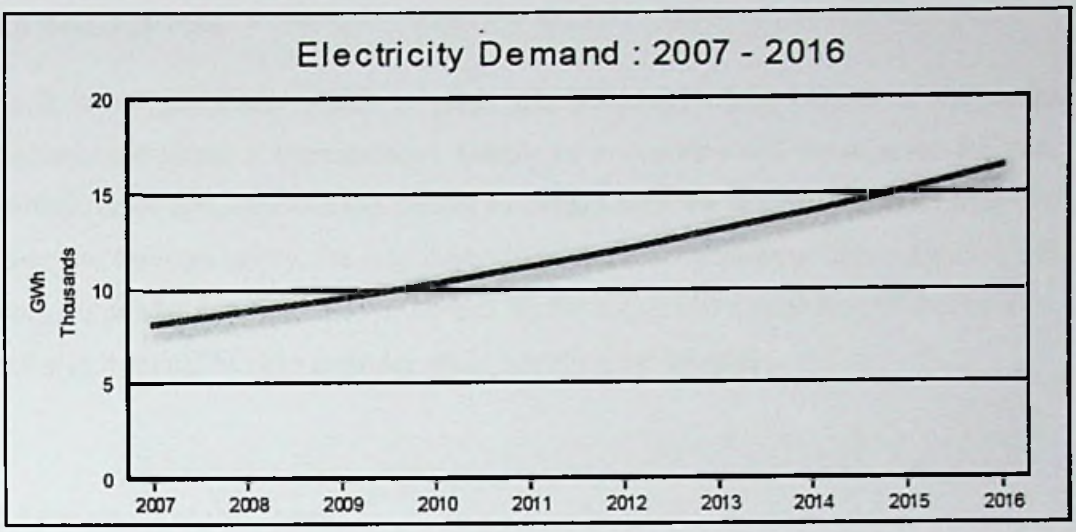


Figure 5: Electricity Demand prediction

1.3 Aim and Objectives

1.3.1 Aim

The aim of this research is to establish the importance of considering domestic energy consumption patterns of consumers by applying data mining techniques to build models and gain wide knowledge about their behaviors and attitudes towards energy consumption as well as energy conservation

1.3.2 Objectives

- Identify major attributes which is effecting for the electricity consumption
- Acquire the knowledge about data mining and other relevant technologies to identify the patterns
- Analyze how to reduce electricity usage by improving the awareness of people
- Develop and implement data mining application
- Analyze how consumers are using electricity appliances in a better way to reduce electricity consumption
- Predicting energy requirements for future needs
- Analyze the electricity norms awareness of consumers

1.4 Research Plan

As it is not practically viable to study the electricity usage pattern of the entire country, and hence a representative sample of consumers will be selected for that. Further, other concerns like the facility to extract accurate information both from the users and from the utility, the easy supervision and management of data collection and analyses processes are deemed important for the successful completion of the research and also it should have to consider while selecting the sample.

1.5 Structure of the Thesis

This Chapter 1 provides the introduction to the electricity usage in Sri Lanka by giving figures and the estimations for the future demand of electricity. Then aim and the objectives by doing this research are described in detail. Chapter 2 presents similar work done by others while Chapter 3 explains the technology adapted. Chapter 4 describes the approach of the research and Chapter 5 is about analysis and design. Chapter 6 is on implementation of the System. Finally, Chapter 7 presents the evaluation of the system and Chapter 8 concludes the results and suggests the further work to continue with this research, and list of references provides as the last section

Chapter 2

2. Review of Other's work

2.1 Introduction

In chapter 1, describes the background and motivation for doing this research and also the aim and objectives of that. The necessity of analyzing electricity consumption patterns in domestic sector is also highlighted by taking the statistical results. The research plan is described at the end of the chapter itself. The purpose of this chapter to highlight previous researches done about the electricity consumption pattern analysis for identifying main key parameters effecting for the electricity consumption as well as conservation behaviors.

Advanced metering devices and new feedback programs and technologies are opening up a wide range of new opportunities to make energy consumption more visible to residential consumers..[1].According to this work once people retrieve energy consumption pattern there are wide variety of things that they can do to reduce the amount of energy they consumed. To retrieve energy consumption patterns there are different types of behaviors of people can be identified. According to the study it can be categorized into the saving actions which is doing infrequently like replacing CFL bulbs, frequently like laundry routines, infrequent but high cost behaviors like purchasing energy efficiency products and appliances. This research has shown that, among many potential types of energy efficiency and conservation behaviors, people are most likely to make changes in a wide variety of everyday practices and engage in some energy saving behaviors. However, this research has been limited for relatively small amount of feedback from consumers. Therefore more research is clearly needed to better understanding this behavior pattern for continuous long period of time with large amount of consumer samples.

There are some research works also conducted by identifying different key factors effective the domestic energy consumption have been researched by researchers[2]. According to their work the type of dwelling, its location, ownership and size, household appliances, attributes of the occupants including number of occupants, income, age and occupancy patterns have significant impacts on electricity consumption. In contrast the floor area of a house is the

most significant factor for the increase of electricity consumption. The electricity consumption units can be also reduced by changing household appliances like washing machine, freezer to a more energy efficiency type.[3]

In a different study ,residential electricity consumption is identified by recognizing habitual behaviors of consumers.[4].According to their study they have discovered 80% of household electricity can be explained in persistent daily routines and pattern of consumption in specific weather conditions. The methodology they have chosen is collection f both qualitative and quantitative household information.[4].According to that methodology they have identified electricity readings as quantitative dataset and the qualitative dataset is extracted by surveys and interviews done by a researcher about the habitual behaviors of household occupants. And the results of the study have found that it is possible to automatically extract persistent routine patterns of households. With related to that the researchers are defined different types of characteristics of the households which is effected for the energy consumption. The unoccupation,whether conditions like hot days and cold days are the main characteristics effecting for more electricity consumption. However one of the drawbacks of this study is lack of interpretative explanation about which appliances should be responsible to produce the loading identified in the analysis.

In a related study electricity load profiles are analyzed to identify electricity consumption patterns.[5].According to this study they have identified electricity load forecasting is very important to power system operation.For that study they have used data mining techniques.SARIMA and ARIMA models are used for this analysis.[5]. ARIMA and SARIMA models are extensions of ARMA class in order to include more realistic dynamics, in particular, respectively, non stationarity in mean and seasonal behaviours.[6].Related to that study load data is categorized into five clusters,hense five models of SARIMA are designed.For that each forecasting models are developed each day except Tuesday,Wednesday and Thursday.Those mentioned dates are modeled as a cluster.Major limitations of this study is additional input variables such as whether data,customer class,event days are not added to that forecasting process.

In a different study was conducted to analyze the trends in use of domestic appliances from household electricity consumption measurements.[7].According their study they have found that there is a great impact on the occupants, number and type of appliances used and occupancy pattern for the annual electricity consumption. For the analysis purpose of large dataset collected they have used Interactive Data Language (IDL) software package.[7] the Interactive IDL is an array-based data processing package and can work with large

datasets.[8].This research study has also found that annual consumption units of dwellings are increased per year.

Similarly there was a study conducted by D D Ananda Namal and K G Chamila Jayasekara to identify the energy conservation opportunities in the domestic sector[9].Main streams to be concerned are the waste streams and their causes, attitudinal and behavioral aspects of people drawbacks in energy conservation and the viability of conservation programs in this sector. This study is based on a survey carried out in the Gampaha district in sample typical households.This study is restricted to the consumers in the second and the third tariff block of the CEB tariff system. The sample was randomly selected based on CEB accounts. A sample of 100 households was selected from gampaha district. These households were visited in the form of a survey and during the survey ,the items of energy consumption, their operating pattern ect was obtained from each household. This is based on well formed questionnaire. Details were also obtained covering attitudes of people towards energy conservation. The energy consumption in the domestic sector, there are opportunities to be addressed in the point of view increasing the utilization efficiency in the sector. Improving the knowledge of people towards proper energy utilization and thereby increasing energy utilization efficiency in the overall sector. And also the equipments like water pump, refrigerator, and washing machine; as far as operating system is concerned obviously it is done by laymen who are not technically educated people. Even the manual are available those are also beyond their level in view of poor technical knowledge on one hand and the use of language on the other hand. This is necessary to focus on this sector at national level and enhance the knowledge of the people on that subject.

Another study was conducted to identify Electrcicity Demand Curve and System Peak reduction by Public Utilities Commision in Sri Lanka[10]. The Electricity system load profile of Sri Lanka has a high evening peak and as a result has a low load factor. On the other hand limitations in the Electricity supply side to accommodate the demand have caused power cuts in recent past. Some steps have already been taken to mitigate the issue with system peak, including the new tariff structure which came into effect from January 2011 onwards[10]. Therefore, studying about the system load profile and finding further options to flatten the system load curve is a timely requirement.

The Public Utilities Commission of Sri Lanka, being the economic, technical and safety regulator of the electricity industry in Sri Lanka, has decided to conduct a study to improve this situation. Therefore, collecting and compiling of relevant data and making conclusions on the same matter were carried out through this study.

The general objective of this study is to conduct detailed analysis of the system load profile, analyze the contributing factors for the high evening peak demand and practical demand side management options to arrest further worsening of the system load factor. Also the scope of the study contained a study about historical characteristics of the system load profile and a study about the consumer response (TOU Consumers) to tariff change in 2011.

The overall study is consisted of a literature survey,a study based on electricity load profile data and electricity consumption data,published by Sustainable Energy Authority (SEA) and submitted by Ceylon Electricity Board (CEB) and a study based on data received from Distribution Licenses (DLs).

With the Literature survey, following aspects have been found that can be used to reduce the peak Electricity demand and flatten the Electricity load profile.They have identified introducing a power factor penalty,introduce a charge for reactive energy usage by consumers,postpone demands of industrial consumers during peak hours,calculating regular audits to find out key issues are factors for reducing electricity load profile.Followings are found out using the data on Electricity load profile and Electricity consumption.

- During the two year period from 2009 to 2011 there is a rapid increase in Electricity sales when comparing with electricity sales growth data before 2009. 15 year average demand increase is 6.8%
- Electricity system Maximum demand has not shown a clear increasing trend from 2006 to 2010. However, from 2010 to 2011 maximum demand shows a rapid increase. Maximum demand growth rate is lower than sales demand growth; the 15 year average maximum demand growth rate is 6.5%.
- Annual System Load Factor, which had been showing an increasing trend from 2008 to 2010, has decreased in 2011 to 60.8%.

- The typical system peak at present occurs- 19.00 to 20.00; with a steep increase from 18:00 to 19:00, and depreciates with a slow rate of decreasing which takes about 3 hours. (From 19:00 to 22:00)
- During a typical day, base active power demand of Sri Lanka is about 40% of the corresponding maximum demand. Also demand goes above 80% of the maximum demand during a period of 4 hours per day.

Similarly another survey was conducted by Public Utility Commission in Sri Lanka to identify electricity consumption pattern. This survey contains information and statistics on electricity consumption patterns of various consumer categories along with license wise revenue collection during the year 2011.Consumer categories are identified as domestic, religious and charitable, general purpose, hotel and industrial. The main difference within this consumer categories are the method of calculating the bill related to different tariff blocks. They have finally summarized all revenue and electricity sales throughout the year by analyzing respective categories, they have come up with different kind of reports like category wise electric sales, group-wise distribution of consumer accounts, group-wise electricity sales, revenue from electricity sales, category wise electricity consumption, time of use electricity consumption ect.The main drawback of this study was only this was generate some reporting based information gathering. There was no any analysis for future demands of future enhancements for improve the revenue collection methods or improve the efficiency of electricity network.

However there are some important points stated by reviewers related to the electricity consumption pattern of domestic consumers, according to the literature review, the feedback is only taken for relatively small amount of feedback from consumers. Therefore more research is clearly needed to better understand this pattern and to determine if households are likely to engage in different types of behaviors as they receive feedback over longer periods of time. In other words, the first steps that people choose to take may be more likely to include new habits and routines, but as time passes and households begin to exhaust low-cost options and build their understanding of energy management options, they may be more likely to make investments in more energy-efficient appliances and products.

The above studies show numerous limitations of analyzing residential electricity consumption in households. The summary of limitations of earlier studies discussed in Table 1.

Table 1: Limitations of earlier studies

Limitation	Study
Limited Amount of sample size	[1]
Less feedback from customers	[1],[2]
Lack of interpretative explanation about which appliances should be responsible to produce the loading identified in the analysis	[3], [4],[6]
Additional input data effecting for the analysis process in not used	[5]

2.2 Summary

The main issues identified so far in the researches are the sample size. The limited sample size will lead to inaccurate results as comparing with analyzing large sample size. Some researchers are mainly identifying only the statistical analysis and it is not answered for a specific solution where are consumers are facing by using electricity for their day today activities. Most of the researches are basically focused on very limited households and from that they are came up with some suggestions. It is very much needed to identify proper sample size with the well defined questionnaire to do this kind of researches.

This chapter summarizes the literature review and the importance of those as well as identified drawbacks of those studies. Next chapter will describe the technology adapted for the analysis.

Chapter3

3. Technologies Adopted for the Research

3.1 Introduction

In chapter 2 the review of other related studies and their importance as well as the improvements are described in a comprehensive manner. This chapter describes the technologies identified to conduct the research. How the questionnaire is developed and the data mining technology is selected for the pattern analysis. The data warehouse technology and web application design technologies are described here.

3.2 Data Collection

3.2.1 The Questionnaire Method

Everyone uses information to make decision about the future. If our information is accurate we have a probability of making a good decision. So better information is usually leads to better decision. Therefore crucial parts of a good research concerned with making sure that the questionnaire design address the needs of research. When the design of the questionnaire following features are taken into account

Decide the information required

The first step to decide what information is needed to know from the respondent in order to meet the survey objective.

Define the target respondent

Define the population where the sample data to be collected

Choose the methods(s) of reaching your target respondent

Choose an appropriate method or methods to reach the respondent in order to collect the data effectively and efficiently. As I have selected random sample and also planned to collect the data through meter readers, paper based questionnaire form has been selected for this purpose

Decide the question content

The questionnaire was based on quantitative and qualitative measures of electricity consumption about households in domestic sector. The questionnaire was designed with the objective of obtaining behavioral patterns of different groups of households that were going to be studied as a whole. These questionnaires have had different structures and contained different questions depending on the type of household. The qualitative as well as quantitative questions are added for that.

The questionnaire is basically focused on the consumption pattern and the knowledge of the households about the energy conservation habits.

Distribution of questionnaire to consumers

The questionnaire is printed and distributed through meter readers once they visit houses for meter reading for the relevant month

3.2.2 Data Collection

Gathered answers for the questionnaire from the documents are entered to Excel sheet by entering individual responses.

3.3 Technology Adapted for data warehousing

To retrieve patterns of electricity usage of domestic consumers, there should be a data repository existing. For the data warehousing SQL Server 2008 R2 is identified as the most appropriate technology for data warehousing.

SQL Server 2008 R2

SQL Server Architecture

SQL Server 2008 R2 is a complete set of enterprise-ready technologies and tools for managing databases among wide variety of networks. The features of the SQL Server 2008 R2 is as follows

- More than a simple relational database management system
- Manage organizational data
- Derive value from information within data
- High performance

- High Availability
- Secure
- Scalable

3.4 Data Mining Approach

SQL server is not a database engine itself, it is having relational and business intelligence components. According to the thesis I had to follow data mining approach, I have gone through different technologies to identify the best suited technology for data mining. According to the study I have found that SQL Server Analysis Services is the most suitable, robust and secure method for implementing data mining applications. Analysis Services provides an integrated platform for solutions that incorporate data mining. You can use either relational or cube data to create business intelligence solutions with predictive analytics[11].

Benefits of SQL Server Analysis Services

SQL Server Analysis Services is using well defined and researched principals to discover patterns in your data. This helps to make intelligent decisions about complex scenarios and problems. There are different kinds of data mining algorithms existing in Analysis Services. By Applying those mining algorithms to your data you can come up with forecasting trends, identify patterns, create rules and recommendations, doing classifications to understand the complex problems in a very advanced manner.
In SQL Server 2008, data mining is powerful, accessible, and integrated with the tools that many people prefer to use for analysis and reporting.[12]

Analysis Services – Data Mining Architecture

Following architecture diagram shows the components of Analysis Services architecture for the data mining.[13]

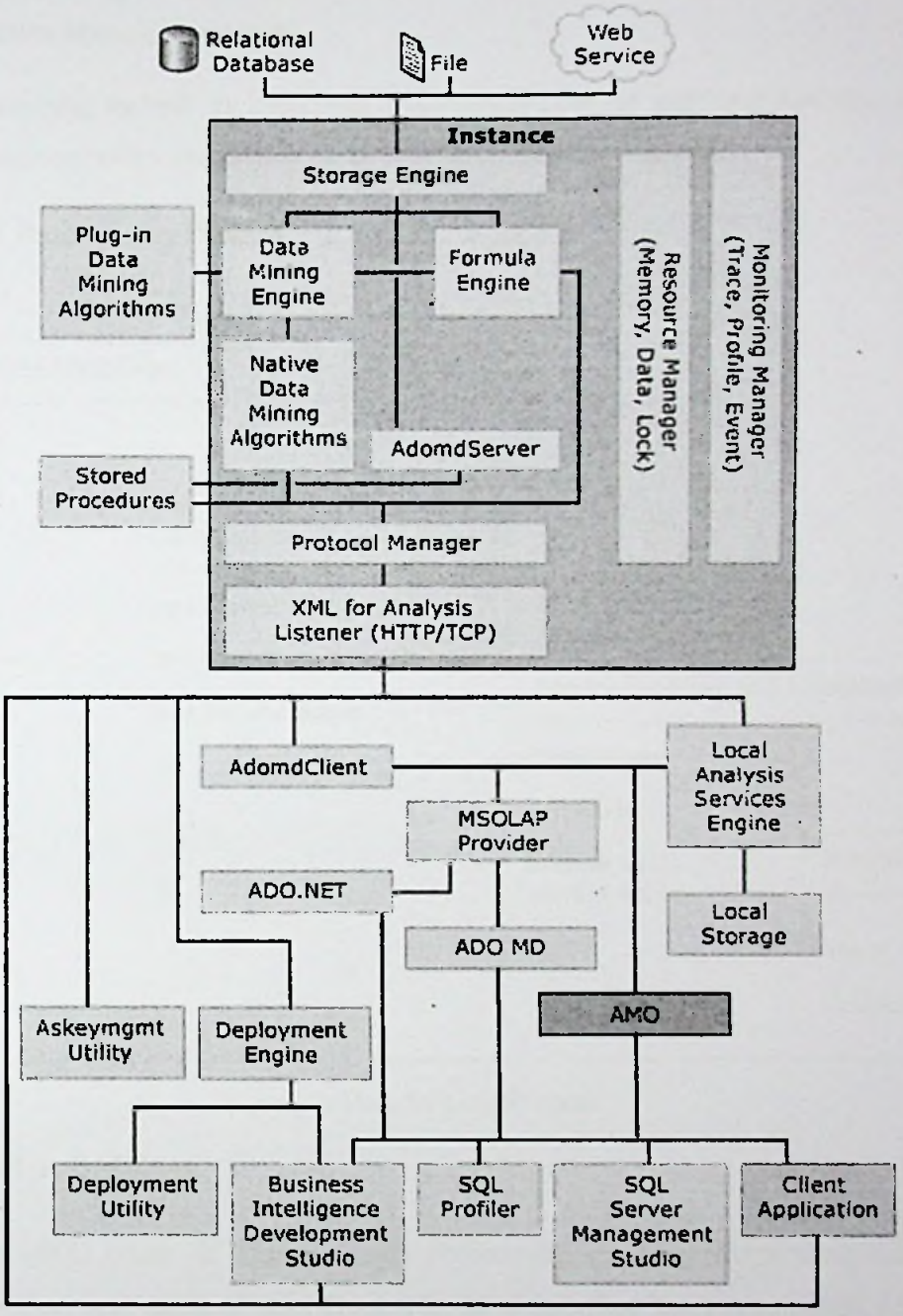


Figure 6 : Architectural Diagram of SQL Server Analysis Services Components

3.5 Data Mining Approach

Data mining technology is adopted to identify the pattern and some statistical analysis to come up with a conclusion about the hypothesis development.

