ENERGY EFFICIENCY STANDARDS AND LABELS FOR ELECTRIC RICE COOKERS IN MALAYSIA

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DISSERTATION SUBMITTED IN FULFILLEMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ENGINEERING

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KUALA LUMPUR

2013

ABSTRACT

Energy efficiency standards and labels for appliances, equipment and lighting are being implemented in many countries around the world where they have a potential for very large energy savings, very cost effective and environmental friendly. Malaysia is one of the countries that being implicates this program to save energy consumption for the future.

In this study, standards and labelling program is being implemented to electric rice cooker on the Malaysian household. The surveys have been conducted to 350 respondents evaluate the energy consumption when electric rice cooker is being used every day. Energy efficiency standards of electric rice cookers is defined as annual energy consumption. After the standard is in place, three types of energy labels are established. One type of the labels was selected according to the respondents input. The study also examines the possible changes in annual energy consumption of Malaysian households in the future by predicting the energy, economical and environmental impacts due to the standards and labels implementation for electric rice cooker.

Once appliance standards and labelling programs have been implemented, it is necessary to evaluate their effectiveness. The energy will save about 11,240 GWh, the bill savings will be about RM 3,770 million. The total emissions reduction are about 5,643,967 ton of carbon dioxide, 34,527,204 kg of sulphur dioxide, 16,149,072 kg of nitrogen oxide and 3,371,253 kg of carbon monoxide.

ABSTRAK

Standard dan label bagi kecekapan tenaga untuk perkakasan dan peralatan rumah serta lampu sedang dilaksanakan oleh banyak negara di seluruh dunia di mana mereka mempunyai banyak potensi untuk menjimatkan banyak tenaga, sangat kos efektif dan mesra alam. Malaysia merupakan salah sebuah negara yang sedang mengimplikasi program ini untuk menjimatkan penggunaan tenaga untuk masa hadapan.

Dalam kajian ini, program standard dan label dilaksanakan ke atas periuk nasi elektrik bagi kediaman di Malaysia. Satu kaji selidik telah dijalankan ke atas 350 responden untuk menilai penggunaan tenaga apabila periuk nasi elektrik digunakan setiap hari. Standard kecekapan tenaga bagi periuk nasi elektrik ditakrifkan dengan penggunaan tenaga tahunan. Selepas standard disetkan, tiga jenis label tenaga ditubuhkan. Satu jenis label telah dipilih berdasarkan input daripada responden. Kajian ini juga mengetengahkan kemunkinan-kemungkinan perubahan yang berlaku ke atas penggunaan tenaga tahunan oleh kediaman di Malaysia pada masa akan datang dengan meramalkan kesan kepada tenaga, ekonomi dan persekitaran akibat daripada perlaksanaan program standard dan label ke atas periuk nasi elektrik.

Apabila program ini dilaksanakan ke atas perkakasan ini, ia adalah perlu untuk menilai keberkesanannya. Tenaga dapat dijimatkan sebanyak 11,240 GWh, penjimatan bil sebanyak RM3,770 juta. Jumlah pengurangan pelepasan gas karbon dioksida sebanyak 5,643,967 ton, sulfur dioksida sebanyak 34,527,204 kg, nitrogen oksida sebanyak 16,149,072 kg dan karbon monoksida sebanyak 3,371,253 kg.

ACKNOWLEDGEMENTS

First, I would like to thank the almighty Allah for giving me this opportunity and his spiritual help to do this dissertation.

Second, I would like to thank my supportive supervisor, Professor Dr. T.M. Indra Mahlia for his kind support and guidance. It was he who sparked my interest in research and helped me appreciate the value of looking into knowledge and serve the humanity.

Above all, I would like also to express my most sincere gratitude to my lovely family who have also offered much needed spiritual support, and have being extremely thoughtful and encouraging during this difficult period.

I would like also to acknowledge all my friends who have been beside me throughout my study and have been so helpful, without their help, I would not have been able to finish my dissertation on time.

Last but not the least; I would like to thank the faculty of engineering staff for their valuable assistance.

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NOMENCLATURES

Symbols	Descriptions	Unit
AEI_s^{rc}	Annual energy efficiency improvement of electric rice cooker	(%)
ANS_i^{rc}	Annualized net dollar savings in year i for electric rice cooker	RM
AS_{i-1}^{rc}	Applicable stock in year i-1 of electric rice cooker	unit
AS_i^{rc}	Applicable stock in year i of electric rice cooker	unit
BAU_i^{rc}	Business as usual energy consumption in year i for electric rice cooker	kWh/year
BEC_s^{rc}	Baseline energy consumption of electric rice cooker	kWh/year
BS_i^{rc}	Bill savings in year i for electric rice cooker	RM
CCE_l^{rc}	Cost of conserved energy for electric rice cooker	RM/kWh
ER_i^{rc}	Emission reduction in year I for electric rice cooker	kg
ES_i^{rc}	Energy savings in year I for electric rice cooker	kWh/year
Em_p^n	Emission p for fuel type n for a unit electricity generation	kg/kWh
E_o^{rc}	Energy consumption of electric rice cooker	kWh/year
E_t^{rc}	Standby energy consumption of electric rice cooker	kWh/year
IC^{rc}	Increment cost of electric rice cooker	RM/kWh
IE_i^{rc}	Efficiency improvement in year I for electric rice cooker	(%)
IIC_s^{rc}	Initial increment cost of electric rice cooker	RM/unit
LEC_l^{rc}	Label energy consumption of electric rice cooker	kWh/year
L^{rc}	Lifespan of electric rice cooker	year
NS_i^{rc}	Net savings in year I for electric rice cooker	RM
$Na_{i-L^{rc}}^{rc}$	Number of electric rice cooker in year i-L	unit
Na_{i-1}^{rc}	Number of electric rice cooker in year i-1	unit
Na_i^{rc}	Number of electric rice cooker in year i	unit
PE_i^n	Percentage of electricity generation in year I of fuel type n	(%)
PF_i^n	Fuel price in year I for fuel type n	RM

Sh_i^{rc}	Shipment in year I of electric rice cooker	unit
SEC_s^{rc}	Standards energy consumption of electric rice cooker	kWh/year
SEI_s^{rc}	Standards energy improvement for electric rice cooker	kWh/year
SF_i^{rc}	Scaling factor in year I for electric rice cooker	(%)
SSF_i^{rc}	Shipment survival factor in year I for electric rice cooker	(%)
UES_i^{rc}	Unit energy savings in year I of electric rice cooker	kWh/year
UES_s^{rc}	Initial unit energy savings in year I for electric rice cooker	kWh/year
U_o^{rc}	Usage hour of electric rice cooker	hour
U_t^{rc}	Standby hour of electric rice cooker	hour
Ysh_i^{rc}	Year i of shipment of electric rice cooker	year
Yse_s^{rc}	Year of standards enacted of electric rice cooker	year
Ytc_T^{rc}	Year target calculation for electric cooker	year
η_l^{rc}	Percentage labels improvement of electric rice cooker	(%)
η_o^{rc}	Percentage improvement of electric rice cooker	(%)
η_t^{rc}	Percentage standby improvement of electric rice cooker	(%)
E	Energy efficiency	kWh/year
CRF	Capital recovery factor	(%)
$PV(ANS_i^{rc})$	Present value of annualized net savings in year I for electric rice cooker	RM
Ydr	Year of discount rate base	year
d	Discount rate per year	(%)

Abbreviations

ASEAN	Association of Southern Asian Nations
CO	Carbon Monoxide
CO_2	Carbon Dioxide
ERWG	Energy Rating Work Group
EU	European Union
ISCE	Industrial Standard Committee- Group E
ISO	International Organization of Standardization
JBEG	Jabatan Bekalan Elektrik dan Gas (Directorate General of Electricity and Gas)
MEPS	Minimum Energy Performance Standards
MS	Malaysian Standard
NO_X	Nitrogen Oxide
PTM	Pusat Tenaga Malaysia (Malaysian Energy Centre)
RM	Ringgit Malaysia
SIRIM	Standard and Industrial Research Institute of Malaysia
SO_2	Sulfur Dioxide
ST	Suruhanjaya Tenaga (Energy Commission)
TCPHEA	Technical Committee on Performance of Households and Similar Electrical Appliances
W	Watt

Superscript

rc	Rice cooker
N	Discounted over the life time
n	Fuel type

Subscript

s	Year of the standard enacted
i	In the particular year
t	Standby hour
l	Year of label enacted
T	Target year
o	Usage hour

CHAPTER 1

INTRODUCTION

1.1 Background of the study

Rice is one of the world's major cereal crops next to wheat and maize, and is the staple food for nearly half of the world's population. It is grown in over 100 countries spread in every continent except Antartica (Juliano, 1985). Rice is grown on the Malaysia Peninsular and on Borneo Islands. About 300 500 hectares on Malaysia Peninsular and 190 000 hectares on Borneo Islands are devoted to rice production.

The cooking process and the choice of cooked rice texture are different from place to place. Consumers in Western countries prefer long grain, light, fluffy or slightly dry individual kernel of rice having cooked flavor with essentially no gritty or hard uncooked core. Japanese preference is for short grain, which produce rather sticky cooked rice. Indian preference is for medium grain with fluffy, light individual kernel of rice with cooked flavor and without hard core (Das et al. 2006).

The two important variables in rice cooking are the amount of water and the control of heating. The water to rice ratio is important in keeping the cooked rice from being either too hard or too soft. Controlled heating ensures that the rice is gently heated and gelatinized to the core without getting scorched. The cooking of rice is associated with complete gelatinization of the starch, complex formation, transformation and interactions involving biopolymer by heat treatment in the presence of water (Suzuki et al. 1976).

Electric rice cooker and pressure cooker are commonly used in domestic rice cooking. The electric rice cooker works on the principle of dielectric heating and originated from military equipment (Juliano and Sakurai, 1985). This method has been improved over the years to make the quality of the cooked rice more acceptable. In the automatic rice cooker, heat is regulated by a thermostat coupled with micro-switch, which switches off the heater when the water is completely absorbed and the temperature begins to rise rapidly. The temperature of rice decreases quickly after the heater is switched off.

Malaysia's consumption of energy increases every year. In 2008, the total energy demand in Malaysia was 522,199 GWh, of which the industrial and transport sectors were the two largest users of energy, accounting more than three-fourths of this total demand. The residential and commercial sector was the third largest user (14%) of energy in Malaysia, and only 1% of the total energy was consumed by the agriculture sector.

The consumption of electricity in Malaysia rises rapidly every year, with an average of 2,533 GWh per year. The electricity consumption, for instance, in 1971 was 3,464 GWh and 94,278 GWh in 2008. By 2020, Malaysia's electricity consumption is expected to increase by about 30% from its present value to 124,677 GWh.

Malaysia's energy sources for electricity are based on a "four-fuel mix" strategy: gas, oil, hydro, and coal. From 1970 to 1980s, oil was relied heavily for electricity generation, but this over-reliance led to rapid depletion oil in Malaysia. But since the mid 1980s, gas and coal are increasingly being relied on for electricity generation. By 2010, for instance, it is estimated that gas and coal would contribute 92% of the sources for electricity generation. Hydro and oil would contribute the rest (7 and 1%, respectively).

Recently, the government has started to introduce a "five-fuel mix" strategy with renewable energy as the fifth source for electricity generation. The most promising potential for renewable energy in Malaysia is the biomass and biogas from the oil palm industry. This is not surprising considering that 15% of the total land area of Malaysia is covered by this single crop alone.

Other than finding sustainable sources of energy, the Malaysian government is planning to improve energy efficiency and to promote awareness among the public on the importance of energy conservation.

