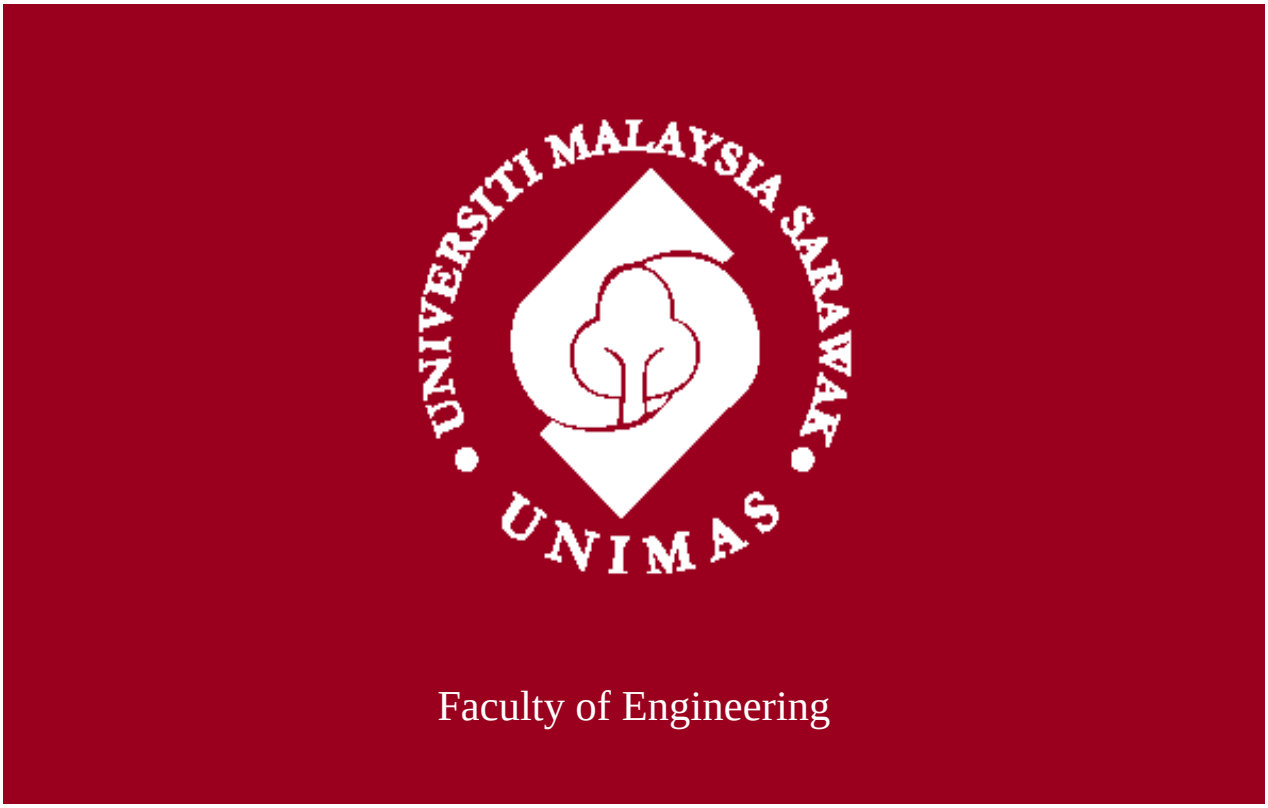

IMPORTANCE OF ENERGY EFFICIENCY STANDARDS AND LABELS FOR HOUSEHOLD REFRIGERATORS IN MALAYSIA

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Bachelor of Engineering with Honours
(Mechanical and Manufacturing Engineering)
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To my beloved family, friends and the one who need it

IMPORTANCE OF ENERGY EFFICIENCY STANDARDS AND LABELS FOR HOUSEHOLD REFRIGERATORS IN MALAYSIA

LAU HUI MING

Thesis Is Submitted To
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ABSTRAK