3.5.1 Data Mining Process

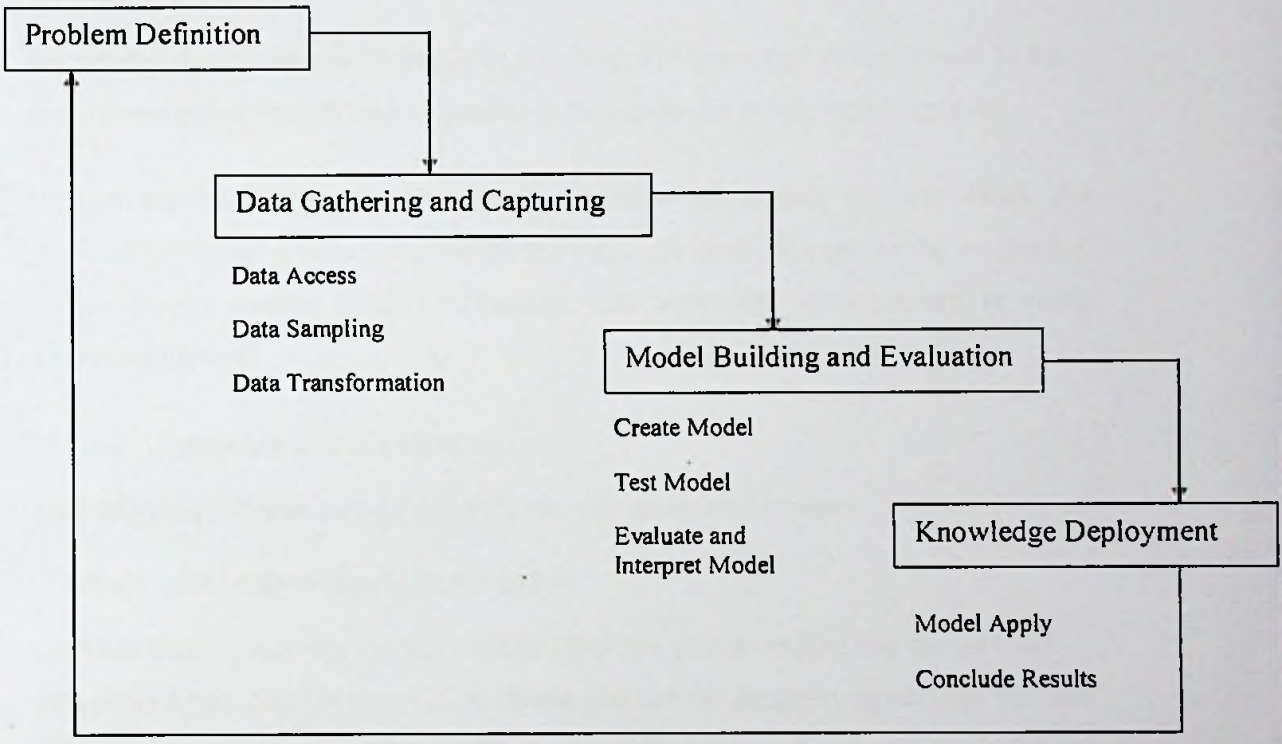


Figure 7: Data Mining Process

Problem Definition

This initial phase of a data mining project focuses on understanding the project objectives and requirements. Once you have specified the project from a business perspective, you can formulate it as a data mining problem and develop a preliminary implementation plan.

Data Gathering and Preparation

The data understanding phase involves data collection and exploration. As you take a closer look at the data, you can determine how well it addresses the business problem. You might decide to remove some of the data or add additional data. This is also the time to identify data quality problems and to scan for patterns in the data.

Model Building and Evaluation

In this phase, you select and apply various modeling techniques and calibrate the parameters to optimal values. If the algorithm requires data transformations, you will need to step back to the previous phase to implement.

Knowledge Deployment

Knowledge deployment is the use of data mining within a target environment. In the deployment phase, insight and actionable information can be derived from data.

Deployment can involve scoring (the application of models to new data), the extraction of model details (for example the rules of a decision tree), or the integration of data mining models within applications, data warehouse infrastructure, or query and reporting tools.

3.6 The Application Development tools

3.6.1 Microsoft Excel Add-In for SQL Server Analysis Services

Overview of the data mining with the add-in

The Data Mining Add-ins for SQL Server 2008 is a free download that can be used with either Excel 2007 or Excel 2010. When you use the data mining add-ins, you can connect to an existing instance of SQL Server 2008 Analysis Services and use the data mining algorithms and services provided by that server to perform data mining on the data in your Excel workbook and other supported data sources.[14]

The Data Mining Add-ins contain two sets of tools: the Table Analysis tools, which let you perform analysis by using wizards and your data in Excel, and the Data Mining Client for Excel, which provides an easy-to-user interface for building data mining models.[14]

This client tool is very easy to understand and work with anyone who is familiar with working in excel sheets. This will be more beneficial for an average person who is not familiar with advanced technologies.

The Architecture of Data Mining Add in for SQL Server 2008

Following diagram illustrates the architecture of the data mining add in for SQL Server 2008 R2 and its components.[14]

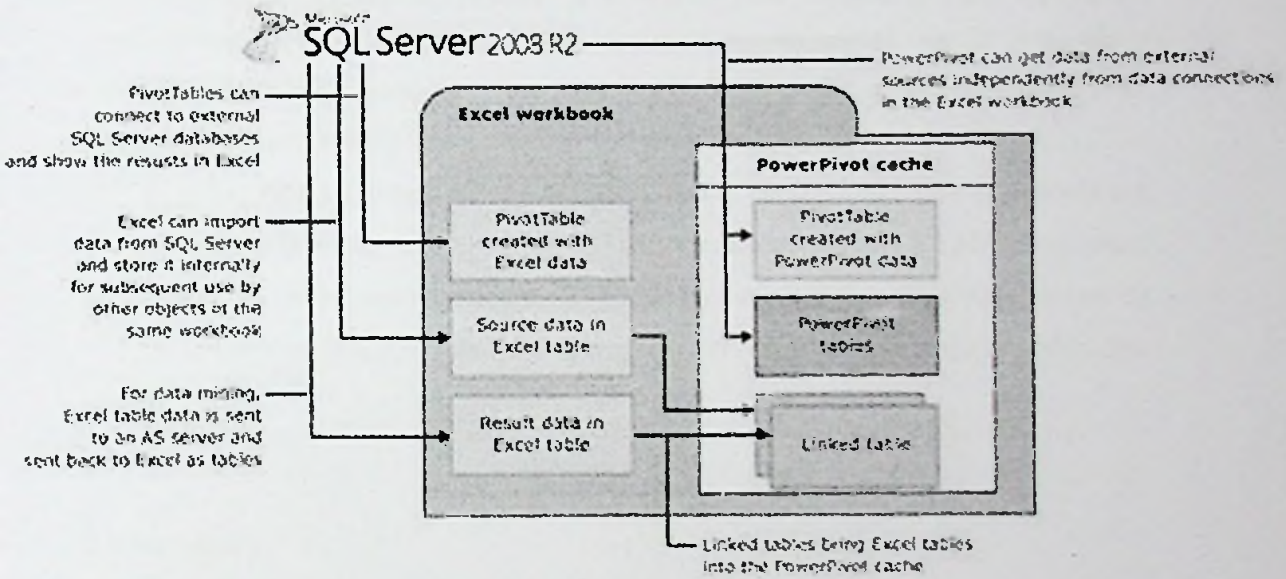


Figure 8: The Architecture of Data Mining Add in for SQL Server 2008

3.6.2 Microsoft .NET Architecture for Web Application Development

For the application development stage Microsoft.NET framework has been used. The reason for selecting this technology is the easy and the awareness of the language. It is having lots of tools and controls for easy development of applications.

The connectivity for the SQL Server database is very reliable and easy to develop inside .NET architecture using inbuilt class libraries. For example to connect to the database there are lots of class libraries like ODBC,OLEDB are provided with lots of database functionalities like connection creations, reading datasets,datareaders,commands ect.

There are lots of functionalities provided for reporting and charting purposes. At the analysis part of the research I have used different kinds of reports for comparing, analyzing and

predicting of electricity consumption patterns of domestic consumers. Basically Microsoft RDLC report component is used for this requirement.

Developing Object Oriented Programming is very easy in .NET framework, where you can have different kinds of Class Libraries and Data Definition Languages to make Object Oriented Concepts in a layered architecture

3.6.3 C# (ASP.NET) Programming Language in Visual Studio 2013

C# for ASP.NET is drastically reduces the amount of code required to build applications within Visual Studio 2013 Integrated development Environment[15]. As C# is an object oriented programming language, it's easy to do the module programming.ASP.NET framework is complemented by a rich tool box and designer in the Visual Studio 2013 environment. Editing, dragging and dropping server controls like powerful tools are provided hence it's easy to do coding[13.The source code and the HTML pages are e write easy to write and maintain. The deployment of the web application to application servers like IIS (Internet Information Server) is easy to manage within few clicks

3.7 Summary

This chapter summarizes the technology adopted for the research and the reasons for choosing that technology in a detailed manner. The next chapter will describe the approach for the research by using the mentioned technologies.

Chapter 4

4. The Approach for the Research

4.1 Introduction

In chapter 4 the technologies adapted for the research is described. This chapter describes the approach for the identify electricity consumption patterns of households using the mentioned technologies in previous chapter.

4.2 Data Collection

4.2.1 The Questionnaire

The questionnaire is developed for identifying the main parameters which are effecting for the electricity consumption. Here I have categorized my questionnaire according to the research questions mentioned below.

- What are the main parameters affecting for the domestic electricity consumption?
- What is the educational background of the family members?
- What kind of equipments are using and the pattern of using them?
- What are the behaviors of the consumers towards energy conservation?
- What is the level of knowledge related to energy awareness?
- What would be the feedback for their electricity bill?

The questionnaire is distributed through meter readers and collect the data and first its entered to an excel sheet. There are two types of questions included in the survey.

Qualitative Approach

The questionnaire is designed to evaluate the behavior pattern of consumers who are using electricity. For example,

- How they use the iron?
- How they use the electric motor?
- How they use the Refrigerator?
- What is the idea about the electricity usage units?

- What is the idea about the current tariff structure?
- What is their knowledge about calculating the electricity bill?

Quantitative Approach

The questionnaire is also designed to understand the quantity measures of the electricity usage of consumers. This included quantitative measurements which can be taken in to the statistical analysis. The total electricity consumption per consumer is also extracted from January 2015.The questions are designed in to different quantitative measures. For example

- The family size
- The electric appliance usage durations
- The education levels
- The size of the house (no of rooms available)
- No of low energy bulbs using
- Ironing time of the day

4.2.2 Billing and Consumption Related data

Data related for billing and consumptions for last 12 months was extracted from billing server database in Ceylon Electricity Board. And also the charges for consumptions units related to different tariff categories are also extracted from there to design the database for analyzing. This research is targeted for Jaffna area. But at the design stage of my research I have designed the system to do this research and do the analysis for any area by continuing of this research with future enhancements. That will be described in details at the design chapter.

4.3 Data Warehouse (SQL Server Analysis Services)

For the data warehouse SQL Server 2008 R2 is used. Here the database is designed in such a way future enhancements can be applied easily. If this research is needed to continue with another area or province or entire country, the database design has the provision to do that. The data extracted from questionnaire is imported to the database.

4.4 Data Mining Approach

4.4.1 SQL Server 2008 Data Mining

SQL Server 2008 Data Mining hides the complexity of an advance technology includes full suite algorithms to automatically extracts information from data, handle large volume of data and complex data. The data can be sourced from relational or OLAP data sources. It delivers a complete framework for building and deploying intelligent applications. Because of this vast variety of advance features for the data mining approach I have selected this technology.

4.4.2 SQL Server Business Intelligent Management Studio

SQL Server Business Intelligent Management studio is integrated with SQL Server 2008 R2, where you can Analysis service projects to do the data mining applications. Business Intelligence Development Studio is an integrated environment for developing business intelligence constructs, such as cubes, data sources, reports, and Integration Services packages[16].Business Intelligence Development Studio includes project templates that provide a context for developing specific constructs. For example, you can choose an Analysis Services project if your objective is to create an Analysis Services database that contains cubes, dimensions, or mining models[16].

In Business Intelligence Development Studio, you can develop projects as part of a solution that is independent of any particular server. For example, you can include an Analysis Services project, an Integration Services project, and a Reporting Services project in the same solution. You can deploy the objects to a test server for testing during development, and later you can deploy the output from the projects to one or more staging or production servers.
Here I have used analysis services project to do the data mining process.

4.4.3 Data Mining Algorithms

This research is basically focused on classification and the clustering of consumers in different ways to identify the pattern of electricity consumption. The electricity consumption as well as the behavioral patterns towards energy conservation and also the awareness of the electricity related theories and practices are analyzed. I have used following data mining

1. Microsoft Decision Trees

Microsoft decision trees are very popular data mining technique used for classification, regression and association

2. Microsoft Clustering

Microsoft Clustering finds natural grouping inside data. It supports for segmentation and anomaly detection tasks

3. Microsoft Naïve Bayes

Microsoft Naïve Bayes is a quick and approachable algorithm for classification.

Those mentioned data mining algorithms are use for extracting the patterns within the data set

Microsoft Excel Add in for SQL Server 2008

This tool is used to do the data mining on the excel sheet itself. The add- in is built a bridge between SQL Server Analysis Services database and excel is acting as a client tool. Every data mining algorithms supporting in SQL Server Analysis services exist inside a ribbon of excel.

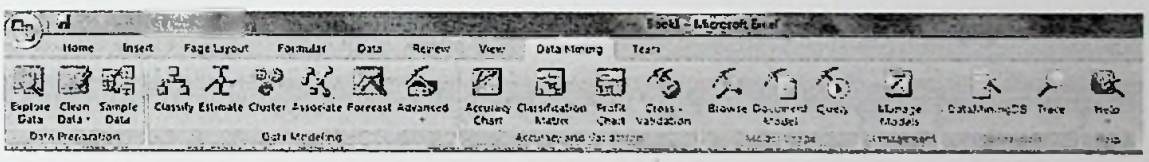


Figure 9 : Excel Data Mining Add in Interface

4.4.4 Web Reporting Application

Web reporting application for the people who are not aware about data mining algorithms and also to get some important analysis reports in timely manner. The application is having a separate interface for entering the answers of the questionnaire for individual consumers. This application is implemented by user authentication hence any area of the country can do the research independently and do the analysis separately. C# ASP.NET in Visual Studio 2012 Integrated Development Environment is used for the development of the application. The reports are designed using Microsoft RDLC reports integrated, in the software package.

4.5 Summary

This chapter was about how the technologies used were handled in order to reach the intended goals of the system. Mainly Visual studio is used here because it is consist of C#, ASP.NET, Microsoft Reporting which are helpful to develop web based application. As the data base technologies SQL Server 2008 and Microsoft Analysis service is been used.SQL Server Business Intelligence Management Studio is used for the data mining application development. CSS used for designing graphical user interface. The next chapter will be on analysis and design of the system.

Chapter 5

5. Analysis and Design

5.1 Introduction

In Chapter 5 the approach for the research is discussed. The approach of using the technologies identified for the analysis of retrieving electricity consumption patterns are described in detail. This chapter discusses the architectural design and analysis details of this research.

5.2 The Top Level Design of the System

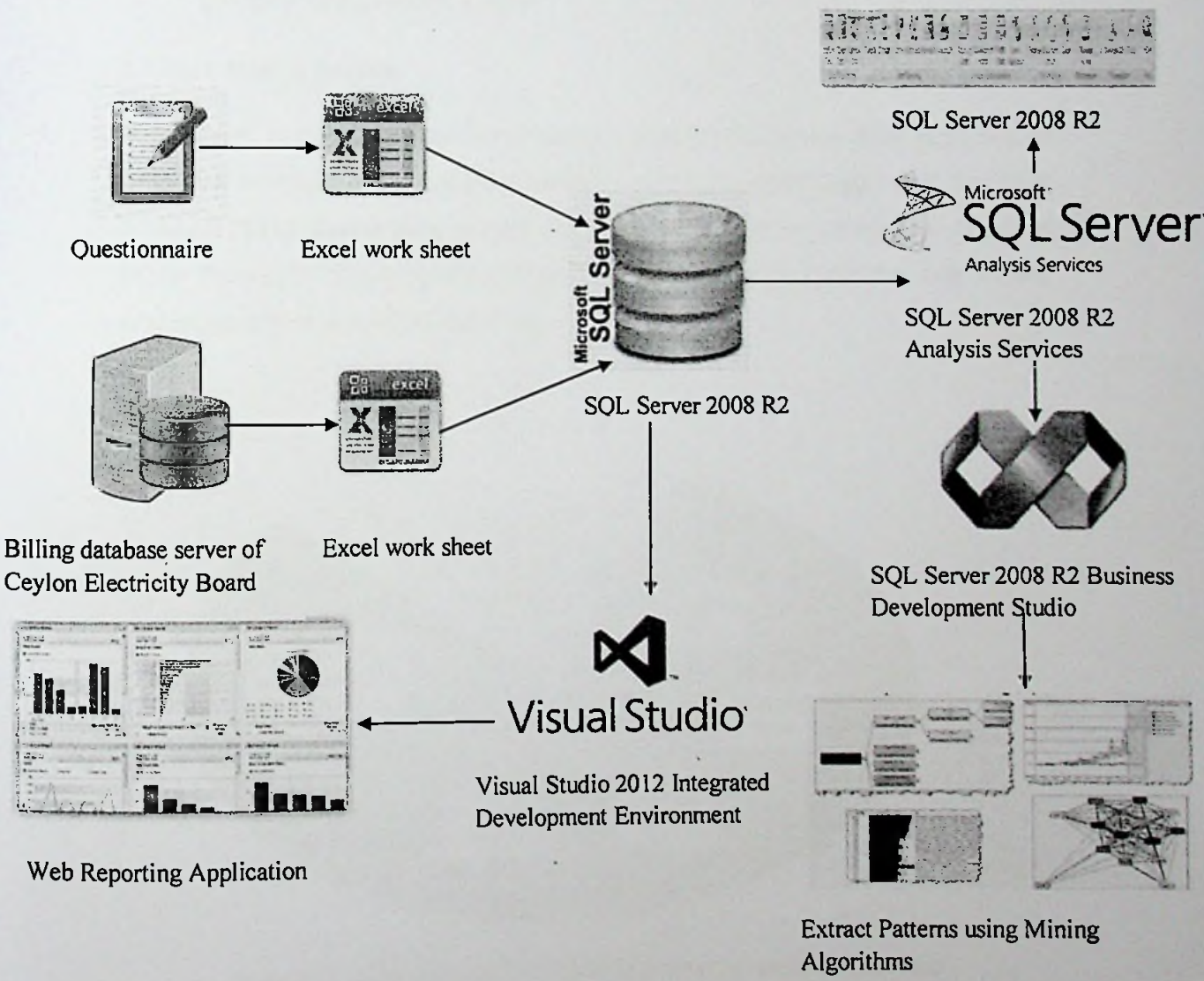


Figure 10: The Top Level Design of the System

The design of the system is consisting with following steps

1. The design of Questionnaire
2. Design the database
3. Import questionnaire to SQL Server Database
4. Extract billing and consumption related data from Ceylon Electricity Board Billing Server Database
5. Import the billing and consumption data to SQL Server Database
6. Apply data mining algorithms to collected dataset for the pattern extraction
7. Web reporting application for further analysis of the dataset using reports, charts, graphs and matrixes for any ordinary person can understand without going through complex analysis

5.3 Data Mining Process

Data mining is the process of discovering actionable information from large sets of data. Data mining uses mathematical analysis to derive patterns and trends that exist in data.[17].The data mining process for SQL Server analysis services is described below figure[17]. The proposed designed is also compatible with the data mining process described in Analysis Services

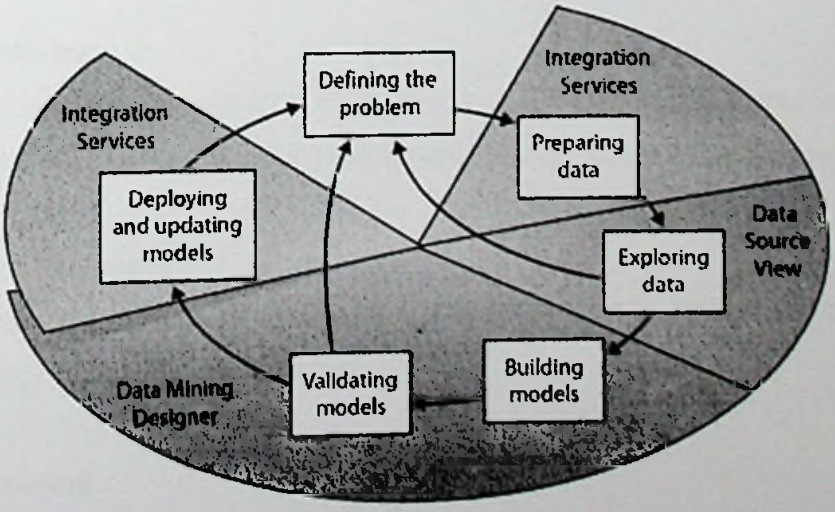


Figure 11: Data Mining Process in SQL Server Analysis Services

Original Data

The original data is the data collected from questionnaire and the data collected from billing application database.

Data Cleaning

The data collected from billing database is cleaned by removing unnecessary data. Here the research is conducted in Jaffna area so the data related to the Jaffna area is extracted.

The information needed basically is the consumption units and the average charge for the consumption units per consumers. The data taken from questionnaire is also analyzed to identify missing values.

Data Integration

Data Extracted from billing application and the data extracted from questionnaire is integrated

Data Selection and Transformation

Data is selected for the mining. Here the consumption units and the consumption charge by individual consumers in Jaffna area is extracted from billing database.

Data extracted from questionnaire is organized in to a flat file.

Data Mining

Here Classification method in Data Mining is used for pattern extraction. Decision trees, Clusters in Classification methods are basically used for this purpose.

Pattern Evaluation

The extracted patterns are evaluated to identify the energy demand and the behavior of energy consumption of the consumers.

Presentation

The results of the evaluation is presented

5.3 Summary

In this chapter, the high level design of the system and the data mining design process is described in details. The main components of the system are also illustrated in the high level design diagram. Integrating all the components together to build up the whole system is also explained. The next chapter will be on the implementation of the consumer electricity consumption pattern analysis.

Chapter 6

6. The Implementation

6.1 Introduction

This chapter describes the implementation details of this system. The implementation can be categorized into four main sections as the implementation of the SQL Server analysis services application for data mining, web reporting application, database implementation tools and the data mining implementations. Following section demonstrates the implementation details of each section of this system with their processes

6.1 The Questionnaire

Questionnaire is already sent with the acknowledgement of Area Engineer in Jaffna to the area office in Jaffna and the meter readers are distributed to the consumers that when they go for the meter reading. For the next bill cycle the questionnaire is collected.

Meanwhile they conducted the telephone interviews when the consumers make inquiries to the help desk. And also the questionnaire is distributed to the consumers who are visited to the CEB Premises. Comparing the first method of distribution questionnaire through meter readers this telephone interviewing was not succeeded as expected.

6.2 Consumption and Billing Related Data Extraction

The Billing and Consumption data in domestic sector of Jaffna area for one year is extracted from the billing database and the consumers are categorized in to different average consumption units. For example

- Consumers with average consumption less than 60 units
- Consumers with average consumption more than 60 and less than 90
- Consumers with average consumption more than 90 and less than 120
- Consumers with average consumption more than 120 and less than 180
- Consumers with average consumption greater than 180

6.3 Analysis Services Application for data mining

The SQL Server Analysis Services application is used for the implementation of data mining application. For that SQL Server is having in build Integrated Development Environment called SQL Server Business Intelligence Development Studio is used. There you can create projects for connecting SQL Server database to do data mining. Below figure shows my sample application interface at the implementation stage of the system.

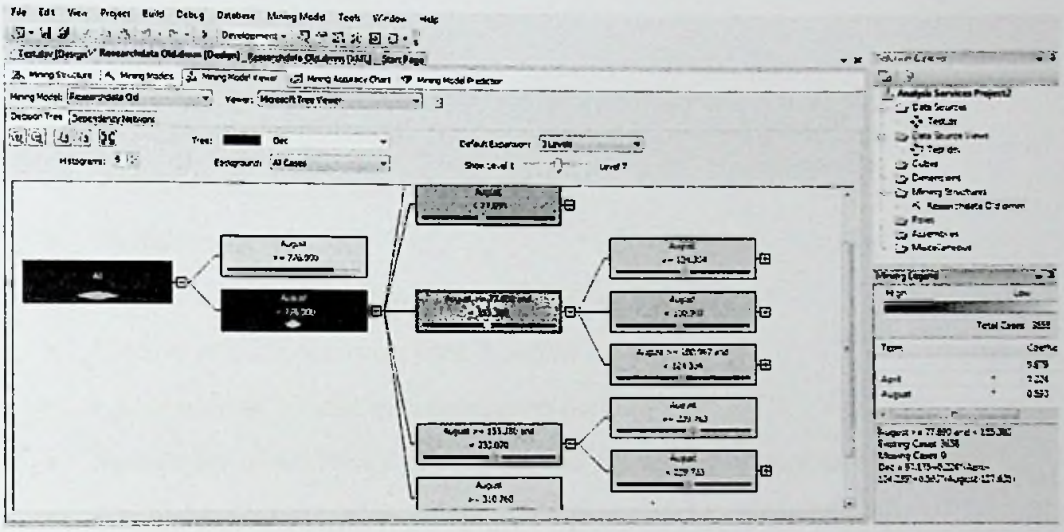


Figure 12: SQL Server Business Intelligent Interface

Here first you need to create a data source from the database columns that you need to extract the patterns and the relationship among those selected attributes. Then you need to add this data source to the data source view where the place you are applying data mining algorithms. Then you can apply data mining algorithms for that data source view. In SQL Server Analysis Services there are different kinds of data mining algorithms existing. The algorithms are

1. Microsoft Association Rules
2. Microsoft Clustering
3. Microsoft Decision Trees
4. Microsoft Linear Regression
5. Microsoft Logistic Regression
6. Microsoft Naïve Bayes
7. Microsoft Neural Networks

8. Microsoft Sequence Clustering
9. Microsoft Time Series

Among those I have basically used Microsoft Decision Tree, Microsoft Clustering and Microsoft Naïve Bayes classification algorithms for my analysis as my research is basically consisting of classifications of consumers in different ways of using electricity.

Selecting Attributes for the data mining

- The occupation
- Monthly Income
- No of people in the house
- The floor area of the house
- Education Level
- Electric Appliances usage pattern (Behavior Pattern)
- Electric Appliances usage time duration
- Knowledge of electricity conservation methods
- Knowledge of electricity calculating and the tariff structure (awareness)
- The highest consumption month of the year and the reasons for that

The implemented application can be hosted in a server and allow people to browse the application in such a manner the consumption pattern can be extracted.

6.4 Web Reporting Application

Web reporting application is implemented using Visual Studio 2012 Development Enviromnet.Here I have used C# (ASP.NET) programming language for the development of the application. That application is having a user login where users are redirected to the specific area related profiles. This method of login will be more important at the expansion of the application to other areas in the country. There is a facility for a user to enter data from the questionnaire directly to the database. A web based data entry form is integrated with this application where administrators of the application can login and enter data for specific area. Hence the future improvements can be done in areas separately.

The application is basically implementing reports, charts, prediction reports, mertixes where you cannot extracted only from applying mining models. From simple to complex analysis are also included this application. This application can be used for average awareness person of computer literacy in Ceylon Electricity Board for take analysis reports when necessary. Some source codes and Graphical user interfaces are shown below. Rest of the source codes and Graphical User Interfaces are in Appendix of the thesis.

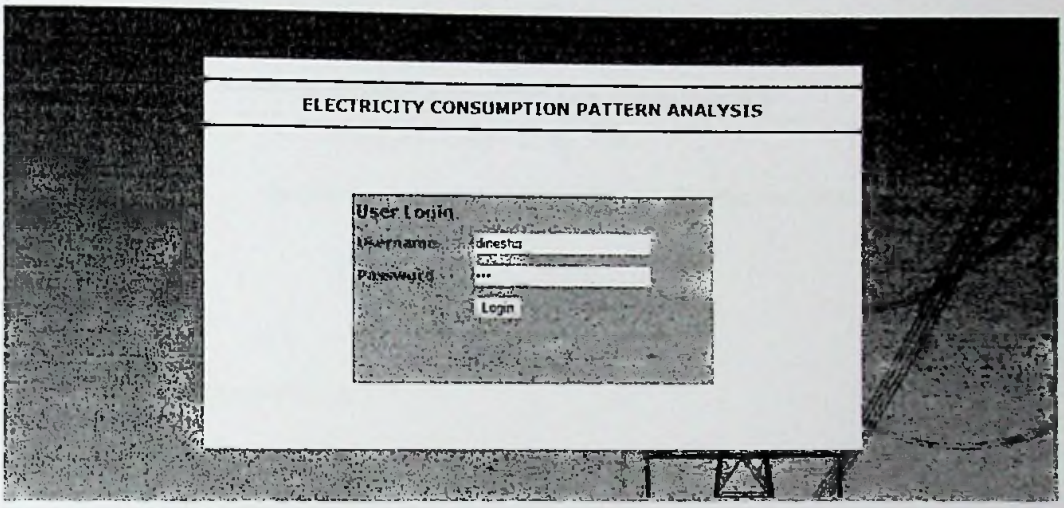


Figure 13: Login page of the web application

Source code for Login

```
using System.Web;
using System.Web.UI;
using System.Web.UI.WebControls;
using System.Data.Sql;
using System.Data.SqlClient;
using System.Data.OleDb;
using System.Data;

public partial class Login : System.Web.UI.Page
{
    SqlDataAdapter adapter;
    SqlCommandBuilder cmdBuilder;
    DataSet ds = new DataSet();
    DataSet changes;

    protected void Page_Load(object sender, EventArgs e)
    {

    }
    protected void Button1_Click(object sender, EventArgs e)
    {
        Logins(TextBox1.Text, TextBox2.Text, lblarea.Text);
    }
```

```
    public bool Logins(string username, string password,string area_code)
    {
        bool isOk = false;
        try
        {
            string sql = "";

           SqlConnection connection = ConStrings.GetConnection();
                connection.Open();
                sql = "select password from users where username='" + username
+ "' and active_st='Y' and area_code='" + area_code + "'";

                adapter = new SqlDataAdapter(sql, connection);
                adapter.Fill(ds);
                connection.Close();

                if (ds.Tables[0].Rows.Count > 0)
                {
                    Response.Redirect("individualConsumption.aspx");
                }



            }

        catch (Exception ex)
        {
        }

        return isOk;
    }
}
```

Source Code for Individual Electricity Usage Pattern analysis

```
using System;
using System.Collections.Generic;
using System.Data;
using System.Data.SqlClient;
using System.Linq;
using System.Web;
using System.Web.UI;
using System.Web.UI.WebControls;
using Microsoft.Reporting.WebForms;

public partial class IndividualUsagePattern : System.Web.UI.Page
{
    protected void Page_Load(object sender, EventArgs e)
    {

    }
    protected void btnView_Click(object sender, EventArgs e)
    {
        AverageConsumption(account_number.Text.Trim());
        AverageCharge(account_number.Text.Trim());
    }

    private DataTable CreateDataTable()
    {
```

```
        DataTable myDataTable = new DataTable();
        DataColumn myDataColumn;

        myDataColumn = new DataColumn();
        myDataColumn.DataType = Type.GetType("System.String");
        myDataColumn.ColumnName = "Month";
        myDataTable.Columns.Add(myDataColumn);

        myDataColumn = new DataColumn();
        myDataColumn.DataType = Type.GetType("System.Decimal");
        myDataColumn.ColumnName = "Consumption";
        myDataTable.Columns.Add(myDataColumn);

        return myDataTable;
    }

    private void AddDataToTable(string unit, decimal count, DataTable myTable)
    {
        DataRow row;
        row = myTable.NewRow();
        row["Month"] = unit;
        row["Consumption"] = count;
        myTable.Rows.Add(row);
    }


    public DataSet AverageConsumption(string acc)
    {
        string month="";
        string sql = "";
        DataSet ds = new DataSet();
        DataTable mytable=CreateDataTable();

        try
        {

            using (SqlConnection connection = ConStrings.GetConnection())
            {

                sql = "select
January,February,March,April,May,June,July,August,September,October,November,De
cember from individualConsumptions where account_number='"+acc+"' ";

                SqlCommand cmd = new SqlCommand(sql, connection);
                cmd.CommandType = CommandType.Text;
                SqlDataAdapter ad2 = new SqlDataAdapter(cmd);
                ad2.Fill(ds, "consumption");

                for (int i = 0; i < 12; i++)
                {
                    if(i==0)
                    {
                        month="January";
                    }
                    if(i==1)
                    {
                        month="February";
                    }
                    if(i==2)
                    {
                        month="March";
                    }
```

```
                    if(i==3)
                    {
                        month="April";
                    }
                    if(i==4)
                    {
                        month="May";
                    }
                    if(i==5)
                    {
                        month="June";
                    }
                    if(i==6)
                    {
                        month="July";
                    }

                    if(i==7)
                    {
                        month="August";
                    }
                    if(i==8)
                    {
                        month="September";
                    }
                    if(i==9)
                    {
                        month="October";
                    }
                    if(i==10)
                    {
                        month="November";
                    }
                    if(i==11)
                    {
                        month="December";
                    }

                    int count = int.Parse(ds.Tables[0].Rows[0][i].ToString());
                    AddDataToTable(month, count,mytable);
                }

                ReportDataSource datasource = new ReportDataSource("DataSet1",
mytable);
                ReportViewer1.LocalReport.DataSources.Clear();
                ReportViewer1.LocalReport.ReportPath =
"ConsumptionByAccountNumber.rdlc";
                ReportViewer1.LocalReport.DataSources.Add(datasource);



            }
        }

        catch (Exception ex)
        {
        }

        return ds;
    }

    public DataSet AverageCharge(string acc)
```

```
    {
        string month = "";
        string sql = "";
        DataSet ds = new DataSet();
        DataTable mytable = CreateDataTable();

        try
        {

            using (SqlConnection connection = ConStrings.GetConnection())
            {

                sql = "select c1,c2,c3,c4,c5,c6,c7,c8,c9,c10,c11,c12 from
individualConsumptions where account_number='" + acc + "' ";

                SqlCommand cmd = new SqlCommand(sql, connection);
                cmd.CommandType = CommandType.Text;
                SqlDataAdapter ad2 = new SqlDataAdapter(cmd);
                ad2.Fill(ds, "consumption");

                for (int i = 0; i < 12; i++)
                {
                    if (i == 0)
                    {
                        month = "January";
                    }
                    if (i == 1)
                    {
                        month = "February";
                    }
                    if (i == 2)
                    {
                        month = "March";
                    }
                    if (i == 3)
                    {
                        month = "April";
                    }
                    if (i == 4)
                    {
                        month = "May";
                    }
                    if (i == 5)
                    {
                        month = "June";
                    }
                    if (i == 6)
                    {
                        month = "July";
                    }

                    if (i == 7)
                    {
                        month = "August";
                    }
                    if (i == 8)
                    {
                        month = "September";
                    }
                    if (i == 9)
                    {
                        month = "October";
```

```
                    }
                    if (i == 10)
                    {
                        month = "November";
                    }
                    if (i == 11)
                    {
                        month = "December";
                    }


                    decimal charge =
decimal.Parse(ds.Tables[0].Rows[0][i].ToString());
                    AddDataToTable(month, charge, mytable);


                }

                ReportDataSource datasource2 = new ReportDataSource("DataSet2",
mytable);
                ReportViewer1.LocalReport.ReportPath =
"ConsumptionByAccountNumber.rdlc";
                ReportViewer1.LocalReport.DataSources.Add(datasource2);



            }
        }

        catch (Exception ex)
        {
        }

        return ds;
    }
}
```

