LB/DON/81/06

THE POTENTIAL OF ENERGY SAVING BY IMPLEMENTATION OF A VOLUNTARY APPLIANCE ENERGY LABELLING PROGRAM IN SRI LANKA

A Research Project submitted to the
Department of Mechanical Engineering, University of Moratuwa
in partial fulfillment of the requirement for the
Degree of Master of Engineering in Energy Technology

By

SISIRA KUMARA PUJITHA VITHARANA

University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

2003 / 2004

LIBRARY
UNIVERSITY OF MORATUWA, SRI LANKA
MORATUWA

Supervised by:

Prof. R.A. Attalage

Dr. A.G.T. Sugathapala

Department of Mechanical Engineering
University of Moratuwa
Sri Lanka

91255

November 2007

University of Moratuwa
91255

91255

DECLARATION

I hereby declare that this submission is my own work and that, to the best of my knowledge and behalf, it contains no material previously published or written by another person nor material which to substantial extent, has been accepted for the award of any other academic qualification of a university or other institute of higher learning except where acknowledgment is made in the text.

UOM Verified Signature

S.K.P. Vitharana ..... Signature

Name of the student

Date : 29-11-2007

Names of supervisors

UOM Verified Signature

Prof. R.A. Attalage

Signature

Date : .....

UOM Verified Signature

Dr. A.G.T. Sugathapala

Signature

Date : 29/11/07.....

ABSTRACT

The potential of energy saving by the implementation of a voluntary appliance energy labeling program in Sri Lanka was studied by analyzing the appliance market and the system load profiles. End use load profiles for 2006 were derived from the Load Research findings and energy statistics published by Ceylon Electricity Board and Energy Conservation Fund. Air-conditioners, Lighting, Motors, Refrigerators and Fans were identified as potential end uses for energy labeling. The market distribution of efficiencies and prices were gathered for the identified end uses and the existing market picture was modeled. Average efficiency level of appliances in the present market was calculated.

Market transformation anticipated by implementation of a voluntary Energy Labelling Program was established under a hypothesis consists of a set of assumptions bases on incremental cost associated with the decision of purchasing a more efficient appliance, pay back period of the additional investment, market penetration of labels, consumer preference on making use of energy efficiency and other related factors. Anticipated market pattern after the implementation of Energy Labelling was modeled based on the market transformation and the average efficiency level of appliances in the transformed market was estimated.

University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

Overall improvement of the average efficiency for each identified appliance was estimated and the energy and demand saving due to that was calculated. It was found that implementation of an voluntary energy labeling program for above identified appliance would result in an annual energy saving of 217.8 GWh and system peak demand reduction of 47.6 MW. Over 9 million US$ and can be saved annually by the energy saving while assuring 60 million US$ avoided capital investment due to the peak demand chipping by 47.6 MW.

ACKNOWLEDGMENT

This research project was carried out under the supervision of Prof. R. A. Attalage and Dr. A.G.T. Sugathapala, Department of Mechanical Engineering, University of Moratuwa. Their guidance, valuable comments and inputs for the project at different stages as well as in the implementation of the Appliance Energy Labelling in Sri Lanka were of immense encouragement and support in completing the project at the level of a Master Degree. I sincerely believe that the experience and exposure I received while working under the guidance of Prof. R. A. Attalage, in the committees representing the Demand Side Management Branch of Ceylon Electricity Board for the implementation of Appliance Energy Labelling Program immensely helped me to complete the research project successfully. So, I am grateful for their dedication and fullest co-corporation extended to me in this endeavor.

The exposure I attained while working in the Demand Side Management Branch of the Ceylon Electricity Board was immense. Mr. Bandula S. Tilakasena, Deputy General Manager of the former Demand Side Management branch of the Board, who entrusted me with the task of facilitating the implementation of Energy Labelling Program in Sri Lanka, extended me with various opportunities to gain first hand experience in the area of Energy Efficiency and Energy Labelling. He helped me a lot to develop my self confidence and to play a leading role in the Energy Labelling Program in Sri Lanka. I am indebted to him for his kind help and for the trust he kept on me.

I am grateful to Mr. Vimal Nadeera and Mr. Athula Jayatunga, Energy Conservation Fund, and Mr. Ananda Namal of Sri Lanka Energy Managers Association for providing me with statistics required for this research study and sharing their views and experience on the implementation of Energy Labelling Program in Sri Lanka.