Peti sejuk merupakan salah satu perkakas elektrik rumah yang tertinggi dalam penggunaan bekalan elektrik di Malaysia. Jadi, perkakas elektrik tersebut telah menjadi sasaran dalam usaha pembaikan penggunaan tenaga elektrik. Hingga kini, Malaysia masih belum menyediakan sebarang piawai dan label untuk penggunaan bekalan elektrik bagi peti sejuk jenis dua pintu. Objektif bagi projek ini adalah untuk mengembangkan satu set piawai dan label penghematan tenaga untuk peti sejuk. Dengan merujuk kepada piawai ujian yang ditetapkan oleh Pertubuhan Piawai Antarabangsa (ISO), satu siri eksperimen penyiasatan telah dijalankan terhadap lima belas buah peti sejuk yang berlainan muatan dan cap. Dengan data-data yang diperolehi melalui eksperimen, satu piawai garis dasar telah dikembangkan secara penghampiran statistik. Satu garis penghematan diperoleh 10% dari piawai garis dasar. Tiga jenis label penghematan tenaga telah direka, dan satu peninjauan telah dijalankan terhadap label-label tersebut di antara pengguna-pengguna peti sejuk. Daripada keputusan tinjauan yang diperoleh, label penghematan yang disukai secara menyeluruh telah dicadangkan di dalam projek ini. Pengenalan piawai penghematan tenaga untuk peti sejuk telah dijangka akan mengurangkan penggunaan tenaga elektrik sebanyak 40869.594 MWh tiap-tiap tahun. Selain itu, isu-isu pencemaran dijangka akan berkurangan sebanyak 10% di Malaysia jika program piawai penghematan tenaga dilaksanakan secara mandatori kepada peti sejuk.

ABSTRACT

Refrigerator-freezers, being one of the major electricity consuming household appliances in Malaysia have become a target for improvement of energy consumption. Until now, Malaysia has not set any standards or labeling for refrigerator-freezers. The objectives of this study are to develop a set of energy efficiency standards and labels for household refrigerator-freezers. By referring to ISO (International Standard Organization) Test Standards, a series of experimental investigations have been conducted towards fifteen units of refrigerator-freezers with different capacities and trademarks. From the experimental data, a baseline standard has been developed by statistical approach. A 10% saving line has been developed from the baseline standard. Three types of energy saving labels have been designed and a survey has been conducted towards these labels among the consumers. From the survey response, a comprehensive energy guide label for refrigerator-freezers has been proposed in this project. It has been estimated that 40869.594 MWh of electricity energy could be saved per year by introducing energy efficiency standards to refrigerator-freezers. With the mandatory implementation of energy efficiency standards for refrigerator-freezers, it has been estimated that at least 10% of pollution issues would be reduced in Malaysia.

TABLE OF CONTENTS

Content			Page
DEDICATION			ii
ACKNOWLEDGEMENTS			iii
ABSTRAK			iv
ABSTRACT			v
TABLE OF CONTENTS			vi
LIST OF TABLES			x
LIST OF FIGURES			xii
LIST OF ABBREVIATIONS			xiii
CHAPTER 1	**INTRODUCTION**		
	1.1	Background	1
		1.1.1 Energy Efficiency Standards	1
		1.1.2 Energy Efficiency Labels	3
	1.2	Status of Energy Consumption Scenario in Malaysia	4
		1.2.1 Energy Supply and Demand in Malaysia	4