Source Code analyze Electricity Equipments using inside a house

```
using System;
using System.Collections.Generic;
using System.Data;
using System.Data.SqlClient;
using System.Linq;
using System.Web;
using System.Web.UI;
using System.Web.UI.WebControls;
using Microsoft.Reporting.WebForms;

public partial class equipmentswithconsumption : System.Web.UI.Page
{
    protected void Page_Load(object sender, EventArgs e)
    {

    }
    protected void btnView_Click(object sender, EventArgs e)
    {
        DataTable mydatatable = CreateDataTable();
        int start = 0;
        int end = 0;
        string unit = "";
        if (ddlunits.SelectedValue.Equals("2"))
```

```
        {

             unit = "0-30";
             start = 0;
             end = 30;
        }

     if   (ddlunits.SelectedValue.Equals("3"))
        {
            start =31;
            end = 60;
             unit = "31-60";
        }
         if (ddlunits.SelectedValue.Equals("4"))
        {
            start =61;
            end = 90;
             unit = "61-90";
        }

         if (ddlunits.SelectedValue.Equals("5"))
         {
             start = 91;
             end = 120;
             unit = "91 to 120";
         }
         if (ddlunits.SelectedValue.Equals("6"))
         {
             start = 121;
             end = 180;
             unit = "121 to 180";
         }
         if (ddlunits.SelectedValue.Equals("7"))
         {
             start =181;
             end = 350000;
             unit = "above 180";
         }

            DataSet ds = Equipments(start,end, "refregerator");
            if (ds.Tables[0].Rows.Count > 0)
            {

                for (int i = 0; i < ds.Tables[0].Rows.Count; i++)
                {
                    AddDataToTable(unit,
int.Parse(ds.Tables[0].Rows[i][0].ToString()), "Refrigerator",
ds.Tables[0].Rows[i][1].ToString(), mydatatable);
                }
            }


            DataSet ds1 = Equipments(start,end, "Iron");
            if (ds1.Tables[0].Rows.Count > 0)
            {

                for (int i = 0; i < ds1.Tables[0].Rows.Count; i++)
                {
                    AddDataToTable(unit,
int.Parse(ds1.Tables[0].Rows[i][0].ToString()), "Iron",
ds1.Tables[0].Rows[i][1].ToString(), mydatatable);
                }
```

```
            }
            DataSet ds2 = Equipments(start, end, "heater");

            if (ds2.Tables[0].Rows.Count > 0)
            {
                for (int i = 0; i < ds2.Tables[0].Rows.Count; i++)
                {
                    AddDataToTable(unit,
int.Parse(ds2.Tables[0].Rows[i][0].ToString()), "Heater",
ds2.Tables[0].Rows[i][1].ToString(), mydatatable);
                }
            }
            DataSet ds3 = Equipments(start, end, "kettle");

            if (ds3.Tables[0].Rows.Count > 0)
            {
                for (int i = 0; i < ds.Tables[0].Rows.Count; i++)
                {
                    AddDataToTable(unit,
int.Parse(ds3.Tables[0].Rows[i][0].ToString()), "Kettle",
ds3.Tables[0].Rows[i][1].ToString(), mydatatable);
                }
            }
            DataSet ds4 = Equipments(start, end, "waterpump");

            if (ds4.Tables[0].Rows.Count > 0)
            {
                for (int i = 0; i < ds.Tables[0].Rows.Count; i++)
                {
                    AddDataToTable(unit,
int.Parse(ds4.Tables[0].Rows[i][0].ToString()), "Water Pump",
ds4.Tables[0].Rows[i][1].ToString(), mydatatable);
                }
            }
            DataSet ds5 = Equipments(start,end, "electricoven");

            if (ds5.Tables[0].Rows.Count > 0)
            {
                for (int i = 0; i < ds5.Tables[0].Rows.Count; i++)
                {
                    AddDataToTable(unit,
int.Parse(ds5.Tables[0].Rows[i][0].ToString()), "Electric Oven",
ds5.Tables[0].Rows[i][1].ToString(), mydatatable);
                }
            }
            DataSet ds6 = Equipments(start, end, "ricecooker");

            if (ds6.Tables[0].Rows.Count > 0)
            {
                for (int i = 0; i < ds6.Tables[0].Rows.Count; i++)
                {
                    AddDataToTable(unit,
int.Parse(ds6.Tables[0].Rows[i][0].ToString()), "Rice Cooker",
ds6.Tables[0].Rows[i][1].ToString(), mydatatable);
                }
            }
            DataSet ds7 = Equipments(start, end, "blender");

            if (ds7.Tables[0].Rows.Count > 0)
            {
                for (int i = 0; i < ds7.Tables[0].Rows.Count; i++)
                {
```

```
                    AddDataToTable(unit,
int.Parse(ds7.Tables[0].Rows[i][0].ToString()), "Blender",
ds7.Tables[0].Rows[i][1].ToString(), mydatatable);
                }
            }
            DataSet ds8 = Equipments(start, end, "fans");

            if (ds8.Tables[0].Rows.Count > 0)
            {
                for (int i = 0; i < ds8.Tables[0].Rows.Count; i++)
                {
                    AddDataToTable(unit,
int.Parse(ds8.Tables[0].Rows[i][0].ToString()), "Fans",
ds8.Tables[0].Rows[i][1].ToString(), mydatatable);
                }
            }
            DataSet ds9 = Equipments(start, end, "tv");
            if (ds9.Tables[0].Rows.Count > 0)
            {
                for (int i = 0; i < ds9.Tables[0].Rows.Count; i++)
                {
                    AddDataToTable(unit,
int.Parse(ds9.Tables[0].Rows[i][0].ToString()), "Television",
ds9.Tables[0].Rows[i][1].ToString(), mydatatable);
                }
            }
            DataSet ds10 = Equipments(start, end, "computer");
            if (ds10.Tables[0].Rows.Count > 0)
            {
                for (int i = 0; i < ds10.Tables[0].Rows.Count; i++)
                {
                    AddDataToTable(unit,
int.Parse(ds10.Tables[0].Rows[i][0].ToString()), "computer",
ds10.Tables[0].Rows[i][1].ToString(), mydatatable);
                }
            }




            ReportDataSource datasource = new ReportDataSource("DataSet1",
mydatatable);

            ReportViewer1.LocalReport.DataSources.Clear();
            ReportViewer1.LocalReport.ReportPath = "NoOfQuipmentsByRange.rdlc";
            ReportViewer1.LocalReport.DataSources.Add(datasource);
        }



    private DataTable CreateDataTable()
    {
        DataTable myDataTable = new DataTable();
        DataColumn myDataColumn;

        myDataColumn = new DataColumn();
        myDataColumn.DataType = Type.GetType("System.String");
        myDataColumn.ColumnName = "unit";
        myDataTable.Columns.Add(myDataColumn);
```

```
        myDataColumn = new DataColumn();
        myDataColumn.DataType = Type.GetType("System.Int32");
        myDataColumn.ColumnName = "count";
        myDataTable.Columns.Add(myDataColumn);

        myDataColumn = new DataColumn();
        myDataColumn.DataType = Type.GetType("System.String");
        myDataColumn.ColumnName = "equipment";
        myDataTable.Columns.Add(myDataColumn);

        myDataColumn = new DataColumn();
        myDataColumn.DataType = Type.GetType("System.String");
        myDataColumn.ColumnName = "status";
        myDataTable.Columns.Add(myDataColumn);



        return myDataTable;
    }
    private void AddDataToTable(string unit, int count, string equipment,string
status, DataTable myTable)
    {
        DataRow row;
        row = myTable.NewRow();
        row["unit"] = unit;
        row["count"] = count;
        row["equipment"] = equipment;
        row["status"] = status;



        myTable.Rows.Add(row);
    }


    public DataSet Equipments(int start,int end,string equipment)
    {

        string sql = "";
        DataSet ds = new DataSet();
        DataTable mydatatable = CreateDataTable();
        try
        {

            using (SqlConnection connection = ConStrings.GetConnection())
            {

                    sql = "select count("+equipment+"),"+equipment+" from
researchdata where avg_consumption > = " + start + " and avg_consumption
<="+end+"  group by "+equipment+"";
                    SqlCommand cmd = new SqlCommand(sql, connection);

                cmd.CommandType = CommandType.Text;
                SqlDataAdapter ad2 = new SqlDataAdapter(cmd);
                ad2.Fill(ds, "consumption");

            }

        }
```

```
        catch (Exception ex)
        {
        }

        return ds;

    }

}
```

The rest of the source codes, Graphical User Interfaces and the outputs are attached in the Appendix section.

6.5 Microsoft Excel Add in for SQL Server 2008 for data mining

This is also a very powerful tool for data mining. At the starting of my application implementation I have used this add in for Excel 2007.Here all you need to do is create a connection to the SQL Server 2008 instance. The connection makes the bridge between Excel and the database. So you can use each and every data mining algorithm in Excel itself to analyze your data. At the implantation stage I have used this tool as well. Below figure shows a sample of a cluster diagram derived from that tool.

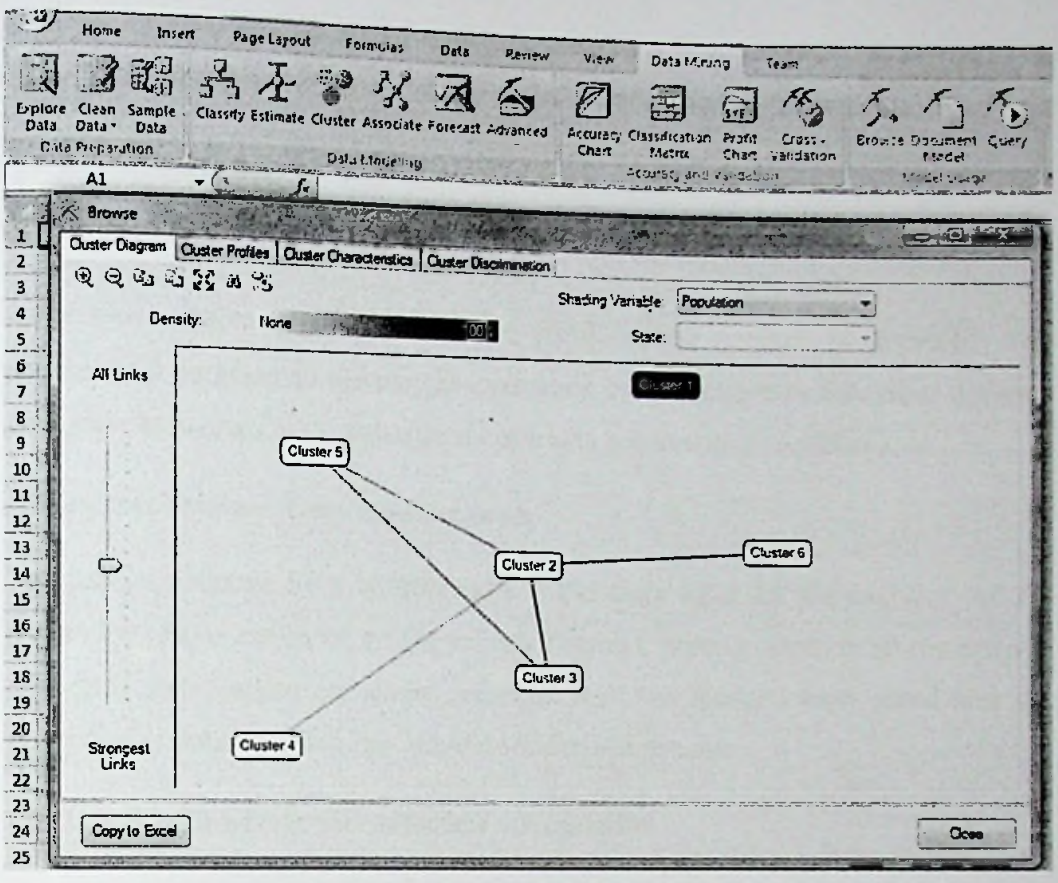


Figure 14: Microsoft Excel Add in for SQL Server 2008 for data mining

6.6 Summary

This chapter summarizes the implementation details of different components and interrelation among them. How the each module of the system is implemented is also described in detail. The implementation is very close relationship with the design of the system because I have tried so many possibilities for design the system and within that I have chosen this design is the most appropriate way of implementing the application in a sophisticated manner. The next chapter will describe the evaluation of the system against objectives. The main Objective of my research is to identify electricity consumption patterns of households and identify the crucial factors affecting for electricity consumption as well as electricity conservation.

Chapter 7

7. Evaluation

7.1 Introduction

In previous chapter the implementation details of the research is described. This chapter will be going to discuss the evaluation of the collection data from different data sources to analyze the patterns of electricity consumption in Jaffna area.

7.2 Dataset obtained from questionnaire

The dataset obtained from questionnaire is the main input for the analysis. All the evaluation results are based on the collected dataset. Since evaluation all the patterns extracting from dataset cannot be described at in this thesis, I have stated how the evaluation is done by using few amounts of derived patterns

7.3 Data entering from user interface – Evaluation

Data entering form has been developed for easy and accurate data entering process. Whole questionnaire can be inserted from the interface provided. Evaluation of data entering is tested and it will take only five minutes to fill and update database. The user interface is having lot of selections from dropdowns and radio button list, make less effort for the user. The user interfaces are attached in Appendix.

7.4 Data Mining Approach – Evaluation

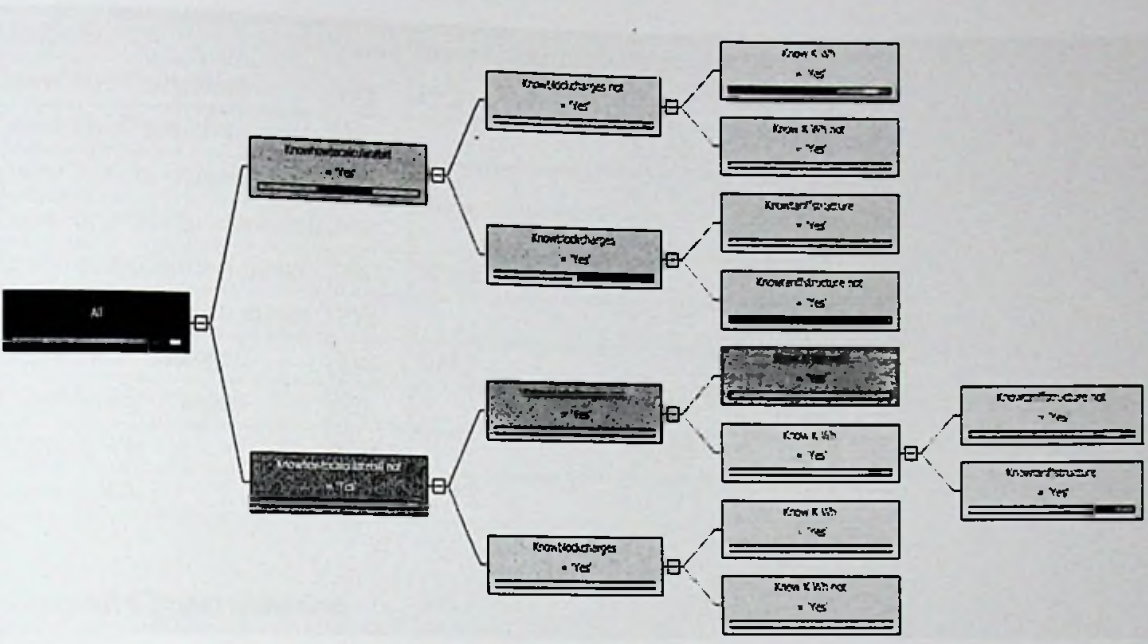
7.4.1 Awareness of electricity related information

Algorithm - Microsoft Decision Tree and Microsoft Clustering, Naive Bayes, Neural Network

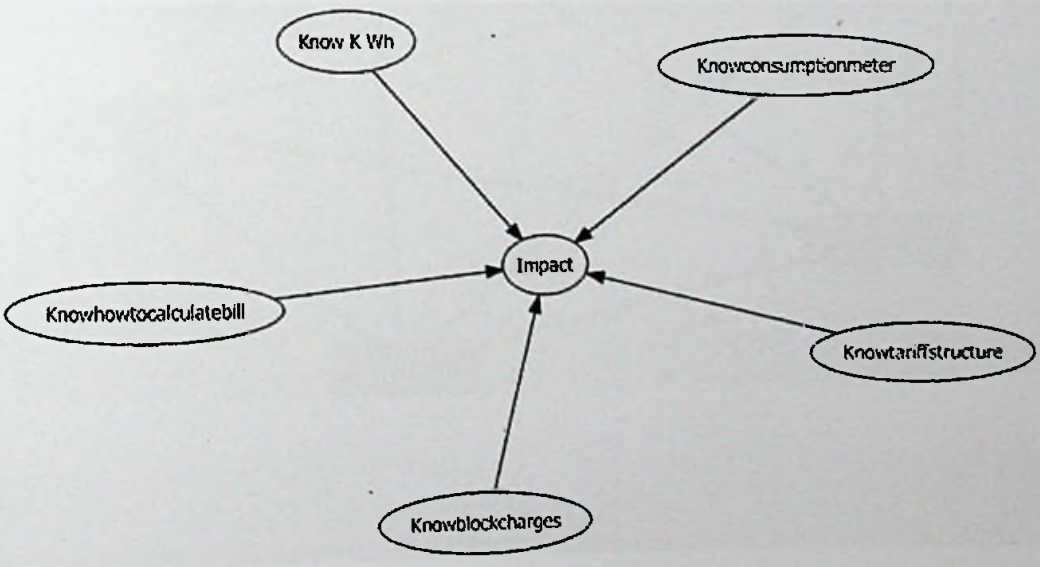
Input for the mining model

- Awareness about block charges
- Awareness about electricity reading by looking at the meter
- Awareness about how to calculate the bill.
- Awareness about KWh charges
- Awareness about tariff structure

Decision tree classification of consumers



Naïve Bayes (Dependency Network)

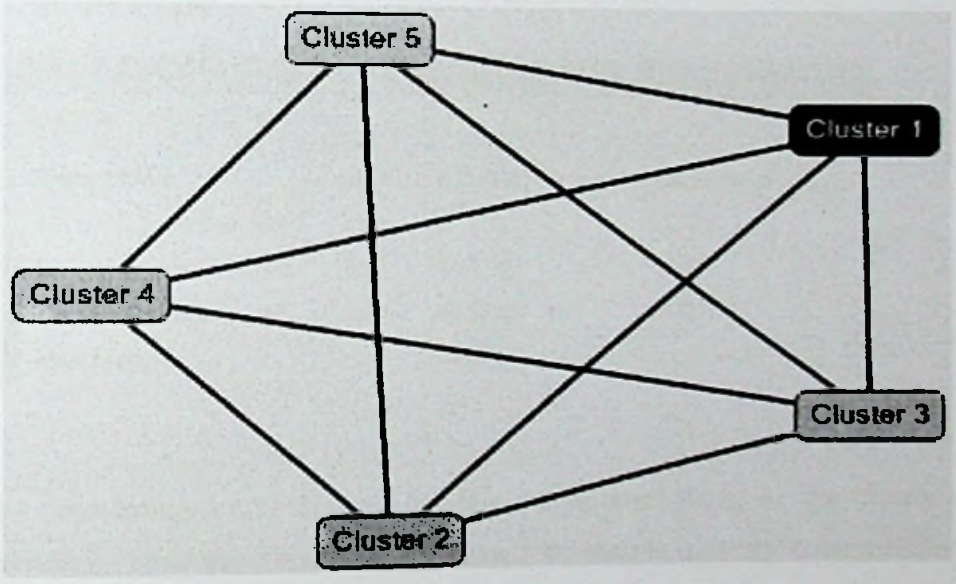


Dependency network shows the interrelationship among the attributes. The colored circles show the different kinds of dependencies among selected attributes.

Microsoft Neural Network

Attribute	Value	Favors negligible	Favors moderate
Know tariff structure	Yes	75.21	
Know tariff structure	No		37.57
Know how to calculate bill	Yes		6.18
Know how to calculate bill	No		1.17
Know consumption meter	No	29.08	
Know consumption meter	Yes		11.57
Know block charges	Yes	100	
Know block charges	No		42.05
Know KWh	Yes		23.92
Know KWh	No	12.58	

Microsoft Cluster Diagram



Evaluation of Cluster Profiles

Variables	State	Population	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Know block charges	No	795	0 %	100 %	46 %	30 %
Know block charges	Yes	480	0 %	0 %	54 %	70 %
Know consump on meter	No	660	0 %	91 %	0 %	0 %
Know consump on meter	Yes	615	0 %	9 %	100 %	100 %
Know how to calculate bill	No	785	0 %	100 %	24 %	5 %
Know how to calculate bill	Yes	490	0 %	0 %	76 %	95 %
Know KWh	No	1075	0 %	100 %	100 %	50 %
Know KWh	Yes	200	0 %	0 %	0 %	50 %
Know tari structure	No	847	0 %	62 %	100 %	0 %
Know tari structure	Yes	428	0 %	39 %	0 %	100 %

Accuracy Chart

Mining Legend

Population percentage: 45.05%

Series, Model	Score	Population correct	Predict probability
ElectricityTermsAwareness	1.00	45.21%	99.37%
ElectricityAwareness-NN	1.00	45.21%	99.29%
ElectricityAwareness-NB	0.97	44.12%	97.20%
Ideal Model		45.00%	

By considering results from all the data mining algorithms, we can clearly see the awareness about the electricity terms among the sample is not up to the satisfied level.

By looking at the accuracy chart, decision tree algorithm is the most appropriate one for the analysis since it has 99.37 prediction probability. Other algorithms Neural Network and Neural Network algorithms also giving good prediction probabilities.

7.4.2. Prediction and Evaluation of December month consumption

Algorithm- Microsoft Decision Tree

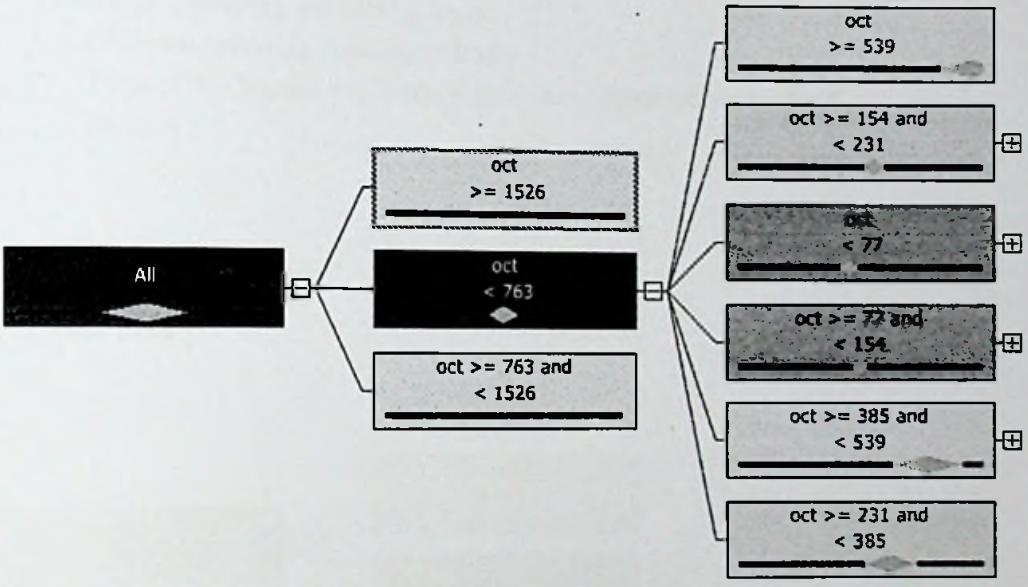
Input for the mining model

Consumption of monthly consumption of consumers in the dataset from January 2015 to November 2015

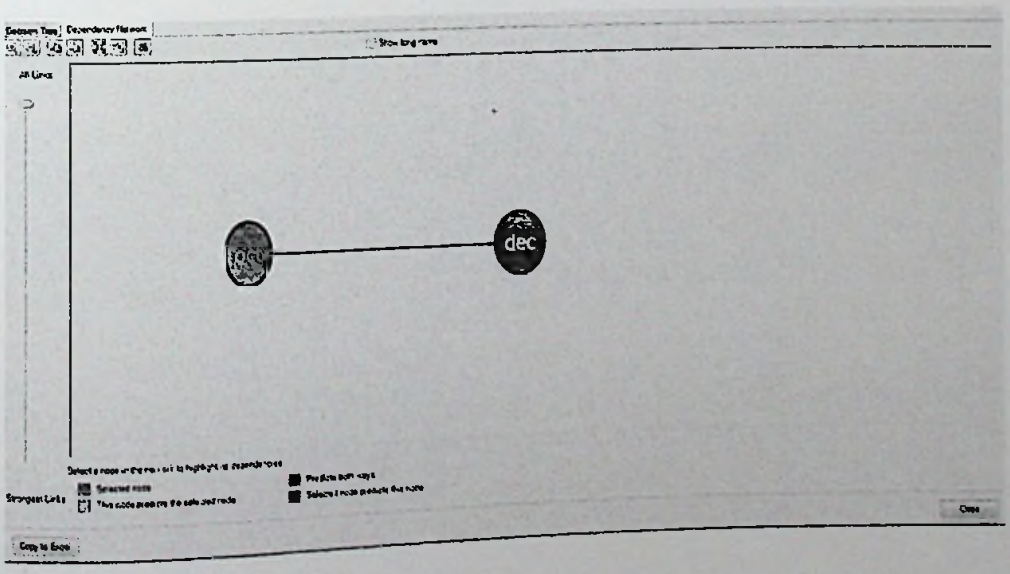
Output

Decision tree classification with the prediction of which months consumptions are mostly effected for the consumption of December month and the December month consumption prediction

Decision Tree



Dependency Network



By analyzing one year consumption data of the sample, prediction of December month consumption is analyzed. Here we can see the consumption of October month is dependent with December month consumption.