In conclusion, Malaysia faces big challenges ahead to meet the country's growing demand for energy using sustainable practices. Malaysia can succeed provided there is a concerted effort for increasing the: 1) implementation and management of sustainable energy sources, 2) energy efficiency, and 3) awareness by the Malaysian public on energy issues and a change of lifestyle that has a lower carbon footprint.

Energy efficiency standards are procedures and regulations that prescribe the energy performance of manufactured products, sometimes prohibiting the sale of products that are less energy efficient than the minimum standard (Stephen and McMahon, 2003). Energy performance improvements in consumer products are an essential in any government's portfolio of energy efficiency policies and climate change mitigation programs. For greatest effectiveness, a government should develop balanced programs, both voluntary and regulatory, those removes cost ineffectiveness, energy wasting products from the marketplace and stimulate the development of cost effective, energy efficient technology.

The effect of well designed energy efficiency labels and standards is to reduce unnecessary electricity and fuel consumption by household appliances. Cost effective reduction in overall fuel combustion has several beneficial consequences such as reducing capital investment in energy supply infrastructure, enhancing national economic efficiency by reducing energy bills, enhancing consumer welfare, strengthening competitive markets, meeting climate change goals and averting urban/regional pollutions.

1.2 Objectives of the study

The purpose of this study is to create an awareness of consumer to the product itself which is in this study the electric rice cooker. This study will show the impacts of standards and labels for electric rice cooker in terms of energy saving, emissions reduction and cost-benefit analysis.

The standards and labelling programs generally aim to achieve the following:

(i) Energy saving when implementing the standards and labelling program.

(ii) Cost benefits analysis when the standards and labelling program applied to electric rice cooker

(iii) Potential emissions reduction when installing the programs.

(iv) Greater public awareness of energy awareness of energy conservation, environmental improvement needs, provisions of readily available, pre-purchase information on energy consumption and efficiency data, where applicable to enable ordinary consumers to select more energy efficient products

1.3 Scope of the study

Malaysia has not been released yet about standard and label program for electric rice cooker. There are limitations in the study in order to make easy and better understanding to analyze data:

i) There are many types of electric rice cooker in the market today. For this study, only electric rice cooker in the household in Malaysia is used to be analyzed.

ii) Electric rice cooker has different power consumption with vary maximum rice cooking capacity and models, therefore in this study, the electric rice cooker with maximum rice cooking capacity 1 L is used to predict the average energy consumption, maximum and minimum energy consumption to set up the standards and labels.

iii) The maximum rice cooking capacity of electric rice cookers varies somewhat among manufacturers in the market, therefore in this study the electric rice cooker with maximum rice cooking capacity from 0.6L to 1.8L only were included in the analysis to develop labels understanding among consumers.

1.3 Organization of dissertation

This dissertation is made up of five chapters. The chapters are organized as follows:

Chapter 1 is an introduction, which introduces the background, objectives, scopes of the study together with organization of the thesis.

Chapter 2 presents a literature review that consist an overview of previous studies on energy test procedure, energy efficiency standards and energy labels and related area.. The history of appliance standards and labels, status of the programs in Malaysia and around the world are also presented. Finally, a brief review on methodology together with an assessment of energy efficiency standard and labels are discussed.

Chapter 3 deals with research methodology that consist the process and procedure of the research conducted and results are calculated. The process starts with methodology of the test procedure selection, standards and energy labels. The methods of conducting data survey, interview and analysis followed by the methods of calculating impact for standards and labels on the energy, economics and environment has also been discussed.

Chapter 4 presented results and discussion on data assessment, the development of electric rice cooker test procedure, energy efficiency standards and labels. Finally, the results of energy, economical and environmental impact are also discussed.

Chapter 5 is divided into two sections, which are conclusion of the present work and recommendation.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Rice has been the main food in every meal for all Asians. Nowadays the electric rice cooker is one of the most necessary household appliances for Asians. The preparation of rice has traditionally been a tricky cooking process that requires accurate timing, and errors can result in inedible undercooked or burnt rice. Rice cookers aim to avoid these problems by automatically controlling the heat and timing in the preparation of the rice, while at the same time freeing up a heating element on the range. Although the rice cooker does not necessarily speed the cooking process, the cook’s involvement in cooking rice with a rice cooker is significantly reduced and simplified.

As a result of the rapid economic growth in the past, the usage of residential electrical appliances for the last two decades has increased rapidly in Malaysia. Like other developing countries with hot and humid climates, Malaysia has been experiencing a dramatic increase in the number of electric rice cookers used, and this is projected to be higher in the future. With the increasing number of electric rice cookers, standards and labels are highly effective policies for decreasing electricity consumption in the residential sector. Standards and labels are also capable to reduce the consumer’s electricity bill and contribute to a positive environmental impact.

Nowadays energy issue is one of the most sensitive and complicated issues in the globe. Energy and its primary sources has become a real worry for many countries.

For example, fossil fuels which are the main source of energy in the world are depleting and there is a rising anxiety around the world about their negative effect on the atmosphere and the environment. Because of the economic expansion, Malaysia is one of the most developed countries among the Association of Southeast Asian Nations (ASEAN) members. The successful implementation of the Industrialization Plan in 1985 has brought forth rapid economic growth and structural transformation away from agricultural-based economy (Gan *et al.*, 2007). The progress in the industrial sector harshly affected the ability to preserve the fuel supply and the ecological balance (Saidur *et al.*, 2009a).

The electrical energy consumption in Malaysia has increased sharply in the past few years, and modern energy efficient technologies desperately needed for the national energy policy. The per capita energy consumption of the majority of the population has been considerably increased especially in the developed countries. Energy growth in developing countries has been realized recently due to major developments in several sectors such as residential, commercial and industrial and transport. The primary energy source such as crude oil, natural gas and other conventional fuels are limited resources form by geological processes through solar energy accumulation into the earth over millions of years because of their fluctuations in reserves and prices due to the increased costs of power stations. The technology for harnessing non-conventional energy sources is still in the infant stage. To tackle this issue, capacity addition in the generating sector and implementation of energy conservation and management programs in the consumption side are two possible options. However, the cost saving one unit of energy is extremely nominal compared to the cost of its production. Hence, it is very important to consider new measures for energy conservation in both developed and developing countries. Energy conservation will definitely save investment of generating energy thereby enhancing the current economy of nations.

Taking into account the growing energy consumption and domestic energy supply constraint Malaysia has set a sustainable development program. At the same time the diversification of energy sources became the main goal of economy's energy policy. The five fuel strategy recognizes the renewable energy resources as the economy's fifth fuel after oil, coal, natural gas and hydro. The 9th Malaysian Plan (2006-2010) emphasizes the security, reliability and cost effectiveness of energy, while focusing on the sustainable development of the energy sector (Al-Mofleh et al, 2009).

2.2 Test procedure

The energy test procedure is the foundation of energy efficiency standards, energy labels and other related programs. A test procedure is a well-defined protocol or laboratory test method to provide manufacturers, regulatory authority and consumers (through energy labels) a way of consistently evaluating energy performance of appliances across different brands and models with respect to the characteristic in design and used of the product (Meier & Hill, 1997).

There are many test procedures used from Asian country such as Hong Kong, South Korea, Thailand and Japan. Hong kong has a Voluntary Energy Efficiency Labelling scheme for electric rice cookers initiated in 2001, with revision implemented in 2007. South Korea has both Mandatory Minimum Energy Performance Standards and Mandatory Energy Efficiency Label targeting the same category of rice cookers as Hong Kong. Thailand's voluntary endorsement labelling program is similar to Hong Kong in program design but has five efficiency grades. Japan's program is distinct in its adoption of the "Top

Runner" approach, in which the future efficiency standards is set based on the efficiency levels of the most efficient product in the country domestic market (Zhou & Zheng, 2008).

Hong Kong's testing requirements for measuring heat efficiency are based on Technical Specifications for Energy Conservation Production Certification for Household Automatic Rice Cooker. The main specified test conditions for testing heat efficiency and energy consumption include:

i. Relative humidity in the range of 45% to 75%
ii. Atmosphere pressure within the range of 86 to 106 kPa
iii. Ambient temperature of 20 °C ±2 °C where the test room will not be affected by wind and heat radiation
iv. The electric rice cooker must not be operating for more than 6 hours prior to the heat efficiency test or the temperature difference among the inner pot, heating element, outer pot and the ambient temperature must be within 5K.

The test results are issued by a laboratory which is accredited by Hong Kong Accreditation Service under Hong Kong Laboratory Accreditation Scheme for laboratory testing of electrical and mechanical appliances other tan the testing based on the technical standards stipulated in the scheme, and the laboratory can demonstrate their capability of carrying out tests on electric rice cookers on the technical standards (i.e. CCET/T11-2006, QB/T3899-1999 and JIS C9212-1993).

Similarly, South Korea's testing requirement includes the same ambient temperature and relative humidity conditions. However, South Korea differs in that it specifies the cooking water must be distilled water or service water that has been settled for more than 2 hours. Additionally, its tests are conducted with different classifications for rice cookers according to the heating method and pressure type. Specifically, separate rice cooker classifications exist for plate versus induction heating and pressure versus non pressure type. The energy test standard for rice cooker was developed in 2002 in order to add the electric rice cooker to Korean Energy Efficiency Label and Standard Program. The standard of rice cooker covers household electric rice cooker and rice warmer with a rated voltage 220V, and less than a rated power consumption of 2 kW. These are the normative reference that Korean Standard follows (Choi et al.,2006):

KS A 0006	Standard atmospheric conditions for testing
KS A 3251-1	Statistical interpretation of data- Part: Statistical presentation of data
KS A 0078	Humidity – Measurement methods
KS A 0511	Temperature measurement – general requirement
KS A 0801	General rules for determination of thermal efficiency
KS C 9310	Electric rice cookers
KS C 9312	Rice jars with electric thermal control
KS G 3602	Household pressure pans and pressure pots

While there are no details on the initial test conditions or testing procedures for Thailand's rice cooker labeling program. It is likely to similar to Hong Kong and Japan's procedures as it uses Hong Kong and Japan's test standards.

Japan, on the other hand, has very different initial conditions for its testing requirements.

i. The ambient temperature of 23 °C ±2 °C and also specifies the same temperature for the cooking water

ii. It requires that the cooking rice be washed three times within 20 seconds each time prior to testing

Like South Korea, Japan also conducts separate tests for rice cookers with the plate versus induction heating method. It also goes a further step to classify the rice cookers by four ranges of maximum capacity sizes, including ≥ 0.54 to < 0.99 L, ≥ 0.99 to < 1.44 L, ≥ 1.44 to < 1.80 L and 1.80 L and over.

Both Hong Kong and South Korea's measurement tests involve pouring water into the inner pot equal to 80% of its rated volume. A major difference between two countries' testing procedure is that Hong Kong uses white rice as a load for its test while South Korea does not seem to have a load. Japan's testing procedures also differs because it uses the water level specified by the manufacturer and uses milled rice as a load for only some parts of the procedure. More importantly, Japan does not conduct the heat efficiency test but its energy consumption measurement tests are much more complex, with four different tests are conducted to determine the annual average energy consumption.

2.3 The Development of Appliance Energy Labeling and Standards

Energy labeling for appliances in Malaysia began when the Directorate General of Electricity and Gas (Jabatan Bekalan Elektrik dan Gas, JBEG), predecessor of the Energy Commission (Suruhanjaya Tenaga, ST) requested Standard and Research Institute Malaysia (SIRIM) to initiate a formation of a working group under Industrial Standard Committee - Group E (ISCE). The purpose of this working group was to develop "Energy Efficiency Standards" for three products, namely fans, refrigerators and air-conditioners.