Mrs. J. Devasurendra and Mr. Anjalo Perara of Sri Lanka Standard Institute assisted me by explaining the present status of Energy Labelling in Sri Lanka and by sharing their knowledge and experience in the Energy Labelling with me. Their inputs were very useful for the success of this study. My sincere gratitude should go to Mrs. Amali Wickramasinghe, Mr Ronald Comester and Mr. Noel Priyantha of Ceylon Electricity Board, Mr.G.B. Wimalaratne of National Engineering Research and Development Center

University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

and Mr. C. A. Abayasinghe of Central Bank of Sri Lanka for providing me with the useful data and information on energy supply, demand, generation expansion planning and present trends on imports and performance of appliances which are required for successful completion of the research.

The valuable expert opinions and information provided by Mr Peter Biermayer of Lawrence Barkeley National Laboratory and Mr. Felix Goonaratne of International Institute for Energy Conservation contributed for the completion of the project comprehensively. I appreciate their kind assistance towards me.

Further, I appreciate all of my friends and colleagues who encouraged and assisted me in different ways towards the completion of this thesis successfully.

University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

CONTENTS

page

DECLARATION i
ABSTRACT ii
ACKNOWLEDGMENT iii
CONTENTS v
LIST OF TABLES viii
LIST OF FIGURES viii
ABBREVIATIONS ix

CHAPTER 1 INTRODUCTION

1.1. BACKGROUND 1
1.2. PROBLEM STATEMENT 1
1.3. OBJECTIVES OF THE PROJECT 2
1.4. NEED FOR ENERGY EFFICIENCY LABELLING 3
1.5. METHODOLOGY FOLLOWED FOR THE ESTIMATION OF SAVING POTENTIAL 3
1.6. PREVIOUS STUDIES ON SAVING POTENTIAL USING ENERGY EFFICIENCY LABELLING 4
1.7. RESULTS OF THE RESEARCH PROJECT AND RECOMMENDATIONS 5

CHAPTER 2 PRESENT ELECTRICITY ENERGY SCENARIO OF SRI LANKA

2.1. ENERGY GENERATION AND SUPPLY IN SRI LANKA 6
2.1.1. ENERGY USE IN SRI LANKA 6
2.1.2. ELECTRICITY SHARE OF THE OVERALL ENERGY USE 8
2.2. VITAL SECTORS OF ELECTRICITY CONSUMERS AND END USES 9
2.3. MAJOR END USERS IN EACH SECTOR 9
2.3.1. DERIVATION OF PRESENT LOAD CURVES FROM LR DATA 9
2.3.2. END USE LOAD PATTERNS OF THE INDUSTRIAL SECTOR 12
2.3.3. END USE LOAD PATTERNS OF THE COMMERCIAL SECTOR 13
2.3.4. END USE LOAD PATTERNS OF THE DOMESTIC SECTOR 13

CHAPTER 3 APPLIANCE ENERGY LABELLING

3.1. ENERGY EFFICIENCY LABELLING INITIATIVE 15
3.2. WORKING PRINCIPLE OF ENERGY EFFICIENCY LABELLING 16
3.3. BENEFITS OF ENERGY EFFICIENCY LABELLING 17
3.4. TYPE OF LABELS 20
3.5. ENERGY LABELLING INITIATIVE IN SRI LANKA 21
3.6. PREVIOUS STUDIES ON SAVING POTENTIAL USING ENERGY EFFICIENCY LABELLING 24

University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

CHAPTER 4 ESTIMATION OF ELECTRICITY SAVING POTENTIAL BY ENERGY LABELLING OF APPLIANCES

4.1. METHODOLOGY 26
4.2. POTENTIAL END USES IN EACH SECTOR 29
4.3. ESTIMATION OF SAVING POTENTIAL BY LABELLING OF AIR CONDITIONERS 30
4.3.1. SAVING POTENTIAL OF SPLIT AIR CONDITIONERS 31
4.3.2. SAVING POTENTIAL OF PACKAGE AIR CONDITIONERS 35
4.4. ESTIMATION OF SAVING POTENTIAL BY LABELLING OF LIGHTING 36
4.4.1. SAVING POTENTIAL OF BALLASTS 38
4.4.2. SAVING POTENTIAL OF COMPACT FLUORESCENT LAMPS 39
4.4.3. SAVING POTENTIAL OF HIGH PRESSURE SODIUM LAMPS 40
4.4.4. SAVING POTENTIAL OF METAL HALIDE LAMPS 41
4.4.5. SAVING POTENTIAL OF MERCURY VAPOUR LAMPS 42
4.5. ESTIMATION OF SAVING POTENTIAL BY LABELLING OF MOTORS 44
4.6. ESTIMATION OF SAVING POTENTIAL BY LABELLING OF REFRIGERATORS 47
4.7. ESTIMATION OF SAVING POTENTIAL BY LABELLING OF FANS 49
4.8. ESTIMATION OF SAVING POTENTIAL BY LABELLING OF TELEVISIONS 50