1.2.2 Electricity Consumption for Malaysia's Domestic Sector 8

1.3 Objectives 12

CHAPTER 2 LITERATURE REVIEW

2.1 History of Household Appliance Standards and Labels 13

2.2 Energy Standards and Labels in European Union (EU) 16

2.3 Appliance Energy Efficiency in Canada 19

2.4 Appliance Labeling and Standards in Australia 21

2.5 Energy Efficiency Standards and Labeling in China 23

2.6 Efficiency Labels and Standards in Japan 26

2.7 Energy Standards and Labeling in Korea 28

2.8 Energy Efficiency Standards for Electric Appliances in Thailand 30

CHAPTER 3 METHODOLOGY

3.1 Developing Steps for Energy Standards and Labels Programs 33

3.1.1 First Step (Step D) 34

3.1.2 Second Step (Step T) 35

3.1.3 Third Step (Step L) 36

3.1.4 Fourth Step (Step S**)** 37

3.1.5 Fifth Step (Step M) 38

3.1.6 Sixth Step (Step E) 39

3.2 Energy Test Procedure 40

3.3 Applicability of International Organization for Standardization (ISO) Test Procedure for Refrigerator in Malaysia 41

3.4 Project Scope 43

3.5 Experiment Instrumentation 43

3.6 Experimental Procedure 44

CHAPTER 4 RESULTS, ANALYSIS AND DISCUSSIONS

4.1 Energy Consumption of Two Doors Refrigerator-freezers 46

4.2 Effect of Ambient Temperature 50

4.3 Development of Energy Efficiency Standards 52

4.4 Development of Energy Efficiency Labels 56

4.4.1 Token Label 57

4.4.2 Tachometer Label 58

4.4.3 Letter Label 58

4.5 Energy Labeling Surveys 62

4.6 Proposed Malaysian Test Standards for Refrigerator-freezers 63

4.7 Energy Savings 67

4.8 Greenhouse Gases Emissions Reductions 69

CHAPTER 5 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion 73

5.2 Recommendations 75

5.2.1 Recommendations for Further Works 75

5.2.2 Recommendations to Manufacturers 76

5.2.3 Recommendations to Consumers 77

REFERENCES 78

APPENDIX A 83

APPENDIX B 87

LIST OF TABLES

Table		Page
1.1	Malaysia Home Energy Use Estimate 180 m^2 Terrace House	10
2.1	An Overview of the Appliances Standard and History	15
2.2	Relative Efficiency Grades Used in the Energy Label for Refrigerators	18
4.1	Energy Consumption (kWh/Day) of Refrigerator-freezers (2 Doors Type)	46
4.2	Energy Consumption of 2 Doors Type Refrigerator-freezers (kWh/Day and Wh/Day/*l*)	47
4.3	Ambient Temperature during the Experiment Period	50
4.4	Proposed Energy Efficiency Standard for Refrigerator-freezers	53
4.5	Labeling Survey Output	61
4.6	Specifications of Load Packages Required for ISO Tests	64
4.7	Emission Factors of Fossil Fuels for Electricity Generation	68

4.8 Percentages of Mix Fuel in Electricity Generation from 2000 to 2010 69

4.9 Emission of Greenhouse Gases due to Mix Fuel Energy Generation Used by Refrigerator-freezers in 2008 70

LIST OF FIGURES

Figure		Page
1.1	Natural Gas Consumption by Sectors (ktoe)	5
1.2	Electricity Consumptions by Sectors (ktoe)	7
1.3	Net Exports of Energy from Year 2000 to 2035	7
1.4	Average Energy Used by Various Appliances for 180 m^2 Terrace House	9
1.5	Yearly Household Refrigerator-Freezer Sales in Malaysia	12
3.1	Typical Steps in the Process of Developing Consumer Product Energy Efficiency Standards and Labels	33
4.1	Energy Consumption (Wh/Day/*l*) for 2 Doors Refrigerator-freezers	55
4.2	Token Label	59
4.3	Tachometer Label	60
4.4	Letter Label	61

LIST OF ABBREVIATIONS

°C	-	Degree Celsius
CO	-	Carbon Monoxide
CO_2	-	Carbon Dioxide
DOE	-	Department of Energy
EC	-	Electricity Consumption (kWh)
EEA	-	Energy Efficiency Act
EFF	-	Emission Factor of Fuel (kg/kWh)
EGAT	-	Energy Generating Authority of Thailand
ENCON	-	Energy Conservation Promotion Act
EPA	-	US Environmental Protection Agency
EPACT	-	Energy Policy Act
EU	-	European Union
GJ	-	Giga Joule
GOT	-	Government of Thailand
GPD	-	Growth Production Rate
GW	-	Gigawatt
h	-	Hour
IEC	-	International Electrotechnical Commission
ISO	-	International Standard Organization

KEMCO	-	Korea Energy Management Corporation
kg	-	Kilogram
ktoe	-	Kilotonne or Kilometric Ton
kWh	-	Kilowatt-hour
kWh/Day	-	Kilowatt-hour per Day
l	-	Capacity in Liter
m^2	-	meter square
MEPS	-	Minimum Energy-Performance Standards
mmbtu	-	Million British Thermal Unit
MOCIE	-	Korea Ministry of Commerce, Industry, and Energy
MS	-	Malaysian Standards
MW	-	Megawatt
NEPC	-	National Energy Policy Council
NO_X	-	Nitrogen Oxide
NRCan	-	Natural Resource of Canada
NSW	-	New South Wales
PEGF	-	Percentage of Electricity Generated by the Specific Fuel
PJ	-	Peta Joule (10^{15} Joules)
PLC	-	Programmable Logic Controller
PTM	-	Pusat Tenaga Malaysia
RM	-	Ringgit of Malysia