The working group was later upgraded to Technical Committee on Performance of Households and Similar Electrical Appliances (TCPHEA) with the mandate not only to develop the energy efficiency standards for the three products but also to look into the development of performance standards of other appliances.

TCPHEA decided that two Malaysian Standards (MS) would be developed for each appliance:

i) Energy Performance Testing Standards: Testing standards that specify protocols for testing the performance of products and equipment imported, produced and sold in Malaysia. The standards specify procedures for testing the energy performance of appliance and energy-using equipment.
ii) Energy Efficiency Labeling Standards: labeling standards specify a label design, rules for label application, criteria for categorizing appliance and energy using equipment based on energy performance.

The performance testing standards can either be adopt or adapt whenever possible the international testing standards for the equipment, such as from the ISO and the IEC standards. Energy Efficiency Labeling Standards however require more attention and work. By September 2002, SIRIM issued a "Draft Malaysian Standard (02E003R0) for Public Comment: Energy Labeling for Electric fan". The draft standard includes a label design, rules for label application, and criteria for categorizing fans based on energy performance testing. TCPHEA has also been pursuing similar work in parallel for refrigerators. With the creation and mandate of the newly formed Suruhanjaya Tenaga (ST), it has been decided to transfer the TCPHEA work and output on energy efficiency labeling to a new End Use Energy Rating Work Group (ERWG). Under the new arrangement, roles of institutions in the development of energy-efficiency regulations and programs affecting appliances and end-use equipments are clearly defined as shown in Figure 2.1. The development of energy performance testing, energy labeling and minimum energy performance standards, have been properly charted.

ST is responsible for issuing directives for energy efficiency labeling of energy using products. ST has the authority to issue directives to set MEPS for the energy using equipment. The End-Use ERWG and its Sub-Work Groups play a critical role in advising ST on technical contents, technical and policy aspects of the design and implementation of energy labeling and MEPS.

The objectives of the End-Use ERWG as stated in its Term of Reference is “to develop and propose policies for energy rating programs for end-use appliances including labeling and minimum energy performance (MEPS) and coordinate the implementation of programs and mechanisms to promote public awareness of energy-efficient appliances in the sector”.

Department of Standards (TCPHEA) is responsible to the establishment and maintenance of testing standards for the appliances and energy using equipments that will be affected by the energy labeling and MEPS directives. As shown in Figure 2.1, each of the ST directives must reference a Malaysian Standard for testing the energy performance (Faridah, 2003).

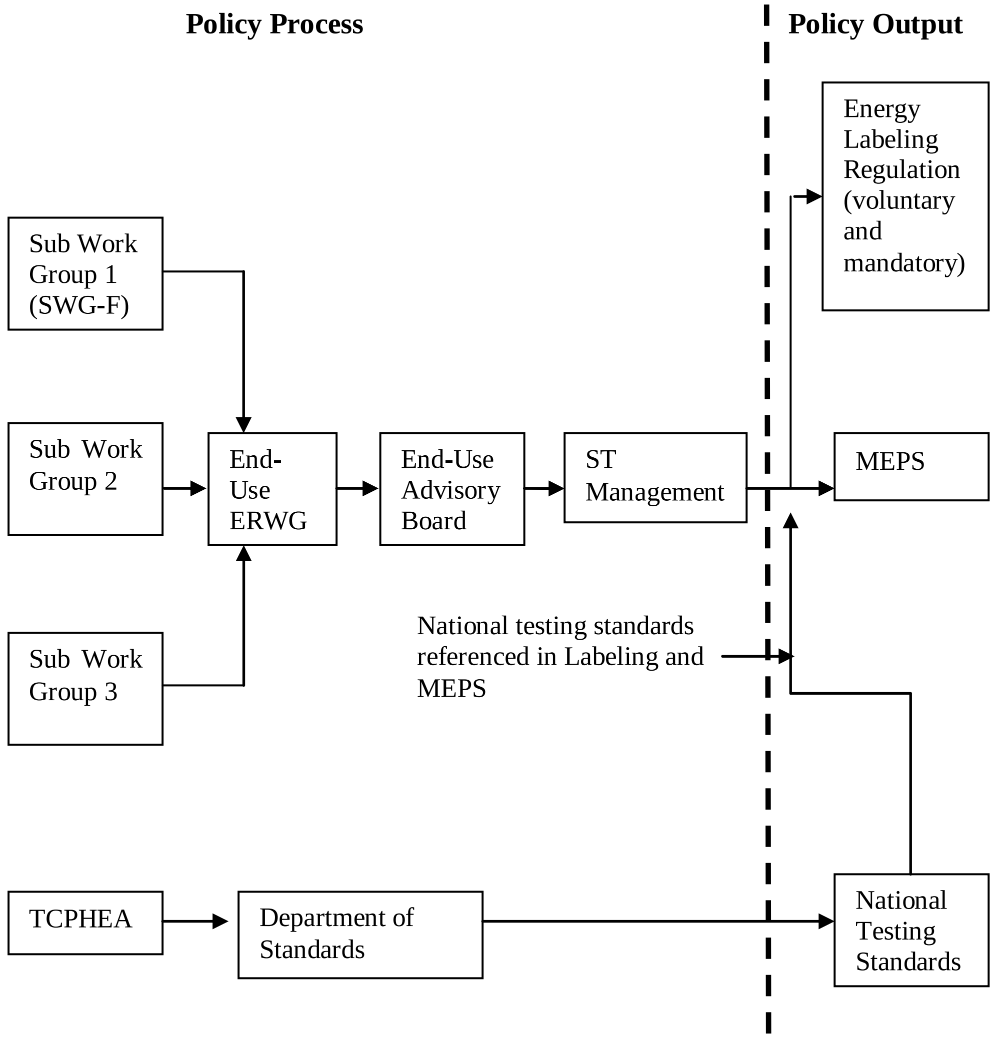

Figure 2.1 Roles of institutions in developments of testing standards, energy labelling regulations, and MEPS in Malaysia (Faridah, 2003)

2.4 Energy efficiency standards and labels

Energy efficiency standards and labels usually come together. Standards are more towards the technical setting of energy efficiency, while labels provide a guideline to consumers to select more efficient appliances when they purchase the product. S. Weil et al had defined exactly what is meant by the terms of labels and standards before discussing many aspects of these two terms.

i. Labels

Energy efficiency labels are informative labels that are affixed to manufactured products and describe a product's energy performance in the form of energy use, efficiency or energy cost to provide consumers with the data necessary for making informed purchases.

ii. Standards

Energy efficiency standards are procedures and regulations that prescribe the energy performance of manufactured products, sometimes prohibiting the sale of products that are less energy efficient than the minimum standards.

Energy performance improvements in consumer products are an essential element in any government's portfolio of energy efficiency policies and climate change mitigation programs (S. Weil et al, 2003). A government should developed balanced programs both voluntary and regulatory for greatest effectiveness that remove cost ineffective, energy wasting products from the marketplace and stimulate the development of cost effective, energy efficient technology.

Conceptually, energy efficiency labels and standards can be applied to any product that consumes energy as it provides its services. The national benefits of labels and standards applied to the most prevalent and energy intensive appliances, such as home refrigerators and commercial air conditioning systems are generally substantially higher than the cost of implementing the labels and standards programs and producing the efficient products.

The unit distribution of the appliances in the market due to implementation of the standards is usually represented by two curves that describe the market situation before and after the energy efficiency standards and labels are introduced. The evolution of market transformation and product distribution due to the energy efficiency standards is expected to follow the process presented in Fig. 2.2.

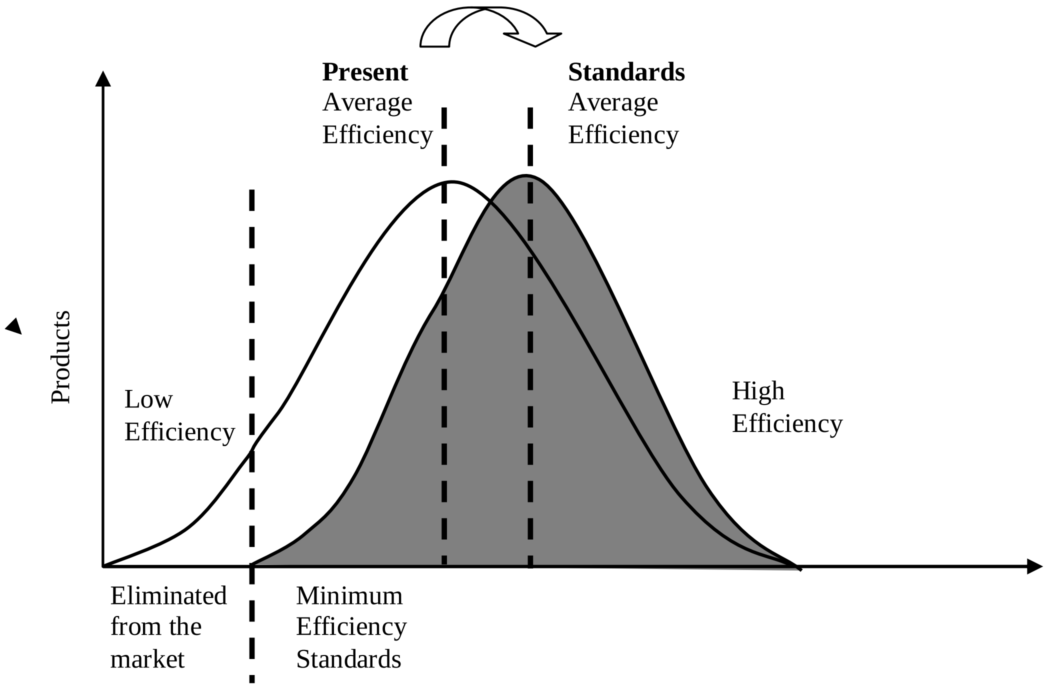

Fig. 2.2 Market transformation and products distribution due to standards implementation (Mahlia, 2004)

The market transformation is forcing the average efficiency of the appliances from the first curve (baseline average efficiency) towards the second curve (standards average efficiency) after the standards are eliminated. The average efficiency of the appliances distributions is pushed by the standards to be more efficient in the year the standards are implemented.

Introducing energy labels encourages the availability of a more efficient product in the market. This is because every manufacturer willing to produce the most energy efficient product to win the market because it is expected that consumers will purchase the more efficient product from the market due to the energy labels. This will increase the availability of the high energy efficiency models in the marketplace and increase the average energy efficiency of the appliance.

Therefore, the product distribution is represented by three curves, which are the baseline, minimum energy efficiency standards and energy labels. The evolution of market transformation and product distribution due to the energy labels implementation is expected to follow the process in Fig. 2.3.