7.4.3. Predicting consumption type by taking income, children spending duration at home, adults spending duration at home and the house type (floor area)

Algorithm – Microsoft Decision Tree

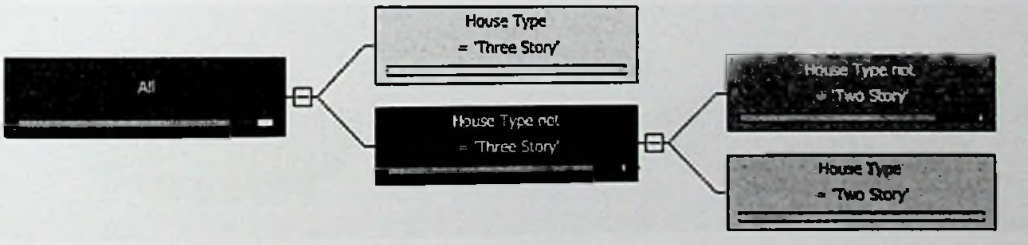
Inputs

- Adults spending duration at home
- Children spending duration at home
- Type of the house (single story, two story, three story or other)
- Income

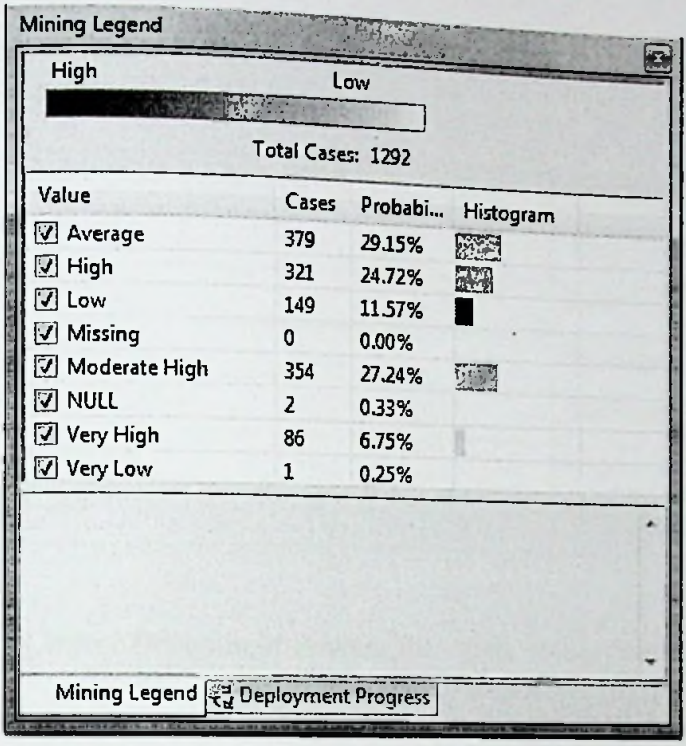
Output

- Consumption Type

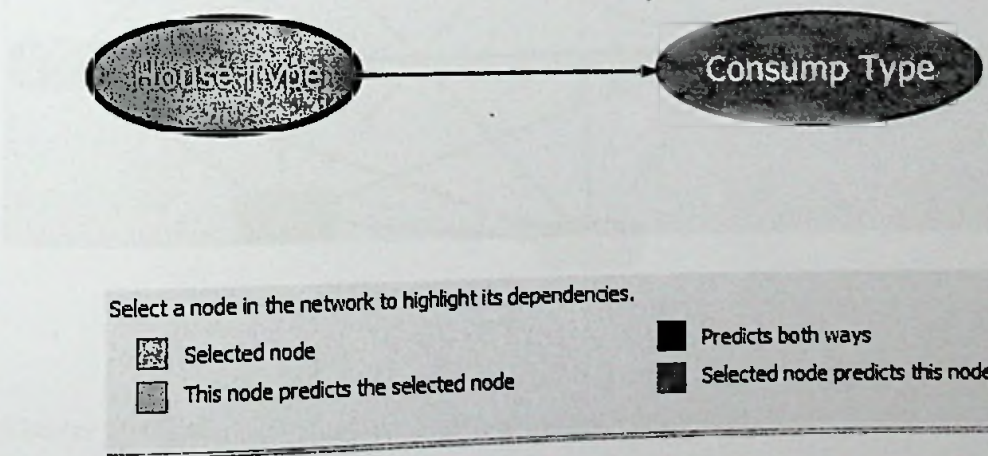
Decision Tree



Mining Legend



Dependency Network



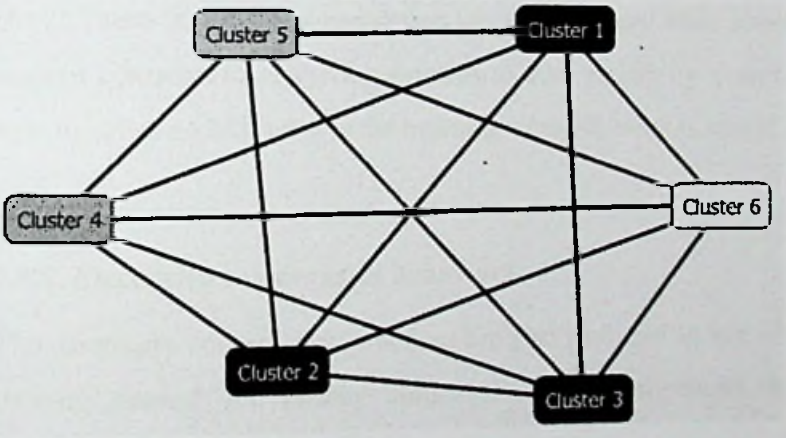
Here we can see among the attributes selected consumption type is basically related to the house type. There is no relationship with the adults and the children spending duration.

7.4.4. Categorizing Consumption types

Consumption types are categorizing using unit blocks as follows and apply for the sample.

Consumption Units (KWh)	Consumption Type
0-30	Very Low
31-60	Low
61-90	Average
91-120	Moderate High
121-180	High
>180	Very High

Cluster Diagram of consumption type categorization



Cluster Profiles

Variables	States	Population (All)	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6
Size		1292	375	356	325	148	87	1
Consump Type	Average	375	1.000	0.000	0.000	0.000	0.000	0.000
Consump Type	Moderate High	356	0.000	1.000	0.000	0.000	0.000	0.000
Consump Type	High	325	0.000	0.000	1.000	0.000	0.000	0.000

Consump Type	Low	148	0.000	0.000	0.000	1.000	0.000	0.000
Consump Type	Very High	87	0.000	0.000	0.000	0.000	1.000	0.000
Consump Type	Very Low	1	0.000	0.000	0.000	0.000	0.000	1.000
Consump Type	missing	0	0.000	0.000	0.000	0.000	0.000	0.000

Cluster characteristics

Variables	Values	Probability
Consump Type	Average	29.025%
Consump Type	Moderate High	27.554%
Consump Type	High	25.155%
Consump Type	Low	11.455%
Consump Type	Very High	6.734%

In this sample we can see the consumption types are Average, Moderate High and High. There is very less percentage consuming very high consumption. So we can suggest consumers are striving towards to save electricity even they are not aware of how to calculate bill, what is the meaning of tariff, what is meant by KWh ect.

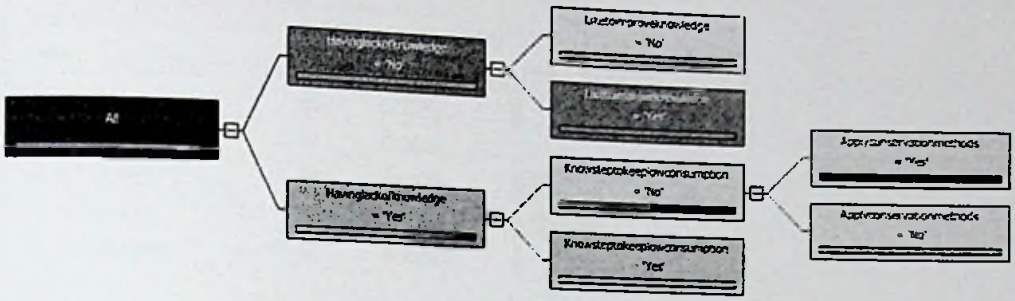
7.4.5. Electricity conservation behaviors

The electricity conservation practices are also analyzed to see whether consumers are striving toward for energy conservation.Some questions are included in the questionnaire to check that.That is,

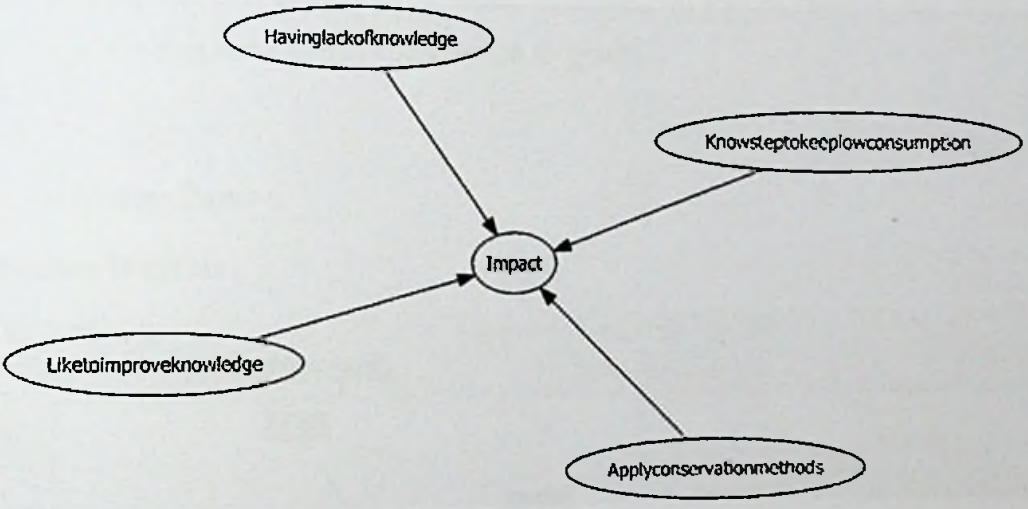
- Are they applying energy conservation methods?
- Are they aware of the steps can be taken to keep low consumption
- Do they like to improve knowledge about energy conservation methods?
- Do they believe that they are having lack of knowledge about energy conservation practices?

Microsoft Decision Tree Algorithm is used to classify data. The consumers are categorized in to different categories according to the impact of their knowledge by grouping them to critical, moderate, significant, and negligible.

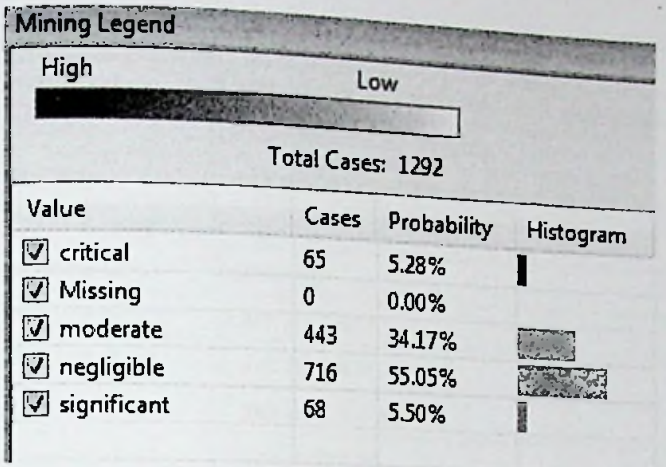
Decision Tree



Dependency Network



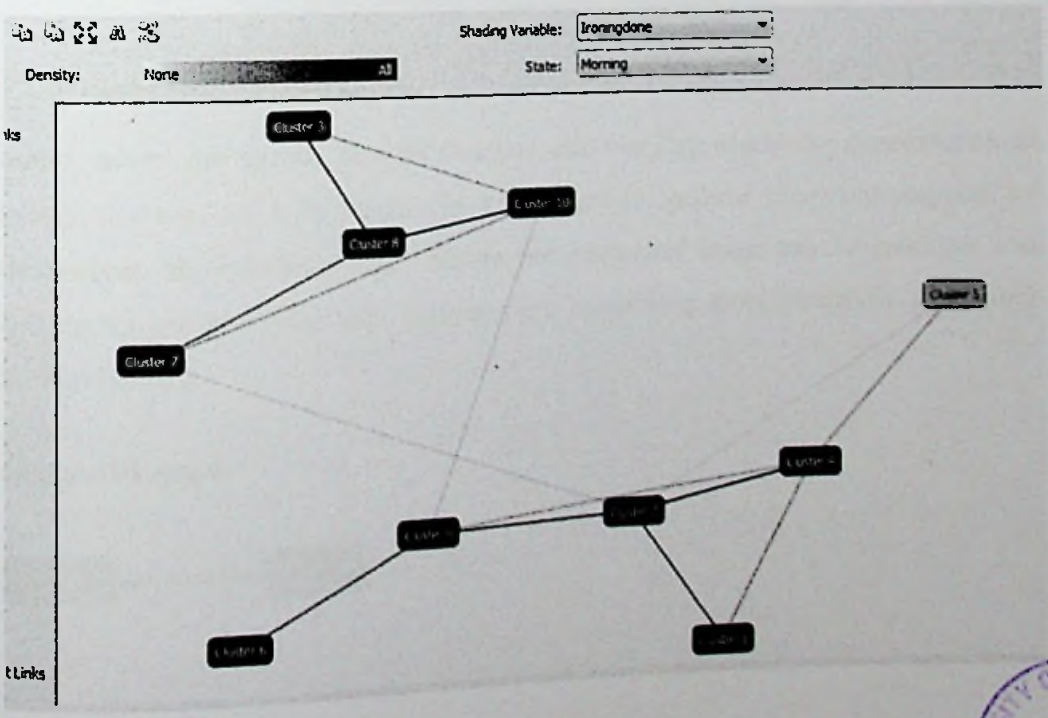
Mining Legend



Here we can see total of 1292 consumers the 716 number of consumers impact is negligible. That means out of 1292,716 consumers are practicing energy conservation methods. Only 65 of people are in impact of critical. So we can retrieve that sample and can conduct some energy conservation programs.

7.4.6 Ironing Pattern

Cluster Diagram



Cluster Characteristics

Variables	Values	Probability
Ironing	Hard Materials first and soft materials later	21.749%
Ironing	No sequence of ironing	33.514%
Ironing	Soft materials first and hard materials later	44.737%
Ironing done	Evening	7.276%
Ironing done	Morning	92.724%
Ironing time	6 am to 7 am	11.920%
Ironing time	6 am to 8 am	10.526%
Ironing time	7 am to 7.30 am	16.176%
Ironing time	7 am to 8 am	31.811%
Ironing time	7 am to 8.15 am	6.037%
Ironing time	7 pm to 8 pm	12.461%
Ironing time	7 pm to 8 pm	11.068%
Iron wet clothes	No	42.492%
Iron wet clothes	Yes	57.508%

By looking at the ironing pattern we can see most of the consumers in the sample is done ironing in morning hours 7 am to 8 am.57.5% are ironing wet clothes,33.514% are not having any sequence of ironing.By looking at this figures,we can suggest some solutions to educate consumers about using electricity equipments,

7.4.7 Smart Meter Preferences

Smart meters are special devices that you can see your electricity consumption in timely manner. So it is useful for consumers to analyze their consumption by themselves. By installing smart meters the electricity usage can be calculate and consumers can see what time durations are consuming more electricity than other normal hours.

Cluster Diagram

Cluster profiles

Variables	States	Population (All)	Cluster 1	Cluster 2
Size		1292	665	627
Smart meters	Yes	665	1.000	0.000
Smart meters	No	627	0.000	1.000
Smart meters	missing	0	0.000	0.000

Cluster characteristics

Variables	Values	Probability
Smart meters	Yes	51.471%
Smart meters	No	48.529%

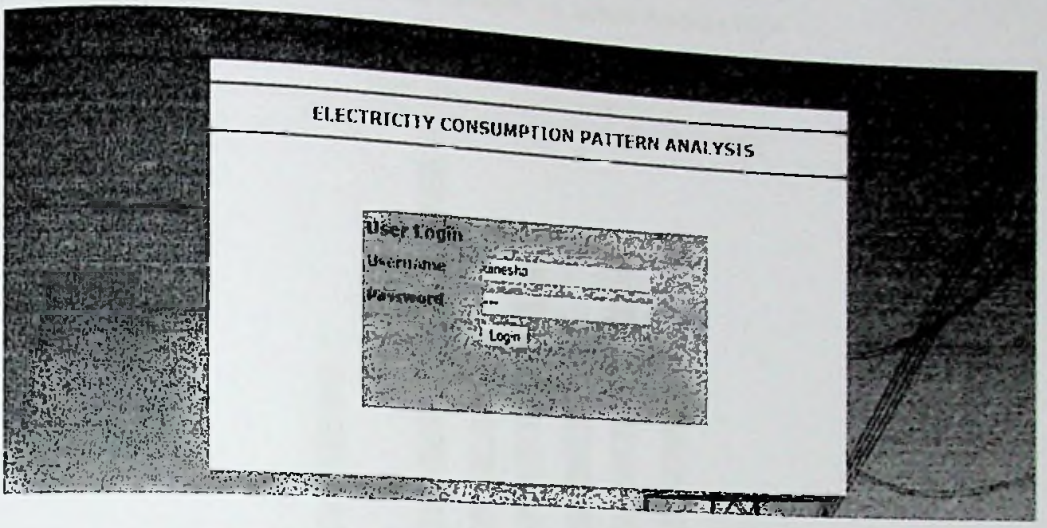
Here nearly 52% of consumers in this sample is prefereed to install smart meters,so this would be benefited for consumer as well as for the country to save energy.