s	-	Second
SAVE	-	The Principal Energy Efficiency Program of European Union
SIRIM	-	Standard and Industrial Research Institute of Malaysia
SO_2	-	Sulpha Dioxide
SWG-F	-	Sub-work Group for Refrigerators (Malaysia)
TNB	-	Tenaga Nasional Berhad
TV	-	Television
TWh	-	Terawatt-hour
US	-	United States
USD	-	US Dollars
US$	-	US Dollars
Wh	-	Watt-hour
Wh/Day/ *l*	-	Watt-hour per day per liter
±	-	Plus or minus
∑	-	Summations of energy consumptions for fifteen units of Refrigerator-freezers (2 doors Type)

CHAPTER 1

INTRODUCTION

1.1 Background

Energy efficiency standards and labels are being introduced internationally, as a simple and effective strategy for providing guidance to residential consumers in their purchase of household appliances. Energy efficiency standards are tools for market transformation. Market pull and market push are complementary market transformation strategies. Establishing energy performance standards “pushes” the market by eliminating the least efficient models. Labels “pull” by encouraging customers to purchase higher efficiency models, and “push” by encouraging manufacturers to produce more efficient models (Masjuki *et al.*, 2000).

1.1.1 Energy Efficiency Standards

Energy efficiency standards are a set of procedures and regulations that prescribe the energy performance of manufactured products, sometimes prohibiting the sales of products that are less energy efficient than the minimum standard. It means that the appliance manufacturers must meet the minimum efficiency level set by the

standards in order to sell the products. Energy efficiency standards can be either mandatory or voluntary. They can be in the form of minimum allowable energy efficiency or a maximum allowable energy use. The term “standards” generally expressed as “well-defined protocols”, which refers to protocols or laboratory test procedures applied to obtain a sufficiently accurate estimate of the energy performance of the product in the way it is typically used, or at least a relative ranking of its energy performance compared to other models. Another denotation for “standards” is defined as “target limits on energy performance”, which is maximum energy use or minimum energy efficiency based upon a specified test protocol (Stephen *et al.*, 2003). Besides, the term “norm” is sometimes used instead of “standard” in Europe and Latin America to refer to the target limit.

Energy efficiency standards consist of three types, which are: prescriptive standards, minimum energy-performance standards (MEPS), and class-average standards. Prescriptive standards require that a particular feature or device like insulations be installed or not installed in all new products. Minimum energy-performance standards (MEPS) prescribe minimum efficiencies or maximum energy consumptions that manufacturers must achieve in every product, by specifying the energy performance but not the technology or design details of the products. Class-average standards specify the average efficiency of a manufactured product by allowing each manufacturer to select the level of efficiency for each model so that the overall average is achieved.

1.1.2 Energy Efficiency Labels

Energy efficiency labels are informative labels that are attached to manufactured products and describe a product's energy performance in the form of energy use, efficiency, or energy cost. Energy Labels create consumers awareness by convincing them to buy more efficient appliances. Energy labels also encourage manufacturers to improve the standards of their products and use efficiency as a feature of their sales campaign. There are three types of energy labels namely: endorsement, comparative, and information-only (Saidur *et al.*, 2003).

Endorsement labels are essentially "seals of approval" given according to products that meet specified criteria. Generally, they are based on a "yes-no" cutoff, and offer little additional information. The EPA's (US Environmental Protection Agency) energy star label is an example of an endorsement label for energy efficiency. Another type of endorsement labels is the "eco-label". They are used to indicate that a product or process has superior environmental performance or a minimal environmental impact.

Comparative labels allow the consumers to compare performance among similar products using either discrete categories of performance or a continuous scale (Stephen *et al.*, 2003). The categorical labels use a ranking system that allows consumers to notify how energy-efficient a model is compared to other models in the market. Meanwhile, the continuous-scale provides comparative information that

allows consumers to choose between models, but do not use specific categories. The US and European energy labels are examples of comparative labels.

Information-only labels simply provide data on the technical performance of the single labeled products. They offer no simple way to compare energy performance between products. These types of labels are generally not consumer-friendly because they contain only technical information. The Philippine's energy labels is an example of these types of label.