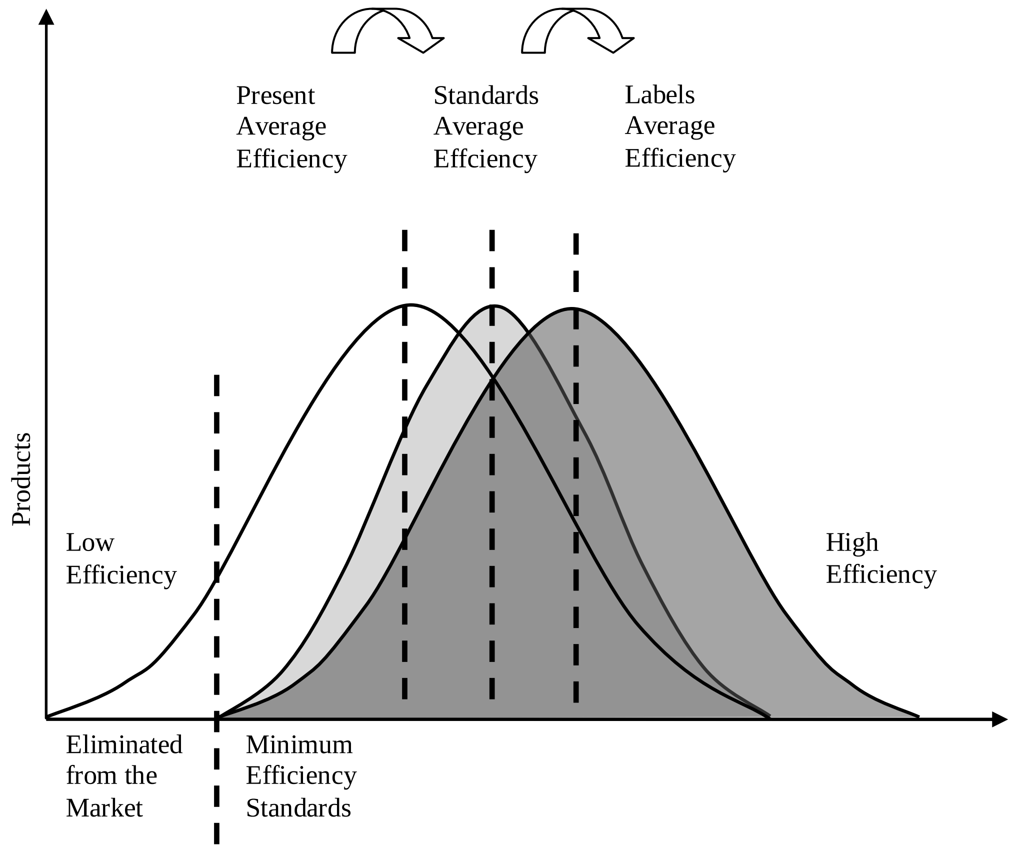

Fig. 2.3 Market transformation of products distribution due to standards and labels implementation (Mahlia, 2004)

2.4 Recommendations for energy conservation

Energy efficiency standards and labels can be the most effective long term energy efficiency policy any government can implement. Introducing energy efficiency standards eliminate inefficient products from the marketplace, and as a result, the market transformation on the efficiency of the appliances will be towards higher values.

Introducing energy labels paired with standards encourages manufacturers to produce more efficient appliances that will cause the transformation in the market. Because of the labels, it is expected that the consumer will purchase more efficient models from the market. This will gradually pull the availability of the high efficiency models into the marketplace (Mahlia, 2004).

There are the recommendation for energy conservation that are taking efforts by consumer itself where they will strive to purchase electric rice cooker with superior energy efficiency, and also to use it appropriately and efficiently in order to reduce energy consumption. Especially, in order to save energy, users will strive to refrain from using warm mode over long periods of time. Instead, they may refrigerate or freeze the cooked rice and heat it with a microwave oven when necessary.

Vendors will strive to promote electric rice cooker with superior energy efficiency. Also, by using energy efficiency labels, vendors will strive to provide appropriate information so that consumers can select energy efficient electric rice cookers. Upon using the energy efficiency labels, vendors should clearly display them and prevent users from misunderstandings.

For the manufacturers, they will promote technological development in order to improve the energy efficiency of electric rice cookers and strive to produce products with higher energy efficiency. Aiming at penetration of energy efficient electric rice cookers, manufacturers will plan the swift implementation of energy efficiency labels and will strive to provide appropriate information so that consumers will purchase them. Upon using energy efficiency labels, manufacturers should clearly display them and prevent consumers from misunderstanding.

Aiming at dissemination of energy efficient electric rice cookers, the government will promote the efforts of consumers and manufacturers and will take the necessary measures to foster it. The government will regularly and continually work to understand the implementation status of displaying information by manufacturers. The government will strive to employ appropriate laws so that manufacturers provide consumers with accurate and comprehensible information about energy efficiency of products. With respect to energy efficiency standards based on the Top Runner System, since it is a highly effective method for improving products' energy efficiency, the government will take the appropriate opportunities to promote the system internationally.

CHAPTER 3

METHODOLOGY

3.1 Introduction

Research methodology is a crucial factor to bring in an effective research with accredited results. It can be defined in many ways such as procedures, ways, methods and techniques that are applied to incorporate and gather all relevant information for the research. This chapter explains how the whole research was conducted and shows the methods by which energy savings, emission reduction and cost benefit analysis have been calculated and how the standard and label has been set up for the electric rice cooker.

Surveys on electric rice cookers efficiency are conducted and efficiency data from some other countries are collected for reference. At the same time, the data on electric rice cooker ownership, electricity pattern in domestic sector, climate conditions, comfort range and effective temperatures are also collected. The test procedure for this appliance is developed based on the power consumption and time required to cook using the electric rice cooker. The combination of statistical and engineering/economic approaches is adopted for setting the standards where the engineering/economic analysis is to determine potential efficiency improvement of electric rice cooker to reach the standards. As the standard is in place, the energy labels are to develop because the standard is a minimum value of the labels. The energy label is determined based on the respondent's selection. Finally, after the analysis is completed, it came to a point whether to reevaluate or recommend is inappropriate, which means it right be high or low. If it necessary, the standards must be re-set in accordance to the planning target.

3.2 Test procedure

An energy test procedure is the foundation of energy efficiency standards, labels and other related programs. A test procedure is a well defined protocol or laboratory test method by which a relative ranking of energy efficiency among alternative technological designs providing an energy consuming service can be obtain. Energy test procedure represents the technical foundation for all energy standards and labels. Energy labels cannot be created without an energy test procedure. Test procedure provides consistent measurement of appliance energy consumption. Energy standards, labels and efficiency programs are dependent on test procedure. The purpose of the test procedure is to establish a uniform and repeatable procedure or standards method for measuring specific appliances characteristic (Mahlia et. al,2002)

MS ISO 50001:2011 specifies requirements for establishing, implementing, maintaining and improving an energy management system, whose purpose is to enable an organization to follow a systematic approach in achieving continual improvement of energy performance, including energy efficiency, energy use and consumption. This standard specifies requirements applicable to energy use and consumption, including measurement, documentation and reporting, design and procurement practices for equipment, systems, processes and personnel that contribute to energy performance. This standard applies to all variables affecting energy performance that can be monitored and influenced by the organization. It does not prescribe specific performance criteria with respect to energy. MS ISO 50001 has been designed to be used independently, but it can be aligned or integrated with other management systems.

MS ISO 50001 is applicable to any organization wishing to ensure that it conforms to its stated energy policy and wishing to demonstrate this to others, such conformity being confirmed either by means of self-evaluation and self-declaration of conformity, or by certification of the energy management system by an external organization. The implementation of MS ISO 50001 is intended to lead to reductions in greenhouse gas emissions, energy cost, and other related environmental impacts, through systematic management of energy.

Table 3.1 Malaysia Standards and International Standards for electric rice cooker

PRODUCT TYPE / CATEGORY	**DOMESTIC STANDARDS**	**RELEVANT INTERNATIONAL STANDARDS**
Electric rice cooker	MS IEC 60335-1:2003 MS IEC 60335-2-15:2004	IEC 60335-1:2001 IEC 60335-1-15:2002

3.3 Energy efficiency standards

Energy efficiency standards is the prescribed energy performance of a manufactured product, sometimes prohibiting the manufacturer of products with less energy efficiency than the minimum standards (Turiel et al.,1997). The terms “standards” commonly encompasses two possible meanings: (1) well-defined protocols (or laboratory test procedures) by which to obtain a sufficiently accurate estimate of the energy performance of a product in the way it is typically used, or at least a relative ranking of its energy performance compared to other models and (2) target limits on energy performance (usually maximum energy use or minimum efficiency) based upon a specified test protocol. There are three types of energy efficiency standards:

- *Prescriptive standards* - requiring that a particular feature or device be installed such as insulation or not installed such as pilot lights in all new products;

- *Minimum energy performance standards* – prescribing minimum efficiencies (or maximum energy consumption – usually as a function of size or capacity) that manufacturers must achieve in each and every product, specifying the energy performance but not the technology or design details of the product;
- *Class average standards* – specifying the average efficiency of a manufactured product, allowing each manufacturer to select the level of efficiency for each model so that the overall average is achieved.

Generally speaking, energy efficiency of electric rice cookers significantly improves as model change and it normally takes about a year to develop a new model. An electric rice cooker is a product that consumes electricity in four different modes that include cooking mode, warm mode, timer mode and standby mode. Therefore, energy efficiency of electric rice cookers is defined as the annual energy consumption of a general household. In addition, the measuring method is specified as follows. First, measure energy in cooking mode, warm mode, timer mode and standby mode separately and then multiply each of them by the annual number of times that the rice cooker is used. Then, add these values together to yield an overall value (Nan Zhou and Nina Zheng,2008).

Furthermore, the measuring method described above evaluates energy saving performance of electric rice cookers in actual operating conditions. It is not intended to evaluate the taste and finished condition of cooked rice, which relate to cooking performance of rice cookers.

3.3.1 Legal status of the standards

Energy efficiency standards can be either mandatory or voluntary in nature. They can be in the form of minimum allowable energy use. Standards can be performance based or prescriptive in nature. Performance type standards state allowable energy use or energy efficiency whereas prescriptive standards require the presence of some features. Mandatory energy efficiency standards are generally the most effective way of rapidly improving the energy efficiency of appliances. Meanwhile, voluntary energy efficiency standards are an alternative option to energy efficiency programs. This is established by negotiation between government and manufacturers they have merit of being less controversial and hence some easier to enact but does not work well in some countries (Mahlia et al.,2002).

For electric rice cooker, China has adopted mandatory standards in 1989 and South Korea has minimum efficiency performance standards. However, in this country, standards are essentially voluntary in name only; failure to meet standards is likely to result in substantial embarrassment or imposition of mandatory standards. Based on the experience of other countries, the program should implement as mandatory since it works effectively in many countries. The program seems to be beneficial to be implemented in Malaysia in order to reduce future electricity demand in the residential sector and mitigated emissions in the country.

3.3.2 Approach of setting standards

There are two approaches mainly used for establishing energy efficiency standards. These are engineering/economic and statistical approach. This study used both approaches to develop energy efficiency standards for electric rice cookers. The statistical approach is adopted for establishing standards while the engineering/economic analysis approach is used to calculate the potential efficiency improvement of the least efficient models in the market to overcome the standards.

Energy efficiency standard is established using the statistical approach. This approach identified the models available at the market and the regression analysis is conducted to determine the dependence of energy use or performance with respect to capacity. Then, the percentage of models that are willing to be eliminated from the market average can be decided. From the average line, the least efficient model that is under the line will be eliminated from the market. The efficiency index of a model is the percentage of energy consumption or efficiency above or below the reference line. The data required are one that gives a current characterization of the marketplace for the products of interest namely the number of models by energy use or efficiency rating currently available in the market (Mahlia et al.,2002).

The theory developed in this study is a combination of the statistical and engineering economic approach. Since data is easier to be obtained in the statistical approach, it was used to set standards while the engineering economic approach used to analyze the energy, economic and environmental impact of the standards since it is more accurate.

3.3.3 Standards efficiency improvement

There are two types of efficiency improvement for appliances. The first type is active power improvement, which is efficiency improvement of the appliance when it is operating. The other is standby power improvement, which is energy consumption improvement of the appliance when it is on the standby mode. Standards efficiency improvement of the appliance is a percentage (a combination active and standby mode) of energy consumption improvement willing to set by the policymakers. Mostly, this improvement is a certain percentage below the average energy consumption in the market. This means the setting depends on the available appliance energy consumption data in the market. The market average is 100%, the standards is willing to set below the average level of energy consumption (Mahlia et al.,2002).

Liu Wei, China Institute of Standardization, said senior engineer, energy efficiency standards for electric cookers is 2000 watts the following products, including the energy efficiency rating, energy efficiency, limit values, evaluating values of energy efficiency, standby power consumption, heat and energy consumption. Before the rice cooker is metal, the product is relatively high thermal efficiency, the last two years the market has emerged to ceramics, Purple products for the liner material, thermal efficiency is relatively low, but the performance and functionality in the insulation has an advantage out of the rice taste so good, so when considered in the formulation of the standard non-metallic liner in the rice cooker, and the entry threshold down.

Not long ago, the EU issued a directive to require some products shall not exceed 1 W standby power consumption value over a few years, this indicator will drop to 0.6 watts. Therefore, the rice cooker energy efficiency standards also made especially for standby power requirements for the products have standby energy consumption of no more than 2 watts standby, in the future this indicator will drop to 1 Watt. On the thermal energy, Liu said, because the standard when the standard test method has not been modified, and therefore that the original test method under modified a bit, when the product load for 4 hours, 4 and 5 and a half hours. This 3-hour time point to energy consumption standards for insulation, they can be qualified.

3.3.4 Energy impact of the standards

The energy impact of the standards is calculated based on the average energy efficiency of the electric rice cookers and the energy efficiency of the standards. The essential inputs to calculate the energy impact are the appliance shipment, the number of electric rice cookers affected by the standards, scaling factor and shipment survival factor.

3.3.4.1 Baseline energy consumption

The baseline energy consumption is a function of energy consumption and usage hours of the appliance in the year of the standards enacted. The baseline energy consumption is calculated by the following equation (Mahlia et al., 2002):

$$BEC_s^{rc} = \frac{(E_o^{rc} \times U_o^{rc}) + (E_t^{rc} \times U_t^{rc})}{1000} \tag{3.1}$$

3.3.4.2 Standards energy consumption

The standards energy consumption is a function of energy consumption and usage hours of appliance multiplied by the percentage of efficiency improvement of appliance plus the standby energy consumption and standby hours multiplied by percentage standby efficiency improvement in the year of the standards enacted. The standards energy consumption is calculated by the following equation (Mahlia *et al*.,2002):

$$SEC_s^{rc} = \frac{(E_o^{rc} \times U_o^{rc}) \times (1 - \eta_o^{rc}) + (E_t^{rc} \times U_t^{rc}) \times (1 - \eta_t^{rc})}{1000} \tag{3.2}$$

Energy efficiency of electric rice cooker is defined as annual energy consumption (kWh/year), for this study the value is predicted from survey data with maximum rice cooking capacity 1 L.

3.3.4.3 Initial unit energy savings

The initial unit energy savings is the difference between the annual unit energy consumption of a unit meeting the standards and the unit energy consumption of the average unit that would have been shipped in the absence of standards. Thus, the initial energy savings is (Mahlia et al.,2002):

$$UES_s^{rc} = BEC_s^{rc} - SEC_s^{rc}$$

(3.3)

3.3.4.4 Shipment

Shipment data comprise the number of particular appliances in the predicting year minus the number of appliances in the previous year plus number of retired appliances in current year. The mathematical equation can be written as (Mahlia et al.,2002):

$$Sh_i^{rc} = (Na_i^{rc} - Na_{i-1}^{rc}) + Na_{i-L^{rc}}^{rc}$$

(3.4)

3.3.4.5 Scaling factor

The scaling factor would linearly scale down the unit energy savings and the incremental cost to zero over the effective lifetime of the standards. The scaling factor can be expressed in a mathematical form as (Mahlia et.al,2002):

$$SF_i^{rc} = 1 - (Ysh_i^{rc} - Yse_s^{rc}) \times \frac{AEI_s^{rc}}{SEI_s^{rc}}$$

(3.5)

3.3.4.6 Unit energy savings

The unit energy savings were adjusted downward in the years after standards is implemented using the efficiency trend scaling factors. This factor accounts for the natural progress in efficiency expected in the baseline case. The unit energy saving can be expressed in the mathematical form as follows (Mahlia et.al,2002):

$$UES_i^{rc} = SF_i^{rc} \times UES_s^{rc} \tag{3.6}$$

3.3.4.7 Retirement function

A retirement function or also known as survival curve is used to estimate the rate of appliances. In the linear function, no appliances retire in the first 2/3 of their average life, and all units are retired by 4/3 of this average life. The relation between age/average lives with appliance survival factor as shown in Fig. 3.2. Expressed as equations, this function is as follows (Mahlia et.al,2002):

If Age < [2/3 x (Average Life)] then 100% survive

If Age < [2/3 x (Average Life)] and Age < [4/3 x (Average Life)]

Then [2 – Age x 1.5 / (Average Life)] survive

If Age > [4/3 x (Average Life)] then 0% survive

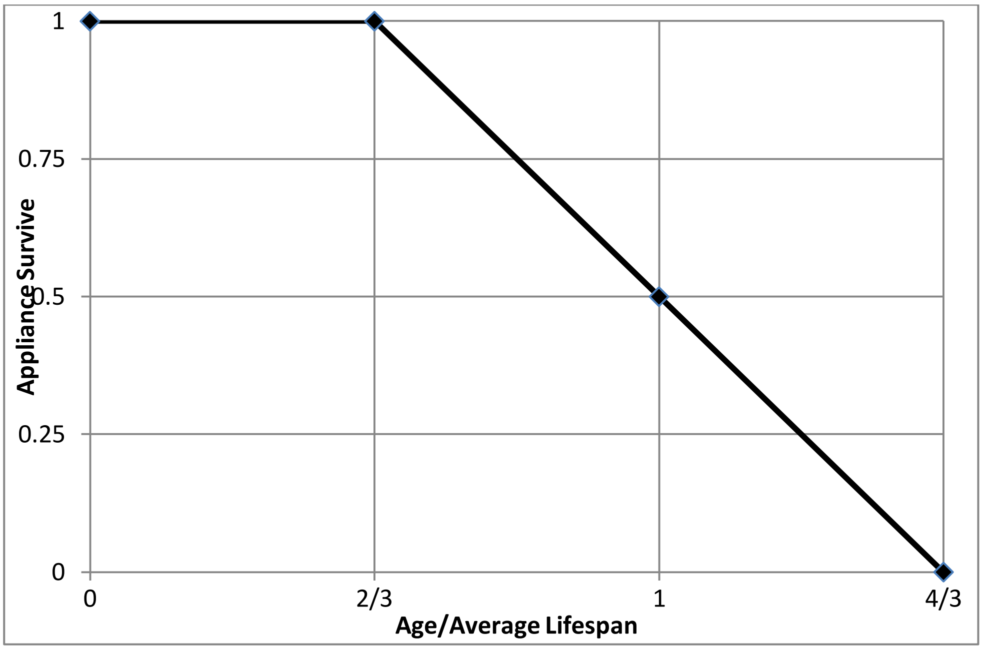

Figure 3.1 Appliance survival factor

3.3.4.8 Shipment survival factor

The shipment survival factor is a function of the annual retirement of the annual retirement function. If the standards setting is shorter than 2/3 of the average lifespan of appliances shipment survival factor will be 100%. Shipment survival factor can be calculated using the following equation (Mahlia et.al,2002):

$$SSF_i^{rc} = 1 - \left[\frac{(Ytc_T^{rc} - Ysh_i^{rc}) - 2/3L^{rc}}{(4/3 - 2/3) \times L^{rc}}\right]$$

(3.7)

3.3.4.9 Applicable stock

The appliance stock is the shipments plus number of appliances affected by standards in previous year multiplied by shipment survival factor. In the mathematical expression can be written as (Mahlia et.al,2002):

$$AS_i^{rc} = (Sh_i^{rc} \times SSF_i^{rc}) + AS_{i-1}^{rc}$$

(3.8)

3.3.4.10 Annual energy savings

The initial unit energy savings associated with each standards is multiplied by the scaling factor in any year to determine the unit energy savings for appliances purchased in that year. This unit energy savings is then multiplied by the number of appliances purchased in that year, which still exist to calculate the annual energy savings associated with the cohort of the appliances in those years. In the mathematical expression it can be written as follows (Mahlia et.al,2002):

$$ES_i^{rc} = \sum_{i=s}^{T} AS_i^{rc} \times UES_i^{rc} \times SF_i^{rc} \tag{3.9}$$

3.3.4.11 Business as usual

Business as usual is the energy consumption of the appliance in the absence of standards. Business as usual can be expressed in the mathematical form as the following equation (Mahlia et.al,2002):

$$BAU_i^{rc} = AS_i^{rc} \times SSF_i^{rc} \times BEC_s^{rc} \times IE_i^{rc} \tag{3.10}$$

3.3.5 Economic impact of the standards

The economic impact consists of potential bill savings, net savings and cumulative present value. The economic impact is actually a function energy savings and investment for more efficient appliances due to the standards. The comprehensive description of each variable is explained in the following section.

3.3.5.1 Initial incremental cost

Initial incremental cost per unit of appliance is a function of unit energy savings and incremental cost and can be calculated using the following equation (Mahlia et.al,2002):

$$IIC_s^{rc} = UES_s^{rc} \times IC^{rc}$$

(3.11)

3.3.5.2 Capital recovery factor

Capital recovery factor is the correlation between the real discount rate and the lifespan of the appliance. This correlation can be expressed by the following mathematical equation (Mahlia et.al,2002):

$$CRF = \frac{d}{(1-(1+d)^{-L^{rc}})}$$

(3.12)

3.3.5.3 Cost of conserved energy

Cost conserved energy due to standards is a function of initial incremental cost, capital recovery factor divide by initial unit energy savings and expressed in mathematical forms (Mahlia et.al,2002):

$$CCE_s^{rc} = \frac{IIC_s^{rc} \times CRF}{UES_s^{rc}}$$

(3.13)

3.3.5.4 Bill savings

The bill savings is the energy savings multiplied by an average fuel price and can be expressed as follows (Mahlia et.al,2002):

$$BS_i^{rc} = ES_i^{rc} \times PF_i^{n}$$

(3.14)

3.3.5.5 Net savings

There are two ways to estimate economic impact: annualized costs and cash flow. In the first method, the incremental cost is spread over the lifetime of the appliance so that the pattern of expenditures matches the flow bill savings. This method smoothen the net savings over time. The annualized net dollar savings is the main economic indicator used in this analysis, is calculated using the following equation (Mahlia et.al,2002):

$$ANS_i^{rc} = ES_i^{rc} \times PF_i^n - \sum_{i=s}^{T} AS_i^{rc} \times CRF \times SF_i^{rc} \times IIC^{rc}$$

(3.15)

The second method considers the cash flow over the lifetime of the investment assuming that the appliance is paid for full when it is installed. Purchasers incur the incremental cost when the appliance is purchased, but benefits of higher energy efficiency are spread over the lifetime of the appliance. To calculate the net savings in a certain year in term of actual cash flows, the following equation is used (Mahlia et.al,2002):

$$NS_i^{rc} = ES_i^{rc} \times PF_i^n - Sh_i^{rc} \times SF_i^{rc} \times IIC^{rc}$$

(3.16)

3.3.5.6 Cumulative present value

The cumulative present value can be calculated using a percentage real discount rate. The cumulative present value of annualized net savings can be expressed in the mathematical form as follows (Mahlia et.al,2002):

$$PV(ANS_i^{rc}) = \sum_{i=s}^{T} \frac{ANS_i^{rc}}{(1+d)^{(i-Ydr)}}$$

(3.17)

3.3.6 Environmental impact of the standards

The environmental impact of the standards is the potential reduction of greenhouse gasses or other element that cause negative impact to the environment. The common potential reductions of the standards are consisting carbon dioxide, sulfur dioxide, nitrogen oxide and carbon monoxide. The environmental impact is also a function of energy savings. Environmental impact of the standards can be calculated using the following equation (Mahlia et.al,2002):

$$ER_i^{rc} = ES_i^{rc}\left(PE_i^1 \times Em_p^1 + PE_i^2 \times Em_p^2 + PE_i^3 \times Em_p^3 + \cdots + PE_i^n \times Em_p^n\right) \tag{3.18}$$

3.4 Energy labels

Energy labels enable consumers to compare the energy efficiency of appliances on a fair and equitable basis. Usually energy efficiency standards and labels are developed together. Energy labels will create competition between manufacturers. The energy labels acts as an indicator telling the potential buyer how efficient the product is. Energy labels not only set guidelines of efficiency that manufacturers should follow, it also encourages them to improve their product while keeping their cost low to win the market. The labels must be displayed in the front part of each product and their packaging so that the consumers get the information at the time of purchase (Mahlia et al., 2005).

3.4.1 Legal status of the labels

Similar to energy standards, the legal status energy labels are also can be either mandatory or voluntary. A mandatory energy labels prescribed all appliances must be affixed by an energy labels when it sells in the market. Selling appliances without an energy labels or removal of the labels before consumer purchase is considered to be violating the law. The labels prepared by the authority is subjected under the country law. On the other hand, voluntary energy labels is an alternative option. Under the voluntary energy labels only some appliances, with the agreement of the manufacturers who agree to carry labels will affixed with the labels. This is established by negotiation between the government and manufacturers. However, a voluntary label does not work well in many countries.

Hong Kong has a Voluntary Energy Efficiency Labelling scheme for electric rice cookers initiated in 2001, with revision implemented in 2007. South Korea has both Minimum Efficiency Performance Standards and Mandatory Energy Efficiency Label targeting the same category of rice cookers as Hong Kong. Thailand's voluntary endorsement labelling program is similar to Hong Kong in program design but has five efficiency grades. Japan's program is distinct in its adoption of the "Top Runner" approach, in which the future efficiency standards is set based on the efficiency levels of the most efficient product in the current domestic market. Although the standards are voluntary, penalties can still be evoked if the average efficiency target is not met.

3.4.2 Energy impact of the labels

The impact of energy labels can be predicted based on their grades. The prediction scenario depend on the possible grade choose by consumers when they purchased the appliances. In order to calculate energy impact of the labels, some essential calculation has to be made. There are some differences between calculating potential savings standards and labels. However, the clear difference between them is the energy labels does not affected by scaling factor to calculate the energy impact. This is due to the standards (energy consumption of the standards) as baseline of the labels is static. Essential inputs to calculate energy impact are appliance shipment, the number of appliances affected by the labels, and shipment survival factor. The comprehensive description of each variable are explained in the following section.

3.4.2.1 Baseline energy consumption

The baseline energy consumption for calculating energy impact of the labels is the standards energy consumption.

3.4.2.2 Labels energy consumption

The labels energy consumption is a function of standards energy consumption multiplied by the percentage improvement of the labels grade. This calculation is made based on predicting grade of labels choose by the consumer. This prediction can be calculated by various scenarios such as optimist, normal and pessimist prediction or by labels grades such as at A, B and C etc. The labels energy consumption can be expressed in a mathematical form as follows (Mahlia et.al,2002):

$$LEC_l^{rc} = SEC_s^{rc} \times (1 - \eta_l^{rc}) \tag{3.19}$$

3.4.2.3 Unit energy savings

The initial unit energy savings is the difference between the annual unit energy consumption of the labels and the unit energy consumption of the average unit by standards. The labels unit energy consumption of an appliance is calculated based on the efficiency level of the standards, using the same capacity and usage data as the baseline. Thus, the labels unit energy savings is (Mahlia et.al,2002):

$$UES_l^{rc} = SEC_s^{rc} - LEC_l^{rc} \tag{3.20}$$

3.4.2.4 Shipment survival factor

The shipment survival factor is a function of the annual retirement rate and the retirement function, which can be calculated using the following equation (Mahlia et.al,2002):

$$SSF_i^{rc} = 1 - \left[\frac{(Ytc_T^{rc} - Ysh_i^{rc}) - {}^2\!/_3\, L^{rc}}{\left({}^4\!/_3 - {}^2\!/_3\right) \times L^{rc}}\right]$$

(3.21)

3.4.2.5 Applicable stock

The applicable stock is the shipments in a particular year plus the number of appliances affected by labels in the previous year multiplied by the shipment survival factor. The mathematical equation can be expressed as (Mahlia et.al,2002):

$$AS_i^{rc} = (Sh_i^{rc} \times SSF_i^{rc}) + AS_{i-1}^{rc}$$

(3.22)

3.4.2.6 Annual energy savings

Annual energy savings is the number of appliances affected by the labels in the particular year that still exist multiplies the unit energy savings associated with each labels grade. Since the standards is static, there is no scaling factor used in calculating the energy labels. In the mathematical expression it can be written as follows (Mahlia et.al,2002):

$$ES_i^{rc} = \sum_{i=s}^{T} AS_i^{rc} \times UES_i^{rc}$$

(3.23)

3.4.2.7 Business as usual

Since the labels is developed as a pair of the standards and therefore the business as usual for calculating energy labels is the standards energy consumption of the appliance.

3.4.3 Economic impact of the labels

The economic impact of the labels consists of potential bill savings, net savings and cumulative present value. The economic impact actually stands as a function energy savings and investment for more efficient appliances due to the labels. The comprehensive description of each variable are explained in the following section.

3.4.3.1 Initial incremental cost

Initial incremental cost per unit of an appliance is a function of unit energy savings and incremental cost and can be calculated using the following equation(Mahlia et.al,2002):

$$IIC_l^{rc} = UES_l^{rc} \times IC^{rc} \tag{3.24}$$

3.4.3.2 Capital recovery factor

Capital recovery factor is the correlation between the real discount rate and the lifespan of the appliance. This correlation has been expressed in Eq. (3.12) in the previous section.

3.4.3.3 Cost of conserved energy

Cost conserved energy due to labels is a function of initial incremental cost, capital recovery factor divide by initial unit energy savings. Mathematically it can be expressed by the following equation (Mahlia et.al,2002):

$$CCE_l^{rc} = \frac{IIC_l^{rc} \times CRF}{UES_l^{rc}} \tag{3.25}$$

3.4.3.4 Net savings

Such as the standards, for energy labels, three are also two methods to estimate economic impact: annualized costs and cash flow. In the first method, the incremental cost is spread over the lifetime of the appliance so that the pattern of expenditures matches the flow of bill savings. This method smoothens the net savings over time. Since the standards energy consumption is static, no scaling factors are used to calculate labels savings. The annualized net dollar savings in a particular year, which is the main economic indicator, is calculated using the following equation (Mahlia et.al,2002):

$$ANS_i^{rc} = ES_i^{rc} \times PF_i^n - \sum_{i=s}^{T} AS_i^{rc} \times CRF \times IIC_i^{rc} \tag{3.26}$$

The second method considers the cash flow over the lifetime of the investment assuming that the appliance is paid for full when it is installed. The purchasers incur the incremental cost when the appliance is purchased, but the benefits of higher energy efficiency are spreading over the lifetime of the appliance. To calculate the net savings in a certain year in term of actual cash flows, the following equation can be used(Mahlia et.al,2002):

$$NS_i^{rc} = ES_i^{rc} \times PF_i^n - Sh_i^{rc} \times IIC_i^{rc} \tag{3.27}$$

3.4.3.5 Cumulative present value

The cumulative present value can be calculated using a percentage real discount rate. The cumulative present value of annualized net savings can be expressed in a mathematical form as follows (Mahlia et.al,2002):

$$PV(ANS_i^{rc}) = \sum_{i=s}^{T} \frac{ANS_i^{rc}}{(1+d)^{(i-Ydr)}}$$

(3.28)

3.4.4 Environmental impact of the labels

Common environmental impact from fossil fuel energy sources consist carbon dioxide, sulphur dioxide, nitrogen oxide, carbon monoxide and other greenhouse gasses. The environmental impact is also a function of energy savings. The impact is a benefit to the society by choosing more efficient appliances due to the labels. The environmental impact of the labels can be calculated using the following equation (Mahlia et.al,2002):

$$ER_i^{rc} = ES_i^{rc}\left(PE_i^1 \times Em_p^1 + PE_i^2 \times Em_p^2 + PE_i^3 \times Em_p^3 + \cdots + PE_i^n \times Em_p^n\right)$$

(3.29)

3.5 Interview

Interviews were conducted among 300 respondents that represent the main races in Malaysia which are Malay, Chinese and Indian. The data is analyzed based on labels selected by respondent based on frequency and understanding, respondent understanding for each label and respondent suggestions for label improvement.

There are two types of data obtained namely quantitative and qualitative data. Both type of the data are used for labels development. The quantitative data is required to select the suitable type of the label to be used and qualitative data are used for labels improvement based on the respondents input. In order to get the respondent input, they were asked to select an appropriate energy label that easy to understand and the most suitable one to be used in Malaysia.

3.6 Energy labels selection

There are many types of energy labels around the world. The labels type A (letter types) was introduced in the European Union countries, Iran and Brazil. The labels type B (star types) have been used in Thailand, Australian and India. The labels type C (speedometer types) is self developed and modified from air conditioning survey. All of the energy labels are in Malay language in order to make it more effective and suitable to be used in Malaysia.

3.6.1 Labels type A

Labels type A (letter types) was introduced in the European Union countries but then was adopted by Iran. Brazil is also going to adopt this type of label to replace the United States type because it has proven to be effective in the European Union countries. The developed energy label is presented in Fig. 3.2.

3.6.2 Labels type B

Labels type B (star types) originated from Australia but then was adopted by Thailand and South Korea. The differences between Australian labels with Thailand and Korea style is in last two countries the stars are replaced by numbers and works effectively in those countries. However, the developed energy labels, both the star and number have been adopted. The developed energy labels is presented in Fig. 3.3.

3.6.3 Labels type C

Labels type C is a self developed energy labels where the grades in the labels are similar to type A and type B. Most of Malaysian can understand easily since the concept of this labels is adopted from car and motorcycle speedometer, which is owned by most of Malaysian. The developed of this type of labels is presented in Fig. 3.4.

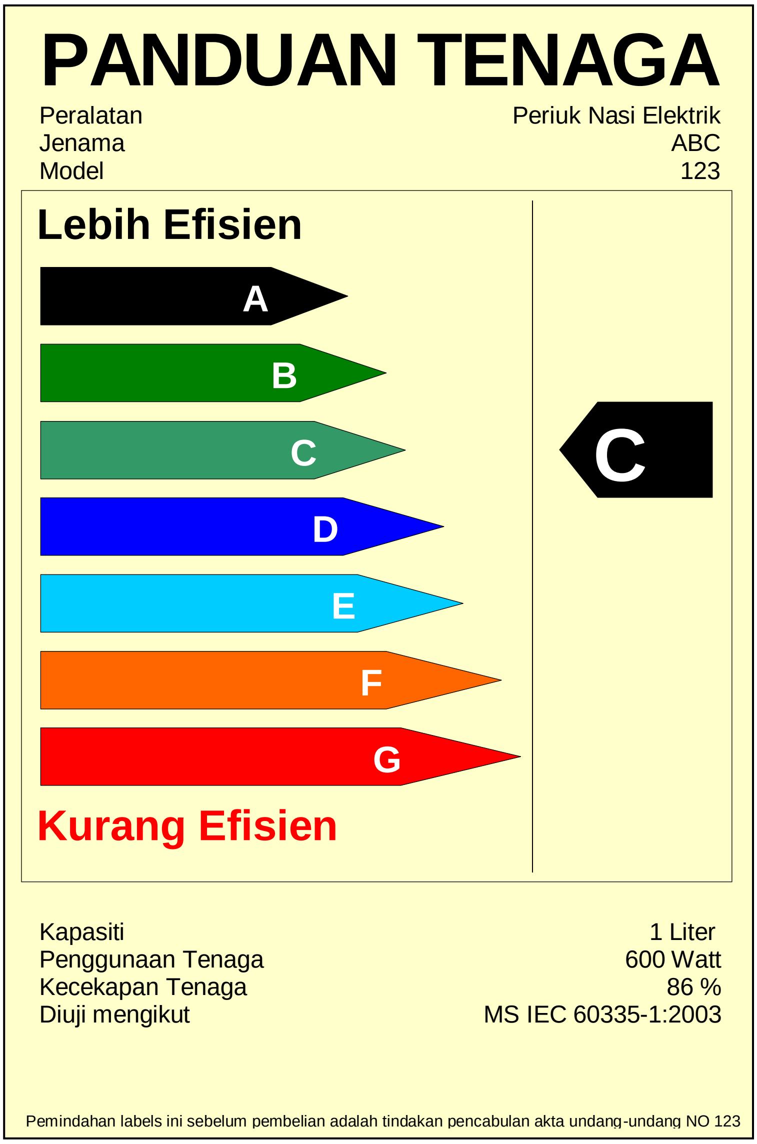

Figure 3.2 Labels types A

Figure 3.3 Labels type B

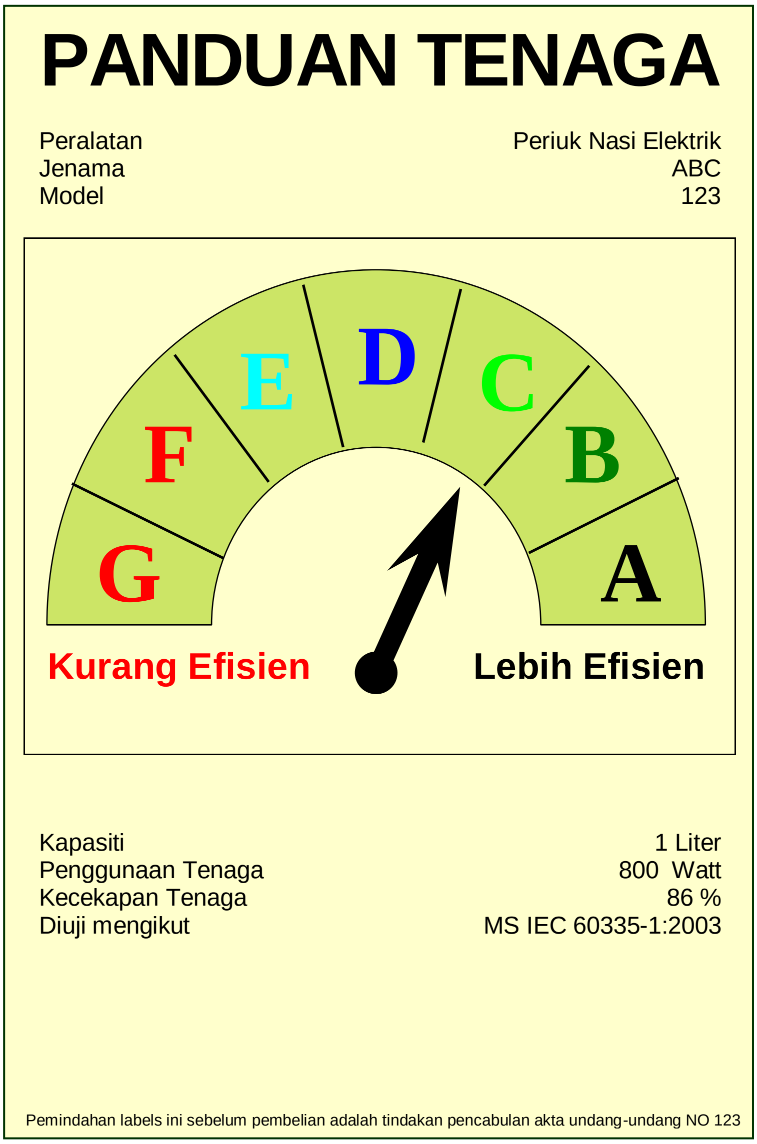

Figure 3.4 Labels type C

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

This chapter discusses the results of implementing standards and labels program for electric rice cooker in Malaysia. The energy impact, economical impact and environmental impact were examined when the standards and labels program is implemented to the electric rice cooker.

4.2 Impact of the standards

The impacts of the standards for electric rice cooker are divided into three sections which are energy impacts, economical impacts and environmental impacts. All the impacts are discussed in the following section.

4.2.1 Data collection and assessment

The technical data necessary for this study are the electricity data, electric rice cooker ownership data, the percentage of electricity generation based on fuel type and fossil fuel emissions for a unit electricity generation. These data are tabulated in Table 4.1, Table 4.2 and Table 4.3 respectively.

Table 4.1 Household and electricity consumption data

Year	Total (GWh)	Residential (GWh)	Household	Electric rice cooker
1970	2175	326	1,890,282	1890282
1980	7912	1348	2,503,974	2503974
1990	19469	3897	3,428,142	3428142
2000	52300	9471	4,662,762	4662762
2001	61151	11081	4,803,299	4803299
2002	66159	11986	4,946,941	4946941
2003	71368	12927	5,093,688	5093688
2004	76779	13905	5,243,539	5243539
2005	82390	14919	5,396,495	5396495
2006	88203	15969	5,552,555	5552555
2007	94217	17055	5,711,720	5711720
2008	100433	18178	5,873,989	5873989
2009	106850	19337	6,039,363	6039363
2010	113468	20532	6,207,842	6207842
2020	190721	34480	8,063,382	8063382

Table 4.2 Percentage of electricity generation based on fuel types

Year	Coal (%)	Petroleum (%)	Gas (%)	Hydro (%)
1994	9.30	22.30	51.70	16.70
2000	15.00	5.00	70.00	10.00
2010	18.00	2.00	50.00	30.00
2020	29.00	1.00	40.00	30.00

Table 4.3 Fossil fuel emissions for a unit electricity generation

Fuels	**Emission (kg/kWh)**			
	CO_2	SO_2	NO_x	CO
Coal	1.1800	0.0139	0.0052	0.0002
Petroleum	0.8500	0.0164	0.0025	0.0002
Gas	0.5300	0.0005	0.0009	0.0005
Hydro	0.0000	0.0000	0.0000	0.0000
Other	0.0000	0.0000	0.0000	0.0000

Due to the lack of data available but in order to illustrate the scale of the issue, it is assumed that the growth rate of x is a function of available data and a response y which seek to find the smooth curve that best fit the data. Quadratic equations have been used to predict the number of residential electricity consumption in Malaysia. Number of electric rice cooker is assume to be equal to household data because even tough every household in Malaysia has more than one rice cooker, they only use one per day for cooking every day. Based on the data presented in Table 4.1, the curve fitting equations are as follows:

$$y_1 = 17.718x^2 - 218.06x + 863.37, R^2 = 0.9981 \quad (4.1)$$

$$y_2 = 1552.30x^2 + 45847.08x + 1890279.09, R^2 = 1.00 \quad (4.2)$$

The quadratic equations have also been used to interpolate between the planning figures of the fuel mix of electricity generation in Malaysia given in Table 4.2. The percentage of coal, petroleum, gas and hydropower uses for electricity generation is interpolated by the following equations:

$$y_3 = 0.15 - 0.001x + 0.0004x^2,\ R^2 = 1.0000 \quad (4.3)$$

$$y_4 = 0.05 - 0.004x + 0.0001x^2,\ R^2 = 1.0000 \quad (4.4)$$

$$y_5 = 0.7 - 0.025x + 0.0005x^2,\ R^2 = 1.0000 \quad (4.5)$$

$$y_6 = 0.1 + 0.03x - 0.001x^2,\ R^2 = 1.0000 \quad (4.6)$$

The results of the predicted data based on Eq. (4.1), (4.2),(4.3),(4.4),(4.5) and (4.6) are tabulated in Table 4.4.

Table 4.4 Predicted electricity consumption, number of electric rice cooker and percentage fuel mix for electricity generation

Year	**Residential (GWh)**	**Electric Rice Cooker**	**Coal (%)**	**Petroleum (%)**	**Gas (%)**	**Hydro (%)**
2003	11962	5093687	15.06	3.89	62.95	18.10
2004	13931	5243539	15.24	3.56	60.80	20.40
2005	14936	5396494	15.50	3.25	58.75	22.50
2006	15976	5552555	15.84	2.96	56.80	24.40
2007	17051	5711720	16.26	2.69	54.95	26.10
2008	18162	5873989	16.76	2.44	53.20	27.60
2009	19308	6039364	17.34	2.21	51.55	28.90
2010	20490	6207842	18.00	2.00	50.00	30.00
2011	21707	6379426	18.74	1.81	48.55	30.90
2012	22959	6554114	19.56	1.64	47.20	31.60

Malaysia does not have complete data for household appliances so; some data had to rely on some other sources. The average annual electricity consumption of electric rice cooker is 110.9 kWh/year, the most efficient model consumes 92 kWh/year which is the data is the minimum energy consumption from the maximum rice cooking capacity 1 L.

From the standpoint of countermeasures against global warming, assuming the tenure of use of an electric rice cooker is approximately 7 years, it is desirable that products achieve the target standards value as soon as possible.

The energy efficiency estimated from the past results of electric rice cookers shipped in fiscal year 2003 is 119.2 kWh/year. The energy efficiency estimated from the target standards value of electric rice cookers shipped in the target fiscal year of 2008 is 106.0 kWh/year. The improvement rate of energy efficiency from 2003 to 2008 is 11.1%. Therefore, the improvement of the efficiency is 2.22 % per year.

Power consumption of electric rice cooker in standby mode cannot be ignored. The Japan Electronics and Information Technologies industries Association (JEITA), the Japan Refrigeration and Air Conditioning Industry Association (JRAIA) and the Japan Electrical Manufacturers' Association (JEMA) announced, in their joint names, an approach to reduce power consumption in standby mode. They self declared that power consumption in standby mode should become as close to zero for products without timer and 1W or below for products with timer by the end of fiscal year 2003 (for air conditioners by the end of September 2004). In order to preserve this declaration, all manufactures made improvement in control circuits of their products and achieved this target 100% for electric rice cooker. Table 4.5 shows the progress of power consumption in standby mode.

Table 4.5 Progress of power consumption in standby mode

Power consumption in Standby Mode in fiscal 2000	Power consumption in Standby Mode in fiscal 2004
1.7 W	0.74 W

For the annual energy efficiency improvement is calculated based on from previous study by Mahlia et.al, 2006. For this case, the annual energy efficiency is 1.08%. Increment cost is the purchase cost of electric rice cooker per power consumption by the product itself. To calculate the electric rice cooker impact, some input data have been identified and presented in Table 4.6.