The evaluation is done in the Integrated Environment for the testing of the application. The patterns are extracted and check the validity of the applicaton.Since the SQL Server Business Intelligent Studio was not a familiar environment and I have not worked on that before. So I have to do lots of testing and experiments to make those data mining models

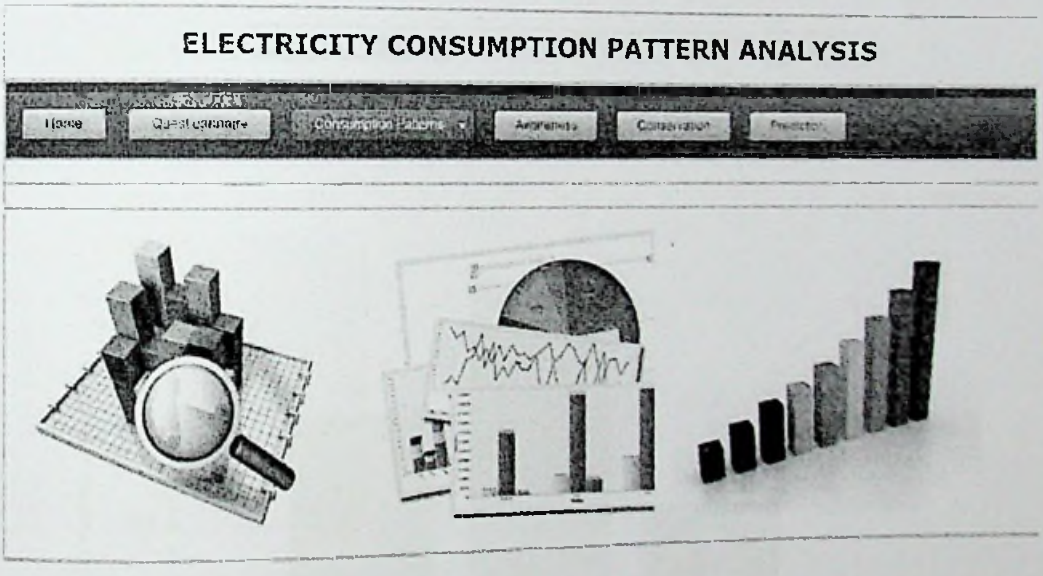
7.5 Evaluation of Web Application

The web application is also evaluated by entering inputs and analyzes the outputs. This application is consisting of different kinds of reports and graphs. Any average user can identify by looking at the reports provided. This application is basically focused of the employees in Ceylon Electricity Board who are having less computer literacy. Evaluations of some reports are described here.

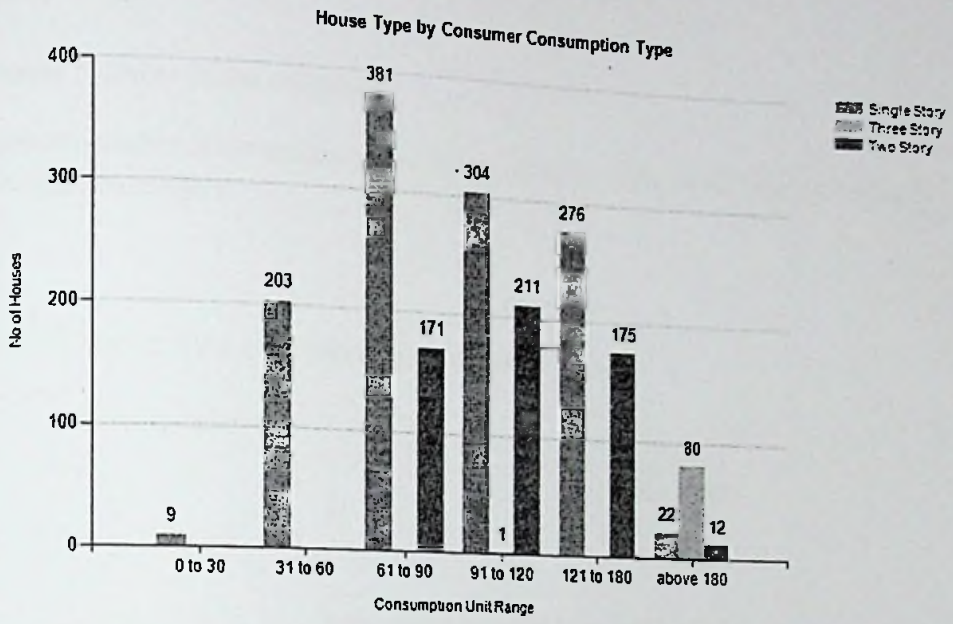
7.5.1 Login Page



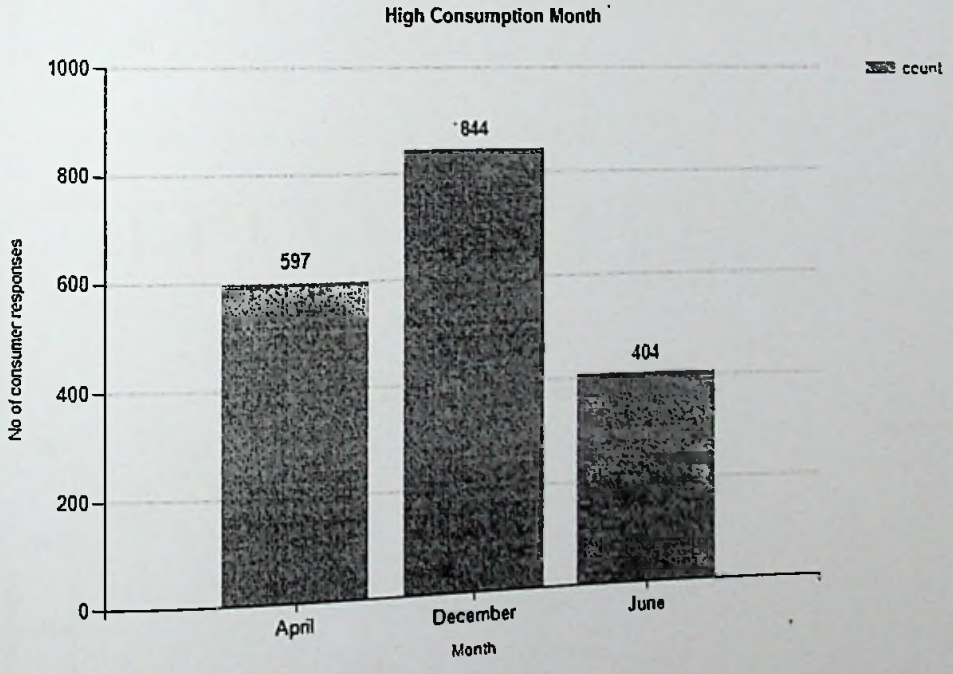
7.5.2 Main Screen



7.5.3 Categorizing houses in the sample by consumption type



7.5.4 High Consumption Month



7.5.5 Individual Usage Pattern

Inputs

Account Number of the consumer

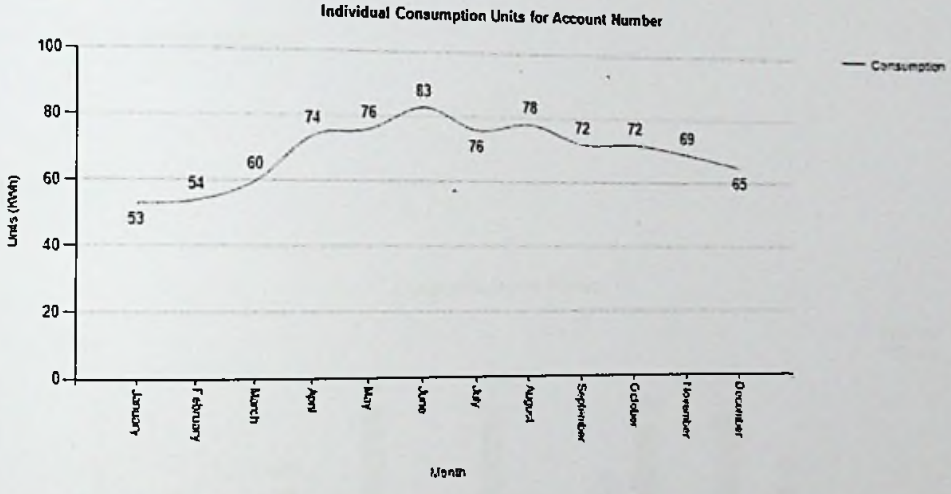
Account Number is the unique value using in Ceylon Electricity Board to identify individual customers

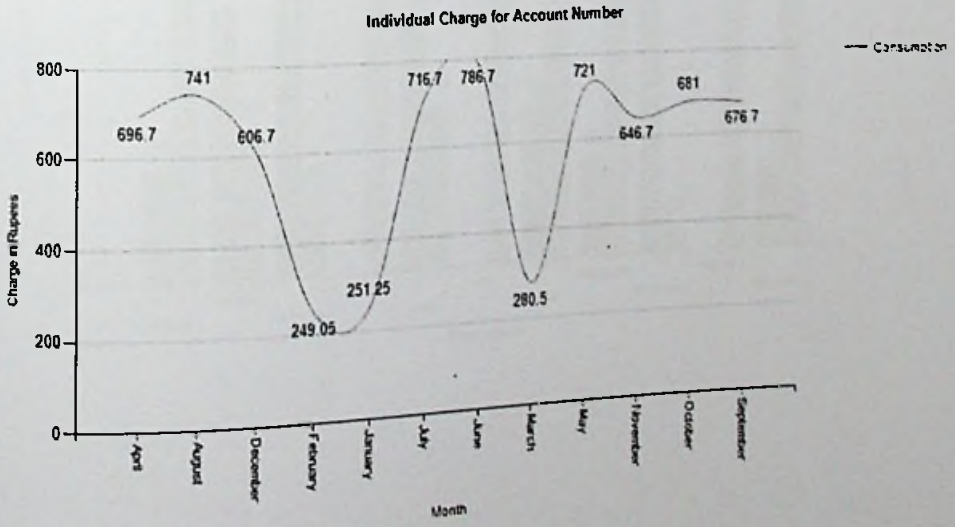
House Type by Consumer Consumption Type

Enter Account Number

1694300617

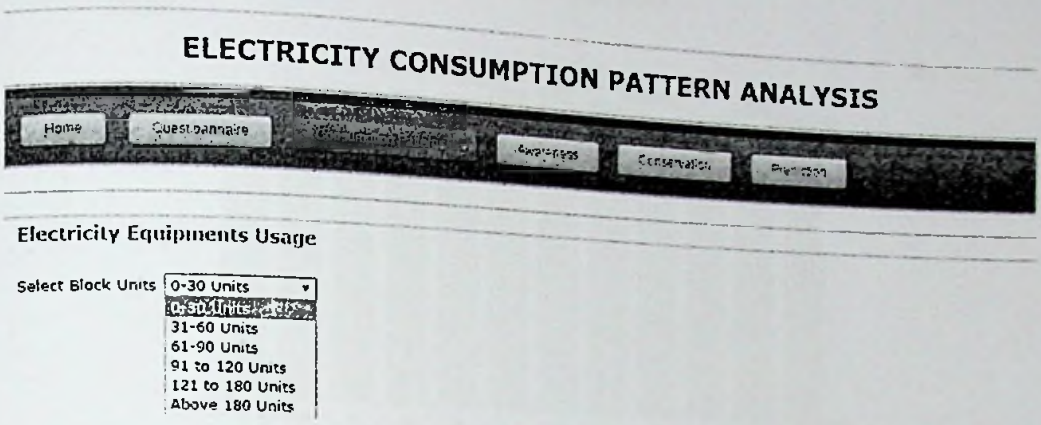
View Consumption





7.5.6 Electricity Equipments usage

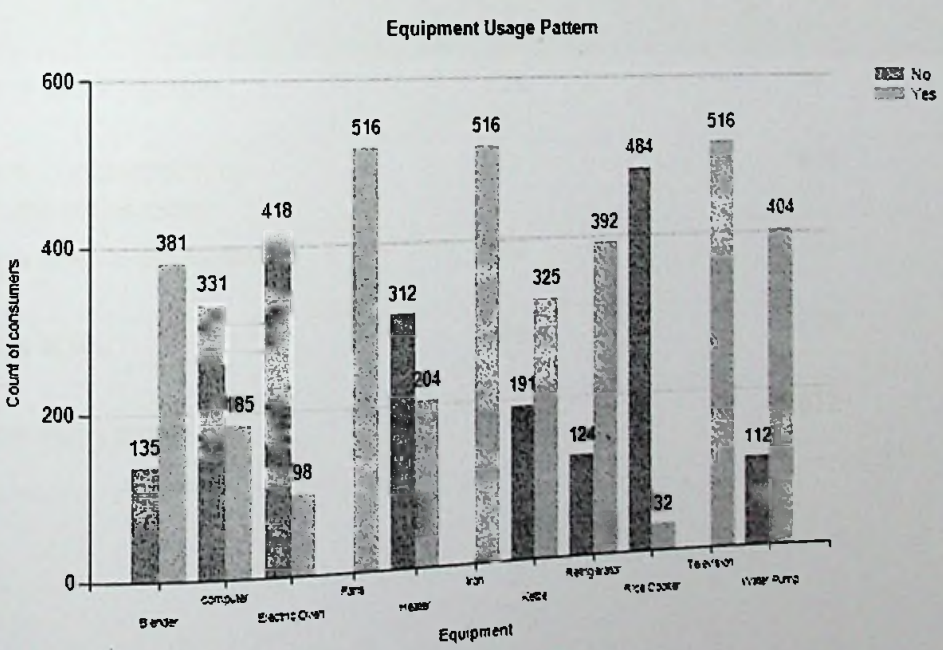
Graphical User Interface



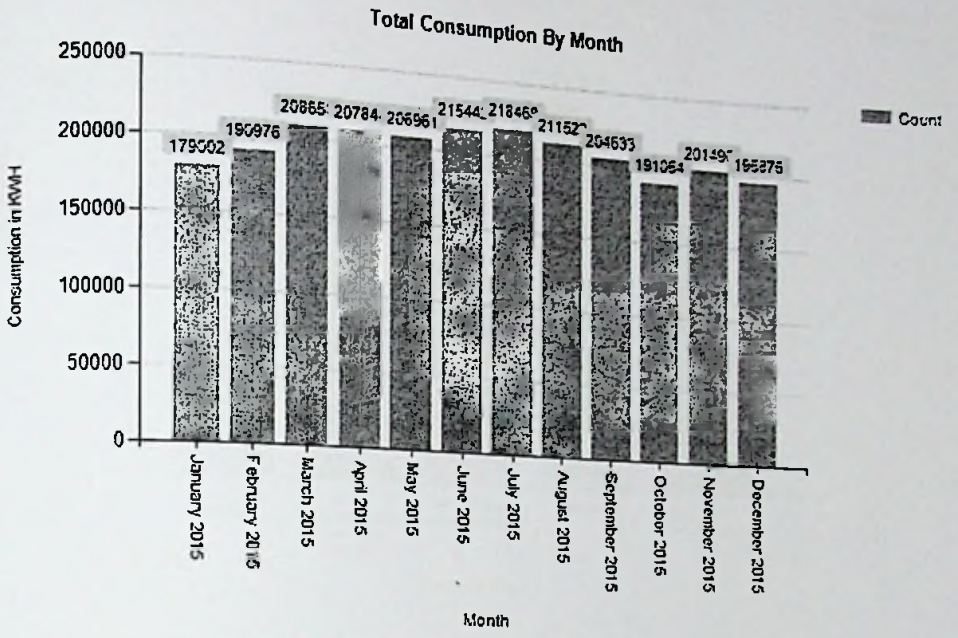
Inputs

- Block units range

Results

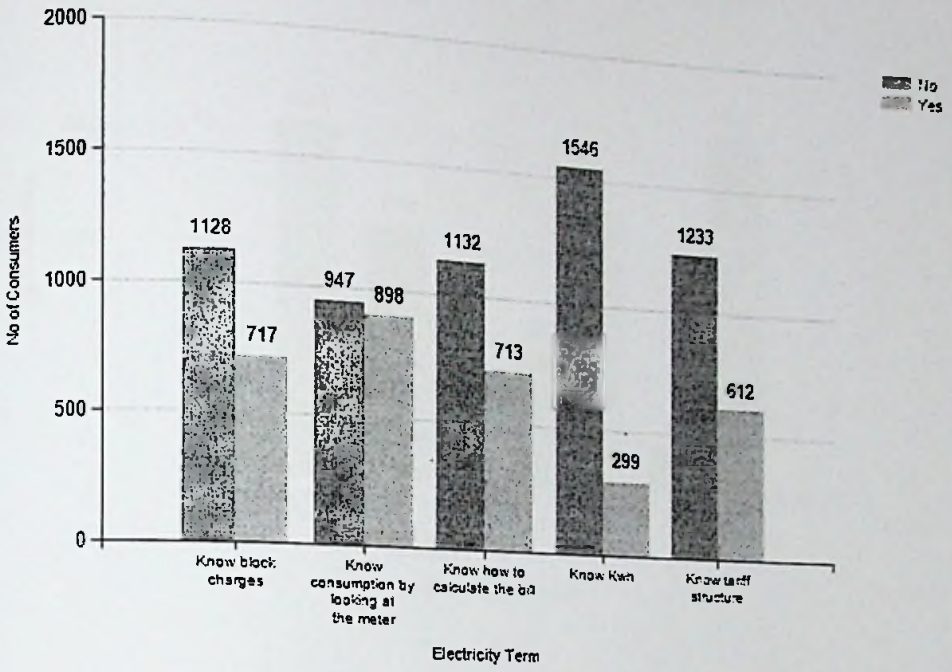


7.5.7 Total Consumption by Month



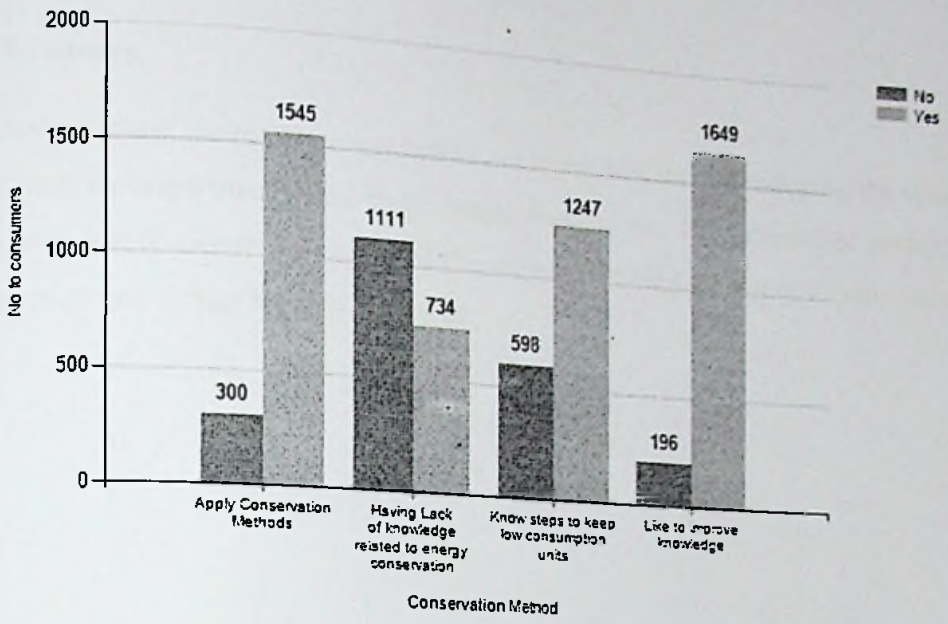
7.5.8 Electricity Terms Awareness

Electricity Term	No	Yes
Know block charges	1128	717
Know consumption by looking at the meter	947	898
Know how to calculate the bill	1132	713
Know KWh	1546	299
Know tariff structure	1233	612



7.5.9 Electricity Conservation Behaviors

Conservation	No	Yes
Apply Conservation Methods	300	1545
Having Lack of knowledge related to energy conservation	1111	734
Know steps to keep low consumption units	598	1247
Like to improve knowledge	196	1649



7.5.10 Electricity Consumption Prediction and Saving Potentials

Consumption Prediction and Energy Saving Potentials

Note:This interface can be use to analyze how consumption units and charge can be reduced for consumers by putting them in to different tariff ranges

Average Consumption range	93 to 105
	Display Results
Total Consumers in the sample	198
Total Consumption	19635
Total Charge	275,959.85
Consumption to be reduced to	90
	Predict Energy Savings
Total consumption (Kwh Units)	17820
Reduced Consumption (Kwh Units)	1815
Total Charge (Rs)	170,478.00
Total Charge Reduced by reducing consumption units (Rs)	105,481.85
Total Units Reduced	1815
Total Charge Reduced for the population (Rs)	89,054,916.44
Total Units Reduced for the population (Kwh Units)	1,532,345.83

7.6 Summary

Evaluation about the research was carried out in the process of developing the system. This was included weekly meetings, questionnaires, etc. The purpose of evaluating regularly was to ensure the objects of the project are being achieving. In next chapter conclusion and further work is discussed.