CHAPTER 5 DISCUSSION AND CONCLUSION

5.1. POTENTIAL CANDIDATES, SAVING POTENTIAL AND PRIORITIZATION 52
5.2. EMISSIONS REDUCTIONS 53
5.3. SAVING OF FOREIGN CURRENCY 53
5.4. FACTORS WHICH COULD REDUCE THE SAVING 54
5.4.1. SENSITIVITY OF ESTIMATED SAVING POTENTIAL TO RELEVANT PARAMETERS ... 54
5.4.2. SELECTION OF EQUIPMENT 55
5.4.3. SYSTEM DESIGN 56
5.4.4. PRACTICES 56

University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

CHAPTER 6 RECOMMENDATIONS

6.1. RECOMMENDATIONS FOR THE SUCCESSFUL IMPLEMENTATION 57
6.2. SUPPORTIVE POLICIES 57
6.3. IMPLEMENTATION BARRIERS 59
6.4. INFRASTRUCTURE 59

REFERENCES 61

BIBLIOGRAPHY 62

APPENDIX A STATISTICS AND LOAD PROFILES 63
APPENDIX B TYPE OF LABELS 75
APPENDIX C ESTIMATION OF SAVING POTENTIAL OF APPLIANCES 78

University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

LIST OF FIGURES

	Page
Figure 2.1 Electricity usage per person and electricity prices (2002 -2004)	-07
Figure 2.2 Petroleum usage per person and Petroleum prices (2002 -2004)	-07
Figure 2.3 Energy supply by secondary source - 2004	-08
Figure 2.4 Total load profile by sectors for year 2000 (LECO + CEB)	-10
Figure 2.5 Total system load profile by sectors for year 2006	-11
Figure 2.6 Load profile of Industrial Sector by End use – year 2006	-12
Figure 2.7 Load profile of Commercial Sector by End use – year 2006	-13
Figure 2.8 Load profile of Domestic Sector by End use – year 2006	-14
Figure 3.1 Market transformation mechanism	-17
Figure 4.1 Projected sales of split Air-conditioners for year 2007and 2008	-32
Figure 4.2 Distribution of EER and prices of split Air-conditioners (>18,000 Btu/h)	-33
Figure 4.3 Market Transformation of split Air-conditioners by EEL (<18,000 Btu/h)	-34

University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

LIST OF TABLES

Table 2.1 Summary of end use loads of industrial sector	-12
Table 2.2 Summary of end use loads of Commercial sector	-13
Table 2.3 Summary of end use loads of domestic sector	-14
Table 4.1 Energy Efficiency Ratios of split Air-conditioners	-31
Table 4.2 Annual sales and sales trend of split Air-conditioners	-32
Table 4.3 Payback period of all possible Efficiency transfers of split air conditioners (capacity <18,000 Btu/h)	-33
Table 4.4 Energy rating of refrigerators available in the market	-47
Table 4.5 Market transfer of Refrigerators after EEL	-48
Table 5.1 Summary of estimated saving potentials	-52
Table 6.1 Summary of sensitivity for market penetration	-55
Table 6.2 Summary of sensitivity for electricity tariff	-55

ABBREVIATIONS

CEA	Central Environmental Authority
CEB	Ceylon Electricity Board
CFL	Compact Fluorescent Lamp
DSM	Demand Side Management
ECF	Energy Conservation Fund
EEI	Electrical and Electronic Institute
GDP	Gross Domestic Product
IEA	International Energy Agency
ITS	Intertek Testing Services
IIEC	International Institute for Energy Conservation
LR	Load Research
NERD	National Engineering and Research Center
LBNL	Lawrence Barkeley National Laboratory
LECO	Lanka Electricity Co. Limited
SLSI	Sri Lanka Standard Institute
SLEMA	Sri Lanka Energy Managers Association

University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk