

LB/DON/106/2016  
IT 01/135

# Research on Electricity Consumption Pattern of Households

M.D Lakmali

139170T

LIBRARY  
UNIVERSITY OF MORATUWA, SRI LANKA  
MORATUWA

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.

University of Moratuwa  
  
TH3170

April 2016

004 "16"  
004 (043)

TH 3170  
+ DVD - ROM  
(TH3160 - TH3180)

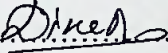
TH3170

## 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 Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.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

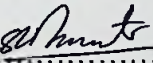
Student Number : 139170T

Signature of the student: .. .....

Date: 29/04/2016

Supervised by

Name of the supervisor: Mr. Saminda Premaratne

Signature of the supervisor: ..... .....

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

Declaration.....	i
Dedication.....	ii
Acknowledgement.....	iii
List of Figures.....	ix
Chapter 1 .....	1
Introduction .....	1
1.1 Background and Motivation.....	1
1.2 Electricity Consumption in Sri Lanka .....	1
1.3 Aim and Objectives.....	8
1.3.1 Aim.....	8
1.3.2 Objectives .....	8
1.4 Research Plan .....	9
2. Review of Other’s work.....	10
2.1 Introduction .....	10
2.2 Summary.....	15
Chapter3.....	16
3. Technologies Adopted for the Research.....	16
3.1 Introduction .....	16
3.2 Data Collection.....	16
3.2.1 The Questionnaire Method .....	16
3.2.2 Data Collection.....	17
3.3 Technology Adapted for data warehousing.....	17
SQL Server 2008 R2 .....	17
3.4 Data Mining Approach .....	18
Benefits of SQL Server Analysis Services .....	18
Analysis Services – Data Mining Architecture .....	18
3.5 Data Mining Approach .....	20
3.5.1 Data Mining Process .....	20
Problem Definition .....	20
Data Gathering and Preparation.....	20
Model Building and Evaluation.....	21

Knowledge Deployment.....	21
3.6 The Application Development tools .....	21
3.6.1 Microsoft Excel Add-In for SQL Server Analysis Services .....	21
The Architecture of Data Mining Add in for SQL Server 2008.....	22
3.6.2 Microsoft .NET Architecture for Web Application Development .....	22
3.6.3 C# (ASP.NET) Programming Language in Visual Studio 2013 .....	23
3.7 Summary .....	23
Chapter 4.....	24
4. The Approach for the Research.....	24
4.1 Introduction .....	24
4.2 Data Collection.....	24
4.2.1 The Questionnaire.....	24
4.2.2 Billing and Consumption Related data .....	25
4.3 Data Warehouse (SQL Server Analysis Services) .....	25
4.4 Data Mining Approach .....	26
4.4.1 SQL Server 2008 Data Mining .....	26
4.4.2 SQL Server Business Intelligent Management Studio .....	26
4.4.3 Data Mining Algorithms.....	26
4.4.4 Web Reporting Application.....	27
4.5 Summary.....	28
5. Analysis and Design .....	29
5.1 Introduction .....	29
5.2 The Top Level Design of the System .....	29
5.3 Data Mining Process .....	30
5.3 Summary.....	32
Chapter 6.....	33
6. The Implementation .....	33
6.1 Introduction .....	33
6.1 The Questionnaire .....	33
6.2 Consumption and Billing Related Data Extraction.....	33
6.3 Analysis Services Application for data mining.....	34
6.4 Web Reporting Application.....	35
6.5 Microsoft Excel Add in for SQL Server 2008 for data mining.....	46



6.6 Summary .....	47
Chapter 7 .....	48
7. Evaluation .....	48
7.1 Introduction .....	48
7.2 Dataset obtained from questionnaire .....	48
7.3 Data entering from user interface – Evaluation .....	48
7.4 Data Mining Approach – Evaluation .....	48
7.5 Evaluation of Web Application .....	60
7.6 Summary .....	68
8. Conclusion and Further Work .....	69
8.1 Introduction .....	69
8.2 Achievements of the objectives .....	69
8.3 Further Work .....	70
8.4 Summary .....	70
References .....	71
Appendix I .....	73
Web Application interfaces .....	73
Appendix II .....	86
Questionnaire .....	86

# List of Figures

Figure 1: Total Energy Sales in Jaffna Area in GWh .....	4
Figure 2 :Total consumers and total domestic consumer accounts in Sri Lanka from 2004 to 2013 .....	5
Figure 3: Total Consumer Growth in Jaffna Area from 2005 to 2015 .....	6
Figure 4 : Total KWH Units consumed by Jaffna area.....	7
Figure 5: Electricity Demand prediction.....	8
Figure 6 : Architectural Diagram of SQL Server Analysis Services Components .....	19
Figure 7: Data Mining Process.....	20
Figure 8: The Architecture of Data Mining Add in for SQL Server 2008 .....	22
Figure 9 : Excel Data Mining Add in Interface.....	27
Figure 10: The Top Level Design of the System .....	29
Figure 11: Data Mining Process in SQL Server Analysis Services .....	30
Figure 12: SQL Server Business Intelligent Interface .....	34
Figure 13: Login page of the web application.....	36
Figure 14: Microsoft Excel Add in for SQL Server 2008 for data mining.....	47

# List of Tables

Table 1: Total Electricity Consumption from 2004 to 2013 and the Domestic Consumption.....2

Table 2: Total Electricity Sales and the Domestic Electricity Sales .....3

## 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