Chapter 8

8. Conclusion and Further Work

8.1 Introduction

This chapter contains a discussion on the results obtained from the research and how the objectives are met. The future works can be done to continue this research for make the broader environment is also discussed.

8.2 Achievements of the objectives

Analyzing electricity consumption patterns should be an important factor in any country for planning future demands. The domestic sector is the most influential party. The highest percentage of consumers in Sri Lanka is in the domestic tariff category. So if we can analyze their pattern consumption of electricity in a timely manner. Many different factors affecting electricity consumption is mainly related to the high electricity consumption usage. The floor area of a house is also the factor effecting for high consumption. By analyzing monthly data the highest consumptions months are identified. This factor would be more important for the load balancing and the future demand of the area.

The knowledge of the energy conservation habits of using equipments can be taken as a good way forward. Most of the consumers in the sample are having energy conservation habits. But the awareness of electricity reading, tariff structure, bill calculation is not sufficient for better utilization of electricity. So awareness programs should be introduced to improve their knowledge.

Furthermore, different characteristics (size, number of occupation and the monthly income) will be related to the consumption pattern analysis in order to observe their effects on the final consumption. The income level is not a key factor for people to towards electricity consumption. People reluctant to give income level for such a questionnaire, so that reason may effected for identification of relationships between consumption and the monthly income level.

8.3 Further Work

This research is basically focused on domestic consumer group in Jaffna area. Sometimes behaviors of people towards electricity consumption may vary according to the different geographical areas. So it's better to expand this research to other areas as well. The design of this research has a provision that can be adapted for any area, any province as well as entire country.

Apart from domestic category, there are consumers in other categories like General Purpose, Industrial Purpose, Religious and Charity purpose, Time Of Use (TOU).For the future expansion of this research , this can be apply for those categories as well to analyze electricity consumption patterns.

8.4 Summary

This chapter contained a conclusion and future works of this research. This chapter consists of a summary of this report. Also it contains explanations on problems encountered during implementation and further work to be done.

References

[1] K. Ehrhardt-Matrtinez, "Changing Habits, Lifestyles, and Choices: The Behaviours That Drive Feedback-Induced Energy Savings," *Proc. 2011 ECEEE Summer Study Energy Effic. Build. Toulon Fr.*, vol. 2011, pp. 6–11, 2011.

[2] Y. G. Yohanis, J. D. Mondol, A. Wright, and B. Norton, "Real-life energy use in the UK: How occupancy and dwelling characteristics affect domestic electricity use," *Energy Build.*, vol. 40, no. 6, pp. 1053–1059, 2008.

[3] Y. G. Yohanis, J. D. Mondol, A. Wright, and B. Norton, "Real-life energy use in the UK: How occupancy and dwelling characteristics affect domestic electricity use," *Energy Build.*, vol. 40, no. 6, pp. 1053–1059, 2008.

[4] J. M. Abreu, F. C. Pereira, and P. Ferrão, "Using pattern recognition to identify habitual behavior in residential electricity consumption," *Energy Build.*, vol. 49, pp. 479–487, 2012.

[5] M. S. bin M. Aras and A. binti Ahmad, "Electricity Load Forecasting Using Data Mining Technique," 2012.

[6] M. Gerolimetto, "ARIMA and SARIMA models," *CaFoscari Univ. Venice Italy*, 2010.

[7] S. Firth, K. Lomas, A. Wright, and R. Wall, "Identifying trends in the use of domestic appliances from household electricity consumption measurements," *Energy Build.*, vol. 40, no. 5, pp. 926–936, 2008.

[8] Visual Information Solutions, "IDL Reference Guide." .

[9] [Online]. Available: http://iesl.ceylonhost.com/IESL_publications/Electrical%20Engineering/Energy%20Engineering/Energy%20Consumption%20Pattern%20In%20The%20Sri%20Lanka%20Urban%20Domestic%20Sector%20by%20D.D.%20Ananda%20Namal%20and%20K.G.%20Chamila%20Jayasekera%202002.PDF. [Accessed: 13-Mar-2016].

[10] [Online]. Available: http://www.pucsl.gov.lk/english/wp-content/uploads/2013/02/STUDY-REPORT-ON-ELECTRICITY-DEMAND-CURVE-AND-SYSTEM-PEAK-REDUCTION.pdf. [Accessed: 13-Mar-2016].

[11] "Data Mining (SSAS)." [Online]. Available: https://msdn.microsoft.com/en-us/library/bb510516.aspx. [Accessed: 11-Mar-2016].

[12] "Data Mining Algorithms (Analysis Services - Data Mining)." [Online]. Available: https://msdn.microsoft.com/en-us/library/ms175595.aspx. [Accessed: 11-Mar-2016].

[13] "Physical Architecture (Analysis Services - Data Mining)." [Online]. Available: https://msdn.microsoft.com/en-us/library/bb510502.aspx. [Accessed: 11-Mar-2016].

[14] "Data Mining Add-ins - Excel." [Online]. Available: https://support.office.com/en-us/article/Data-Mining-Add-ins-cbbce629-df1a-4b15-b40e-c494fec4f022. [Accessed: 11-Mar-2016].

[15] D. H. says: J. 25 and 2013 at 11:10 Pm, "What is ASP.NET? -Top 12 Advantages of ASP.NET | ITegrity." .

[16] "SQL Server Studios Overview." [Online]. Available: https://technet.microsoft.com/en-us/library/ms174170(v=sql.100).aspx. [Accessed: 11-Mar-2016].

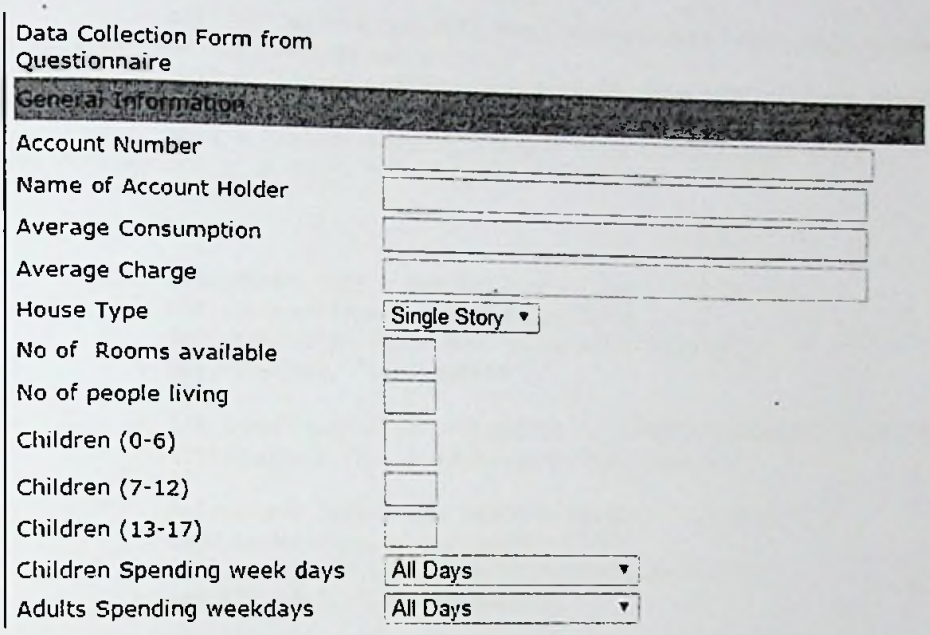
[17] tutorialspoint.com, "Data Mining Knowledge Discovery," *www.tutorialspoint.com*. [Online]. Available:

http://www.tutorialspoint.com/data_mining/dm_knowledge_discovery.htm. [Accessed: 12-Mar-2016].

Appendix I

Web Application interfaces

Questionnaire Entering form



Source Codes

Consumption Prediction

```
using System;
using System.Collections.Generic;
using System.Data;
using System.Data.SqlClient;
using System.Linq;
using System.Web;
using System.Web.UI;
using System.Web.UI.WebControls;

public partial class consumptionreduceprediction : System.Web.UI.Page
{
    protected void Page_Load(object sender, EventArgs e)
    {

    }
    protected void Button1_Click(object sender, EventArgs e)
    {
        int start = int.Parse(from.Text.ToString());
        int end = int.Parse(to.Text.ToString());
        string sql1="";
        string sql2 = "";
        string sql3 = "";
```

```
        DataSet ds1 = new DataSet();
        DataSet ds2 = new DataSet();
        DataSet ds3 = new DataSet();


        using (SqlConnection connection = ConStrings.GetConnection())
        {

            sql1 = " select count(*) from researchdata where avg_consumption
>"+start+" and avg_consumption <"+end+" ";
            sql2 = "select sum(avg_consumption) from researchdata where
avg_consumption >"+start+" and avg_consumption <"+end+"";
            sql3 = "select sum(avg_charge) from researchdata where
avg_consumption >" + start + " and avg_consumption <" + end + "";



            SqlCommand cmd1 = new SqlCommand(sql1, connection);
            cmd1.CommandType = CommandType.Text;
            SqlDataAdapter ad1 = new SqlDataAdapter(cmd1);
            ad1.Fill(ds1, "consumption");

            int totalcount = int.Parse(ds1.Tables[0].Rows[0][0].ToString());
            totconsumers.Text = totalcount.ToString();

            SqlCommand cmd2 = new SqlCommand(sql2, connection);
            cmd2.CommandType = CommandType.Text;
            SqlDataAdapter ad2 = new SqlDataAdapter(cmd2);
            ad2.Fill(ds2, "consumption2");

            decimal totconsumption =
Math.Round(decimal.Parse(ds2.Tables[0].Rows[0][0].ToString()),0);

            tot_consumption.Text = totconsumption.ToString();

            SqlCommand cmd3 = new SqlCommand(sql3, connection);
            cmd3.CommandType = CommandType.Text;
            SqlDataAdapter ad3 = new SqlDataAdapter(cmd3);
            ad3.Fill(ds3, "consumption2");

            decimal total_charge =
Math.Round(decimal.Parse(ds3.Tables[0].Rows[0][0].ToString()),2);
            totcharge.Text = total_charge.ToString();


        }


    }

    protected void predict2_Click(object sender, EventArgs e)
    {

        using (SqlConnection connection = ConStrings.GetConnection())
        {
            DataSet ds4 = new DataSet();
            DataSet ds5 = new DataSet();
            string sql4 = "";
            string sql5 = "";
```

```
            sql4 = "select total from bill_cal where unit=" +
int.Parse(reduced_consumption.Text) + " ";
            SqlCommand cmd4 = new SqlCommand(sql4, connection);
            cmd4.CommandType = CommandType.Text;
            SqlDataAdapter ad4 = new SqlDataAdapter(cmd4);
            ad4.Fill(ds4, "consumption2");

            sql5 = "select total_consumers from areas where area_code='16'";
            SqlCommand cmd5 = new SqlCommand(sql5, connection);
            cmd5.CommandType = CommandType.Text;
            SqlDataAdapter ad5 = new SqlDataAdapter(cmd5);
            ad5.Fill(ds5, "consumption2");

            int population=int.Parse(ds5.Tables[0].Rows[0][0].ToString());


t1.Text=(int.Parse(totconsumers.Text)*int.Parse(reduced_consumption.Text)).ToSt
ring();

            t2.Text=(int.Parse(tot_consumption.Text)-
int.Parse(t1.Text)).ToString();

            decimal charge =
decimal.Parse(ds4.Tables[0].Rows[0][0].ToString());

            decimal total_charge = charge * int.Parse(totconsumers.Text);

            t5.Text = total_charge.ToString();

            t3.Text =( decimal.Parse(totcharge.Text) -
total_charge).ToString();

            t4.Text = (int.Parse(tot_consumption.Text) -
int.Parse(t1.Text)).ToString();



            t6.Text = ((decimal.Parse(t3.Text) / int.Parse(totconsumers.Text))
* population).ToString();
            t7.Text = ((decimal.Parse(t4.Text) / int.Parse(totconsumers.Text))
* population).ToString();


        }

    }
}
```

Average Consumption analysis by type of house

```
using System;
using System.Collections.Generic;
using System.Data;
using System.Linq;
using System.Web;
using System.Web.UI;
using System.Web.UI.WebControls;
using System.Data.Sql;
using System.Data.SqlClient;
using Microsoft.Reporting.WebForms;

public partial class individualConsumption : System.Web.UI.Page
{


    protected void Page_Load(object sender, EventArgs e)
    {

    }

    public DataSet AverageConsumption(int start, int end)
    {

        string sql = "";
        DataSet ds = new DataSet();
        try
        {

            using (SqlConnection connection = ConStrings.GetConnection())
            {

                sql = "select count(avg_consumption)as count,house_type from
researchdata where avg_consumption >=" + start + " and avg_consumption <=" +
end + " group by house_type";
                SqlCommand cmd = new SqlCommand(sql, connection);
                cmd.CommandType = CommandType.Text;
                SqlDataAdapter ad2 = new SqlDataAdapter(cmd);
                ad2.Fill(ds, "consumption");

            }
        }

        catch (Exception ex)
        {
        }

        return ds;
    }
    protected void Button1_Click(object sender, EventArgs e)
    {
        try
        {



        }
        catch (Exception eee)
        {

        }
```

```
    }

    private DataTable CreateDataTable()
    {
        DataTable myDataTable = new DataTable();
        DataColumn myDataColumn;

        myDataColumn = new DataColumn();
        myDataColumn.DataType = Type.GetType("System.String");
        myDataColumn.ColumnName = "unit";
        myDataTable.Columns.Add(myDataColumn);

        myDataColumn = new DataColumn();
        myDataColumn.DataType = Type.GetType("System.Int32");
        myDataColumn.ColumnName = "count";
        myDataTable.Columns.Add(myDataColumn);

        myDataColumn = new DataColumn();
        myDataColumn.DataType = Type.GetType("System.String");
        myDataColumn.ColumnName = "one";
        myDataTable.Columns.Add(myDataColumn);



        return myDataTable;
    }
    private void AddDataToTable(string unit, int count, string one, DataTable
myTable)
    {
        DataRow row;
        row = myTable.NewRow();
        row["unit"] = unit;
        row["count"] = count;
        row["one"] = one;


        myTable.Rows.Add(row);
    }



    protected void btnView_Click(object sender, EventArgs e)
    {
        DataTable mydatatable = CreateDataTable();
        DataSet ds = new DataSet();
        DataSet ds1 = new DataSet();
        DataSet ds2 = new DataSet();
        DataSet ds3 = new DataSet();
        DataSet ds4 = new DataSet();

        try
        {

            string units = ddlunits.SelectedItem.Value;
            if (units.Equals("1"))
            {
                ds = AverageConsumption(0, 30);
                if (ds.Tables[0].Rows.Count > 0)
                {
                    for (int i = 0; i < ds.Tables[0].Rows.Count; i++)
```

```
                {
                    string unit = "0 to 30";
                    int count=
int.Parse(ds.Tables[0].Rows[i][0].ToString());
                    string one = ds.Tables[0].Rows[i][1].ToString();
                    AddDataToTable(unit, count, one, mydatatable);

                }

            }

            ds = AverageConsumption(31, 60);
            if (ds.Tables[0].Rows.Count > 0)
            {
                for (int i = 0; i < ds.Tables[0].Rows.Count; i++)
                {
                    string unit = "31 to 60";
                    int count =
int.Parse(ds.Tables[0].Rows[i][0].ToString());
                    string one = ds.Tables[0].Rows[i][1].ToString();
                    AddDataToTable(unit, count, one, mydatatable);

                }

            }

            ds = AverageConsumption(61, 90);
            if (ds.Tables[0].Rows.Count > 0)
            {
                for (int i = 0; i < ds.Tables[0].Rows.Count; i++)
                {
                    string unit = "31 to 60";
                    int count =
int.Parse(ds.Tables[0].Rows[i][0].ToString());
                    string one = ds.Tables[0].Rows[i][1].ToString();
                    AddDataToTable(unit, count, one, mydatatable);

                }

            }

            ds = AverageConsumption(91, 120);
            if (ds.Tables[0].Rows.Count > 0)
            {
                for (int i = 0; i < ds.Tables[0].Rows.Count; i++)
                {
                    string unit = "61 to 90";
                    int count =
int.Parse(ds.Tables[0].Rows[i][0].ToString());
                    string one = ds.Tables[0].Rows[i][1].ToString();
                    AddDataToTable(unit, count, one, mydatatable);

                }

            }

            ds = AverageConsumption(121,180);
            if (ds.Tables[0].Rows.Count > 0)
            {
                for (int i = 0; i < ds.Tables[0].Rows.Count; i++)
                {
                    string unit = "91 to 120";
```

```
                        int count =
int.Parse(ds.Tables[0].Rows[i][0].ToString());
                        string one = ds.Tables[0].Rows[i][1].ToString();
                        AddDataToTable(unit, count, one, mydatatable);
                    }

                }

                ds = AverageConsumption(180,900000);
                if (ds.Tables[0].Rows.Count > 0)
                {
                    for (int i = 0; i < ds.Tables[0].Rows.Count; i++)
                    {
                        string unit = "above 180";
                        int count =
int.Parse(ds.Tables[0].Rows[i][0].ToString());
                        string one = ds.Tables[0].Rows[i][1].ToString();
                        AddDataToTable(unit, count, one, mydatatable);

                    }

                }

            }

            if (units.Equals("2"))
            {
                ds = AverageConsumption(0, 30);
                if (ds.Tables[0].Rows.Count > 0)
                {
                    for (int i = 0; i < ds.Tables[0].Rows.Count; i++)
                    {
                        string unit = "0 to 30";
                        int count =
int.Parse(ds.Tables[0].Rows[i][0].ToString());
                        string one = ds.Tables[0].Rows[i][1].ToString();
                        AddDataToTable(unit, count, one, mydatatable);

                    }

                }
            }


            if (units.Equals("3"))
            {
                ds = AverageConsumption(31, 60);
                if (ds.Tables[0].Rows.Count > 0)
                {
                    for (int i = 0; i < ds.Tables[0].Rows.Count; i++)
                    {
                        string unit = "31 to 60";
                        int count =
int.Parse(ds.Tables[0].Rows[i][0].ToString());
                        string one = ds.Tables[0].Rows[i][1].ToString();
                        AddDataToTable(unit, count, one, mydatatable);

                    }

                }
            }
```

```
            if (units.Equals("4"))
            {
                ds = AverageConsumption(61, 90);
                if (ds.Tables[0].Rows.Count > 0)
                {
                    for (int i = 0; i < ds.Tables[0].Rows.Count; i++)
                    {
                        string unit = "61 to 90";
                        int count =
int.Parse(ds.Tables[0].Rows[i][0].ToString());
                        string one = ds.Tables[0].Rows[i][1].ToString();
                        AddDataToTable(unit, count, one, mydatatable);

                    }

                }
            }
            if (units.Equals("5"))
            {
                ds = AverageConsumption(91, 120);
                if (ds.Tables[0].Rows.Count > 0)
                {
                    for (int i = 0; i < ds.Tables[0].Rows.Count; i++)
                    {
                        string unit = "91 to 120";
                        int count =
int.Parse(ds.Tables[0].Rows[i][0].ToString());
                        string one = ds.Tables[0].Rows[i][1].ToString();
                        AddDataToTable(unit, count, one, mydatatable);

                    }

                }
            }
            if (units.Equals("6"))
            {
                ds = AverageConsumption(121, 180);
                if (ds.Tables[0].Rows.Count > 0)
                {
                    for (int i = 0; i < ds.Tables[0].Rows.Count; i++)
                    {
                        string unit = "121 to 180";
                        int count =
int.Parse(ds.Tables[0].Rows[i][0].ToString());
                        string one = ds.Tables[0].Rows[i][1].ToString();
                        AddDataToTable(unit, count, one, mydatatable);

                    }

                }
            }


            if (units.Equals("7"))
            {
                ds = AverageConsumption(181, 2500000);
                if (ds.Tables[0].Rows.Count > 0)
                {
                    for (int i = 0; i < ds.Tables[0].Rows.Count; i++)
                    {
                        string unit = "Above 180 ";
```

```
                    int count =
int.Parse(ds.Tables[0].Rows[i][0].ToString());
                    string one = ds.Tables[0].Rows[i][1].ToString();
                    AddDataToTable(unit, count, one, mydatatable);
                }

            }
        }


        ReportDataSource datasource = new ReportDataSource("DataSet1",
mydatatable);

        ReportViewer1.LocalReport.DataSources.Clear();
        ReportViewer1.LocalReport.ReportPath = "averageconsumption.rdlc";
        ReportViewer1.LocalReport.DataSources.Add(datasource);







        }

    catch (Exception ex)
    {
    }


}
protected void Button1_Click1(object sender, EventArgs e)
{
    DataTable mydatatable = CreateDataTable();
    DataSet ds = new DataSet();
    DataSet ds1 = new DataSet();
    DataSet ds2 = new DataSet();
    DataSet ds3 = new DataSet();
    DataSet ds4 = new DataSet();

    try
    {

        string units = ddlunits.SelectedItem.Value;
        if (units.Equals("1"))
        {
            ds = AverageConsumption(0, 30);
            if (ds.Tables[0].Rows.Count > 0)
            {
                for (int i = 0; i < ds.Tables[0].Rows.Count; i++)
                {
                    string unit = "0 to 30";
                    int count =
int.Parse(ds.Tables[0].Rows[i][0].ToString());
                    string one = ds.Tables[0].Rows[i][1].ToString();
                    AddDataToTable(unit, count, one, mydatatable);

                }

            }
```

```
                ds = AverageConsumption(31, 60);
                if (ds.Tables[0].Rows.Count > 0)
                {
                    for (int i = 0; i < ds.Tables[0].Rows.Count; i++)
                    {
                        string unit = "31 to 60";
                        int count =
int.Parse(ds.Tables[0].Rows[i][0].ToString());
                        string one = ds.Tables[0].Rows[i][1].ToString();
                        AddDataToTable(unit, count, one, mydatatable);

                    }

                }

                ds = AverageConsumption(61, 90);
                if (ds.Tables[0].Rows.Count > 0)
                {
                    for (int i = 0; i < ds.Tables[0].Rows.Count; i++)
                    {
                        string unit = "31 to 60";
                        int count =
int.Parse(ds.Tables[0].Rows[i][0].ToString());
                        string one = ds.Tables[0].Rows[i][1].ToString();
                        AddDataToTable(unit, count, one, mydatatable);

                    }

                }

                ds = AverageConsumption(91, 120);
                if (ds.Tables[0].Rows.Count > 0)
                {
                    for (int i = 0; i < ds.Tables[0].Rows.Count; i++)
                    {
                        string unit = "61 to 90";
                        int count =
int.Parse(ds.Tables[0].Rows[i][0].ToString());
                        string one = ds.Tables[0].Rows[i][1].ToString();
                        AddDataToTable(unit, count, one, mydatatable);

                    }

                }

                ds = AverageConsumption(121, 180);
                if (ds.Tables[0].Rows.Count > 0)
                {
                    for (int i = 0; i < ds.Tables[0].Rows.Count; i++)
                    {
                        string unit = "91 to 120";
                        int count =
int.Parse(ds.Tables[0].Rows[i][0].ToString());
                        string one = ds.Tables[0].Rows[i][1].ToString();
                        AddDataToTable(unit, count, one, mydatatable);

                    }

                }

                ds = AverageConsumption(180, 900000);
                if (ds.Tables[0].Rows.Count > 0)
```

```
                {
                    for (int i = 0; i < ds.Tables[0].Rows.Count; i++)
                    {
                        string unit = "above 180";
                        int count =
int.Parse(ds.Tables[0].Rows[i][0].ToString());
                        string one = ds.Tables[0].Rows[i][1].ToString();
                        AddDataToTable(unit, count, one, mydatatable);

                    }

                }

            }

            if (units.Equals("2"))
            {
                ds = AverageConsumption(0, 30);
                if (ds.Tables[0].Rows.Count > 0)
                {
                    for (int i = 0; i < ds.Tables[0].Rows.Count; i++)
                    {
                        string unit = "0 to 30";
                        int count =
int.Parse(ds.Tables[0].Rows[i][0].ToString());
                        string one = ds.Tables[0].Rows[i][1].ToString();
                        AddDataToTable(unit, count, one, mydatatable);

                    }

                }
            }


            if (units.Equals("3"))
            {
                ds = AverageConsumption(31, 60);
                if (ds.Tables[0].Rows.Count > 0)
                {
                    for (int i = 0; i < ds.Tables[0].Rows.Count; i++)
                    {
                        string unit = "31 to 60";
                        int count =
int.Parse(ds.Tables[0].Rows[i][0].ToString());
                        string one = ds.Tables[0].Rows[i][1].ToString();
                        AddDataToTable(unit, count, one, mydatatable);


                    }

                }
            }
            if (units.Equals("4"))
            {
                ds = AverageConsumption(61, 90);
                if (ds.Tables[0].Rows.Count > 0)
                {
                    for (int i = 0; i < ds.Tables[0].Rows.Count; i++)
                    {
                        string unit = "61 to 90";
                        int count =
int.Parse(ds.Tables[0].Rows[i][0].ToString());
                        string one = ds.Tables[0].Rows[i][1].ToString();
```

```
                    AddDataToTable(unit, count, one, mydatatable);
                }

            }
        }
        if (units.Equals("5"))
        {
            ds = AverageConsumption(91, 120);
            if (ds.Tables[0].Rows.Count > 0)
            {
                for (int i = 0; i < ds.Tables[0].Rows.Count; i++)
                {
                    string unit = "91 to 120";
                    int count =
int.Parse(ds.Tables[0].Rows[i][0].ToString());
                    string one = ds.Tables[0].Rows[i][1].ToString();
                    AddDataToTable(unit, count, one, mydatatable);

                }

            }
        }
        if (units.Equals("6"))
        {
            ds = AverageConsumption(121, 180);
            if (ds.Tables[0].Rows.Count > 0)
            {
                for (int i = 0; i < ds.Tables[0].Rows.Count; i++)
                {
                    string unit = "121 to 180";
                    int count =
int.Parse(ds.Tables[0].Rows[i][0].ToString());
                    string one = ds.Tables[0].Rows[i][1].ToString();
                    AddDataToTable(unit, count, one, mydatatable);

                }

            }
        }


        if (units.Equals("7"))
        {
            ds = AverageConsumption(181, 2500000);
            if (ds.Tables[0].Rows.Count > 0)
            {
                for (int i = 0; i < ds.Tables[0].Rows.Count; i++)
                {
                    string unit = "Above 180 ";
                    int count =
int.Parse(ds.Tables[0].Rows[i][0].ToString());
                    string one = ds.Tables[0].Rows[i][1].ToString();
                    AddDataToTable(unit, count, one, mydatatable);

                }

            }
        }
```

```
            ReportDataSource datasource = new ReportDataSource("DataSet1",
mydatatable);

            ReportViewer1.LocalReport.DataSources.Clear();
            ReportViewer1.LocalReport.ReportPath = "averageconsumption.rdlc";
            ReportViewer1.LocalReport.DataSources.Add(datasource);
        }

        catch (Exception ex)
        {
        }

    }
}
```