1.2 Status of Energy Consumption Scenario in Malaysia

1.2.1 Energy Supply and Demand in Malaysia

According to The Star 3rd July 2004, local power sector is currently one of the country's most highly subsidized industries. The price of natural gas has been fixed at RM6.40 per mmbtu since 1997. This represents a 76% discount to average US rates of US$6.39 per mmbtu converted at the prevailing exchange rate. Thus far, the discount has been borne by Petroleum Nasional Bhd (Petronas) in the form of loss of revenue.

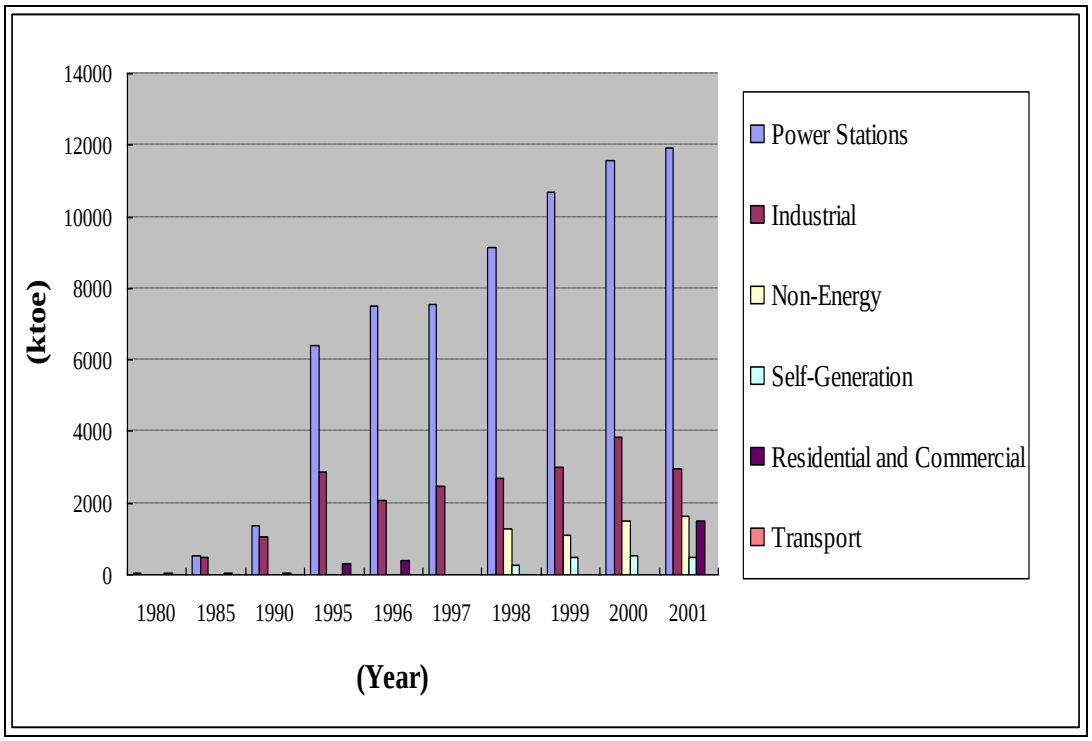

Figure 1.1: Natural Gas Consumption by Sectors (ktoe)

As shown in Figure 1.1 (Ar, 2004), natural gas is mostly consumed in local power sectors. Natural gas was used as energy source for about 71% of power station in 2001 (Ar, 2004). Therefore, the electricity rates cannot be expected to remain stagnant if gas prices go up. According to Avenue Securities power analyst Daniel Griffin, Tenaga Nasional Berhad (TNB) would have to raise its average tariff rate by some 25% in order to maintain its net profit forecast of RM1.6 billion if the government were to remove the gas subsidy completely and allow Petronas to charge international market rates of around RM24.7 per mmbtu.

Industrial sector has been the largest user of electricity. According to Figure 1.2 (Ar, 2004), industrial sector consumed about 53% of electricity generated. Residential and commercial sectors consumed respectively 18% and 28% of generated electricity. The other sectors such as public lighting, and mining consumed only 1% of electricity produced.

Based on the current economic growth rates, Pusat Tenaga Malaysia (PTM) has projected that Malaysia would become a net imported of energy between 2010 and 2015, as shown in Figure 1.3 (Ar, 2004). Besides, a comparison of the 1990 energy use per capita output has Malaysia at about 26 GJ/1000USD, compared to Thailand at 20 GJ/1000USD and Japan at 7 GJ/USD (Ar, 2004). These statistics showed that Malaysians are not using energy efficiency.