Appendix II

Questionnaire

Domestic Electricity Consumption Pattern analysis

Research Project – Msc In Information Technology

Faculty of Information Technology, University of Moratuwa

Electricity bill Account Number: .....
மின் கணக்கு இலக்கம்

Name of Account Holder: .....
கணக்கு வைத்திருப்பவர் பெயர்

Occupation: .....
ஆக்கிரமிப்பு

House Type: Single Story/Two Story/Apartment/Annex/Other

1. Numeber of rooms available inside the house .....
வீட்டிலுள்ள அறைகளின் எண்ணிக்கை

2. How many people are living in the house during most of the year?
வீட்டில் வசிப்பவர்களின் எண்ணிக்கை

1☐ 2☐ 3☐ 4☐ 5☐ 6☐ 7or more☐

3. Children in the age of 0-6 years: ..... 7-12 years: ..... and 13-17 years: .....
சிறுவர்களின் வயது

4. Time that the family members spend at home during weekdays
வீட்டு உறுப்பினர்கள் வேலை நாட்களில் வீட்டில் செலவிடும் நேரம்

Adults spending time in the home: All days: ..... Half days: ..... Only evenings and nights: .....
பெரியவர்கள் செலவிடும் நேரம் : முழுநாள் அரைநாள் பிற்பகல் மற்றும் இரவு

Children spending time in the home: All days: .....Half days: ..... Only evenings and nights:.....
சிறுவர்கள் செலவிடும் நேரம் : முழுநாள் அரைநாள் பிற்பகல் மற்றும் இரவு

5. Education level of family members up to
வீட்டு உறுப்பினர்களின் கல்வித்தகமை

GCE O/L ..... Of persons க.பொ.த. சா/த வரை: .....நபர்கள்

GCE A/L ..... of persons க.பொ.த. உ/த வரை: .....நபர்கள்

University ..... Of persons பல்கலைக்கழகம் வரை: .....நபர்கள்

6. What is the household's total income per month ..... Rupees per month
வீட்டின் மாதாந்த மொத்த வருமானம்: .....இலங்கை ரூபாய்

7. Frequency of usage of the below mentioned appliances (If you don't have such just leave it blank)
கீழே குறிப்பிடப்பட்ட மின்உபகரணங்கள் பயன்படுத்தும் தடவைகள் (உபகரணம் இல்லையாயின் இடைவெளியாக விடவும்)

Please add √ mark inside the appropriate cage (if you are using any other equipments other than this please fill write inside the empty rows)
சரியான கட்டத்தினுள் √ குறியீட்டை இடவும் (வேறு உபகரணங்கள் இருப்பின் குறப்பிடவும்)

	Availability (yes or no) இருக்கின்றதா? (ஆம் /	All day அனைத்து நாட்களும்	Rarely அரிதாக	Once a week கிழமைக்கு ஒரு	2-6 times per week கிழமைக்கு 2-6 தடவை	Once per day நாளிற்கு ஒரு	More than once per day நாளிற்கு ஒரு தடவைக்கு

	இல்லை)			தடவை		தடவை	மேல்
Iron மின்னழுத்தி							
Refrigerator குளிரூட்டி							
Heater கீற்றர்							
Kettle கேத்தல்							
Water Pump தண்ணீர்ப்பம்பி							
Washing machine வோசிங்மெசின்							
Electric Oven மின்னடுப்பு							
Rice Cooker சோற்றடுப்பு							
Blender அரைப்பான்							
TV ரீ.வி							
Computer கணனி							
Hot Plate சூட்டடுப்பு							
Fans மின்விசிறி							

8. What are the estimated hours per day below appliances are consumed கீழே குறிப்பிடப்பட்ட மின்உபகரணங்கள் பயன்படுத்தும் காலங்கள் (If you are not using below equipments daily or monthly keep the cage empty)

	No of hours per day நாளிற்கு பயன்படுத்தும் மணித்தியாலங்கள்	No of hours per month மாதத்திற்கு பயன்படுத்தும் மணித்தியாலங்கள்
Iron மின்னழுத்தி		
Refrigerator குளிரூட்டி		
Heater கீற்றர்		
Kettle கேத்தல்		
Water Pump தண்ணீர்ப்பம்பி		
Washing machine வோசிங் மெசின்		
Electric Oven மின்னடுப்பு		
Rice Cooker சோற்றடுப்பு		
Blender அரைப்பான்		
Fans மின்விசிறி		
TV ரீ.வி		
Computer கணனி		
Hot Plate சூட்டடுப்பு		

9. How many incandescent bulbs are used in the household? Total .....
சாதரண மின் குமிழ்கள் எத்தனை பாவனையிலுள்ளது?

10. How many LED and Low energy light bulbs are used in household? Total .....
எல்.ஈ.டி மற்றும் குறைந்த சக்தி மின் குமிழ்கள் எத்தனை பாவனையிலுள்ளது

11. Do the members in your house turn off lights in rooms when they are not presence? ☐ Yes ☐ No
அறை மின்விளக்குகளை யாரும் அற்ற நேரங்களில் நிறுத்துகின்றீர்களா?

12. Is it the energy efficiency or the price the most decisive factor when buying new home appliances?
வீட்டு மின் உபகரணங்களை தெரிவு செய்யும் பொழுது பிரதான காரணியாகவுள்ளது சக்திசெயல்திறன் அல்லது விலை
Energy Efficiency சக்திசெயல்திறன் ☐
Price விலை ☐

13. Do you use daylight in daytime without using bulbs? ☐ Yes ☐ No
பகல் நேரங்களில் மின் விளக்குகளை பயன்படுத்தாது சூரிய ஒளியைப் பயன்படுத்துகின்றீர்களா?

14. What is the sequence of ironing? (If Iron is available only)
மின்னழுத்தியை பயன்படுத்தும் முறை

- Soft materials first and hard materials later ☐
  மென் ஆடைகள் முதலிலும் கடின ஆடைகள் பிற்பாடும்
- Hard materials first and soft materials later ☐
  கடின ஆடைகள் முதலிலும் மென் ஆடைகள் பிற்பாடும்
- There is no such special sequence ☐
  குறப்பிடத்தக்க எந்த ஒருமுறையும் பின்பற்றுவதில்லை
- Other ☐ please specify .....
  வேறு எனில் குறிப்பிடவும்

15. When ironing is done normally?
மின்னழுத்தியை பயன்படுத்துவது எப்பொழுது

- Morning காலை ☐
- Evening மாலை ☐
- Night இரவு ☐

16. What is the normal ironing time of the day? E.g. from 7pm to 8 pm
.....
மின்னழுத்தியை பயன்படுத்தும் நேரம்

17. Do you iron wet clothes? ஈரஆடைகளை அயன் செய்வீர்களா? ☐ Yes ☐ No

18. When you open the refrigerator (if refrigerator is available only)
குளிரூட்டியை எப்பொழுது திறப்பீர்கள்?

- I open the refrigerator when I need to take each and every item ☐
  ஒவ்வொரு பொருட்களையும் எடுக்கும் தேவை ஏற்படும் பொழுது
- I decide about the things to be taken out from the refrigerator before open it ☐
  திறப்பதற்கு முன்னர் தேவையான பொருட்களை தீர்மானம் செய்த பின்னர்
- I do not decide about the things to be taken out from the refrigerator before open it ☐
  திறப்பதற்கு முன்னர் தேவையான பொருட்களை தீர்மானம் செய்வதில்லை
- Other ☐ please specify .....
  வேறு எனில் குறிப்பிடவும்

19. Do you normally keep food items inside the refrigerator in hot state ☐ Yes ☐ No
சூடான பொருட்களை குளிரூட்டியில் வைப்பீர்களா?

20. Do you keep open the door of the refrigerator for a long time until you take the things out?
குளிரூட்டியின் கதவை கூடுதல் நேரம் திறந்த நிலையில் வைப்பீர்களா? Yes ☐ No ☐

21. Are you sure refrigerator door is keep closed tightly ☐ Yes ☐ No
குளிரூட்டியின் கதவு இறுக்கமாக மூடப்படுகின்றதா?

22. Is it an old one or new one (rough answer is needed) ☐ Old one பழையது ☐ New one புதியது
குளிரூட்டி பழையதா? புதியதா?

23. How many times per month inside the refrigerator is cleaned
குளிரூட்டியின் உட்பகுதி மாதத்திற்கு எத்தனை தடவை சுத்திகரிக்கப்படுகின்றது
Once a moth மாதத்திற்கு ஒரு தடவை ☐

Twice a month மாதத்திற்கு இரு தடவை
Never ஒரு பொழுதும் இல்லை ☐ ☐
Other please specify வேறு எனில் குறிப்பிடவும் ☐
.....

24. How do you decide the time to switch off the water pump?
தண்ணீர்ப்பம்பியை நிறுத்துவதனை எவ்வாறு தீர்மானம் செய்வீர்கள்

- Water pumping is done for a certain duration and the pump is switched off after the particular duration குறிப்பிட்ட நேரத்☐ பிறகு
- The pump is switched off after the tank is overflowed. தண்ணீர்த்தொட்டி நிரம்பியதன்பின்னர்☐
- There is a device which is automatically switches off the water pump after the water level has reached the required level சரியான மட்டத்திற்கு நீர்வந்தபின் தானியங்கி ஆழி தெ☐ப்படும்
- Other please specify வேறு எனில் குறிப்பிடவும் ..... ☐

25. Do you normally wash a machine full or few items at one time? ☐ Full ☐ Few
வோசிங் மெசினை நிரம்பியதாக பயன்படுத்துவீர்களா குறைவாக பயன்படுத்துவீர்களா? நிரம்பியதாக குறைவாக

26. Do you wash heavy weight bath sheets and towels to wash using washing machine? ☐ Yes ☐ No
கடின ஆடைகளை வோசிங் மெசினில் துவைப்பீர்களா?

27. Do you strive to reduce electricity consumption by applying conservation methods? ☐ Yes ☐ No
மின் பாவனையை குறைப்பதற்கு நடவடிக்கை எடுப்பீர்களா?

28. Do you know what are the steps can be taken to keep low electricity consumption? ☐ Yes ☐ No
மின் பாவனையை குறைப்பதற்கான முறைகளை தெரிந்துள்ளீர்களா?

29. Do you like to improve your knowledge of actions that can be taken to keep low electricity consumption? மின் பாவனையை குறைப்பதற்கான முறைகளை தெரிந்துகொள்ள விரும்புகின்றீர்களா? ☐ Yes ☐ No

30. Do you think your are having a lack of knowledge about the electricity conservation methods? மின் பாவனையை குறைப்பதற்கான முறைகள் பற்றிய அறிவு போதுமானதாக உ☐கின்றீர்களா? ☐ Yes No

31. Do you have an idea about how to calculate your bill related to the consumption unit? மின் பட்டியல் கணிப்பீடு தொடர்பாக தெரிந்துள்ள☐ளா? ☐Yes No

32. Do you have any idea of unit blocks and block charges (e.g.0-30, 31-60, 60-90, ect)? ☐ Yes ☐ No
மின் அலகு கட்டமைப்பு மற்றும் அறவீடுகள் தொடர்பாக அறிந்துளளீர்களா?

33. Do you know the meaning of KWh and how it is calculated? ☐ Yes ☐ No
கிலோவாற்று மணித்தியாலம் மற்றும் அது கணிக்கும் முறை தொடர்பாக தெரிந்துள்ளீர்களா?

34. Do you have any idea about the consumption units for a given period by looking at the meter? மின் மானியை அவதானிப்பதன் ஊடாக குறிப்பிட்ட காலப்பகுதிக்கான மின்பாவனை அலகுகளை ☐ ☐ கணிப்பிடுவீர்களா? Yes No

35. Do you prefer smart meters? (Is usually an electronic device that records consumption of electric energy in intervals of an hour or less and communicates that information at least daily back to the utility (CEB) for monitoring and billing) ஸ்மாட் மின்மானியை விரும்☐ன்றீர்களா☐ Yes No

36. Do you have any idea about the tariff structure or tariff rates? ☐ Yes ☐ No
மின் கட்டண அமைப்பு மற்றும் கட்டண விகிதங்கள் தொடர்பாக அறிந்துள்ளீர்களா?

37. What do you think about the electricity bill according to the usage and the monthly income?
மாதாந்த வருமானம் மற்றும் மின் பாவனையுடன், மின் பட்டியல் தொடர்பான உங்கள் கருத்து

☐ Very High மிகஅதிகம் ☐ High அதிகம் ☐ Medium நடுத்தரம் ☐ Low குறைவு ☐ Very Low மிகக்குறைவு

38. What is the month of the year that you are consuming high electricity consumption?
மின்பாவனை கூடுதலாக உள்ள மாதம் .....

What is the reason for that?அதற்கான காரணம் .....

39. What are the methods that you are using to save electricity consumption at home? மின் பாவனையை குறைப்பதற்காக பின்பற்றும் முறைகள் எவை?

.....

.....

.....

40. Any other comments or sugges ons that you would like to provide, please men on below வேறு கருத்துக்கள் மற்றும் ஆலோசனைகள்

.....

.....

.....

.....