Table 4.6 Essential input data

Description	Values
Baseline energy consumption	110.9 kWh/year
Standards energy consumption by an efficient electrical rice cooker	92 kWh/year
Initial unit energy savings	18.9 kWh/year
Standards efficiency improvement	17.04 %
Increment cost	RM 0.8807 / kWh
Initial incremental cost	RM 16.6459/ year
Capital recovery factor	0.15
Current electricity price	RM 0.3354 / kWh
Annual efficiency improvement	1.08 %
Year standards enacted	2003
Appliance life span	9 years

4.2.2 Energy impact of the standards

The potential energy savings is tabulated in Table 4.7. Shipment is the number of new electric rice cooker in that particular year and calculated using Equation 3.4. Applicable stock is the summation of the shipments in the particular year and the number of appliances affected by the standards in the previous year and calculated by Equation 3.8. The scaling factor would linearly scale down the unit energy savings and the incremental coat to zero over the effective period of the standards and the unit energy savings is calculated using Equation 3.6.

Table 4.7 Potential energy savings

Year	**Shipment**	**Applicable stock**	**Scaling factor**	**Unit energy savings (kWh/year)**	**Energy savings (kWh/year)**
2003	4278405	4278405	100.00	18.9000	80861846
2004	4409628	8688033	93.66	17.7021	144048866
2005	4543956	13231989	87.32	16.5042	190701284
2006	4681389	17913378	80.99	15.3063	222053840
2007	4821926	22735305	74.65	14.1085	239440506
2008	4965568	22700873	68.31	12.9106	244299197
2009	5112315	32813188	61.97	11.7127	238176488
2010	5262166	38075354	55.63	10.5148	222732325
2011	5415122	43490476	49.30	9.3169	199744743
2012	5571182	49061659	42.96	8.1190	171114578

Figure 4.1 shows the annual energy savings due to the electric rice cooker standards and increase slowly in the beginning of the analysis period then increase to maximum in the middle of the period. Over a period time, the projected annual efficiency improvement in the baseline begins to catch up the standards. 1,953,173,674 kWh will save when the energy efficient standards implemented in year 2003 to 2012. The figures also shown that the standards is effective for about 10 years and the new standards must be set up again up to the baseline energy consumption.

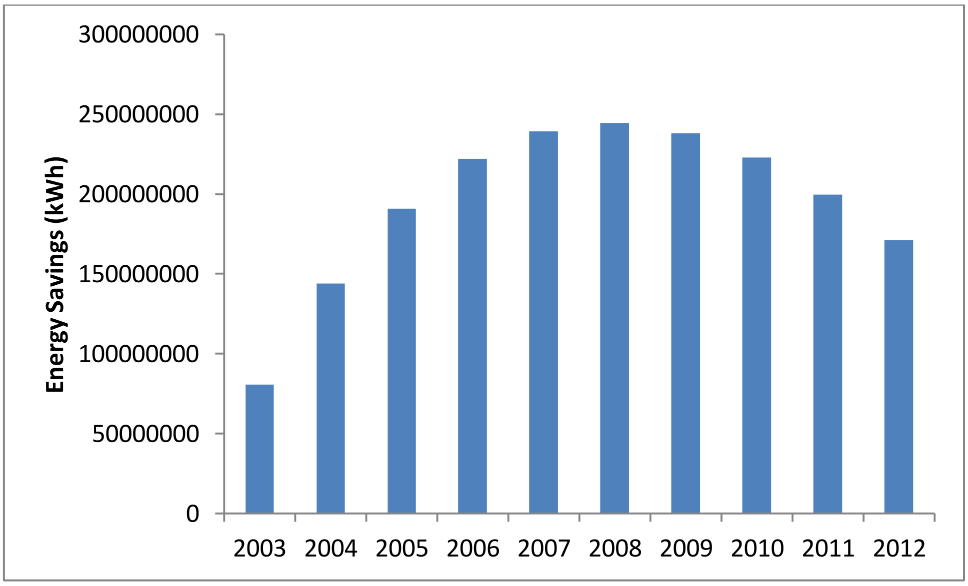

Figure 4.1 Annual energy savings due to the electric rice cooker standards

Table 4.8 Household energy consumption with and without standards

Year	**Household electricity consumption (GWh)**	**Household electricity consumption with standards (GWh)**	**Energy Savings (GWh)**
2003	12962	12881	81
2004	13931	13787	144
2005	14936	14745	191
2006	15976	15754	222
2007	17051	16812	239
2008	18162	17918	244
2009	19308	19070	238
2010	20490	20267	223
2011	21707	21507	200
2012	22959	22788	171

Table 4.8 shows the household energy consumption with and without the implementation of the standards. Energy consumption will save about 1953 GWh when the standards is implemented to the electric rice cooker from 2003 to 2012. This result is illustrated in Figure 4.2.

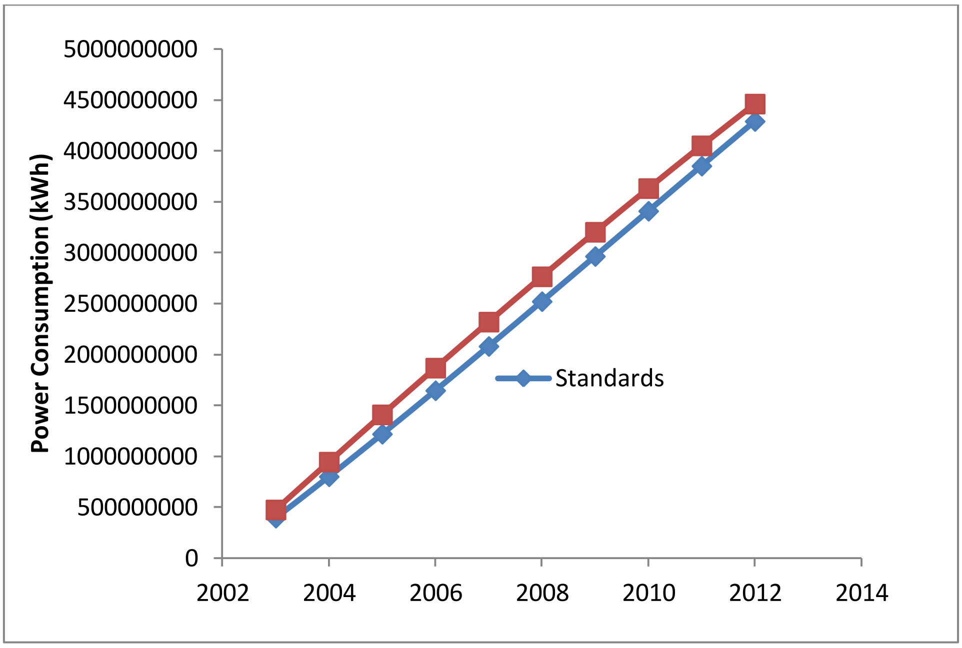

Figure 4.2 Household energy consumption with and without electric rice cooker standards

4.2.3 Economic impact of the standards

The calculation results of cost benefit analysis is tabulated in Table 4.9 and presented in Figure 4.2. The cost benefit analysis consists of the bill savings, annualized net savings, the net savings and cumulative present value of annualized net savings.

Table 4.9 The calculation result of the cost benefit analysis

Year	**Bill savings (RM)**	**Annualized net savings (RM)**	**Net saving (RM)**	**Present value of ANS (RM)**
2003	27,121,063	16,438,379	-44,096,831	16,438,379
2004	48,303,990	27,995,881	-20,435,985	26,164,375
2005	63,961,211	35,110,467	-2,089,086	30,666,842
2006	74,476,858	38,253,765	11,367,826	31,226,467
2007	80,308,346	37,932,650	20,391,991	28,938,637
2008	81,937,951	34,690,826	25,475,511	24,734,079
2009	79,884,394	29,110,404	27,146,933	19,397,491
2010	74,704,422	21,813,487	25,972,831	13,584,344
2011	66,994,387	13,463,751	22,559,383	7,836,026
2012	57,391,830	4,768,023	17,553,956	2,593,489

The programs will result of bill savings RM 655 million, annualized net savings is RM 259 million, net savings is RM 83 million and cumulative present value of annualized net savings is RM 201 million after 10 years of implementation. This is proved that introducing energy efficiency standards of electric rice cooker offers great benefits for the consumers and government.

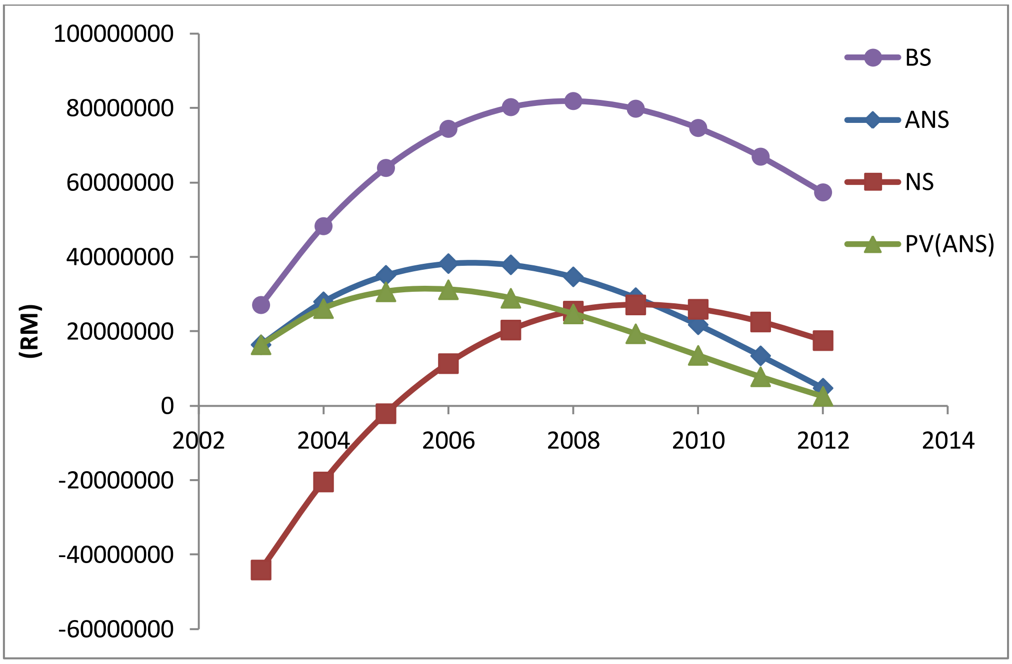

Figure 4.3 Cost benefit analysis of electric rice cooker

4.2.4 Environmental impacts of the standards

The environmental impact of the standards is a potential reduction of greenhouse gasses or other element that give negative impact to the environment. The common potential reductions include carbon dioxide CO_2, sulfur dioxide SO_2 and nitrogen oxide NO_x and carbon dioxide CO. The emission factors of all these gases have already been shown in the Table 4.3. The emissions production is a function of annual energy consumption and the emission factor of the particular fuel. Emissions production when burning diesel was calculated using Equation 3.18. The calculation results of mitigation emissions by standards are tabulated in Table 4.10 and illustrated in Figure 4.4.

Table 4.10 Calculation results of mitigation emissions by standards

Year	**CO_2 (kg)**	**SO_2 (ton)**	**NO_x (ton)**	**CO (ton)**
2003	44022	246309	117001	28516
2004	76682	433040	205800	49207
2005	99527	568528	270033	63170
2006	113938	659766	312847	71413
2007	121149	712587	336969	14861
2008	122264	731872	344784	74365
2009	118281	721782	338420	70703
2010	110119	686016	319844	64592
2011	98640	628087	290964	56698
2012	84686	551639	253749	47638

The results shows that the total emissions reduction are about 989,309 ton of carbon dioxide, 5,939,626 kg of sulfur dioxide, 2,790,412 kg of nitrogen oxide and 1601,162 kg of carbon monoxide after 10 years of implementation the standards to the electric rice cooker.

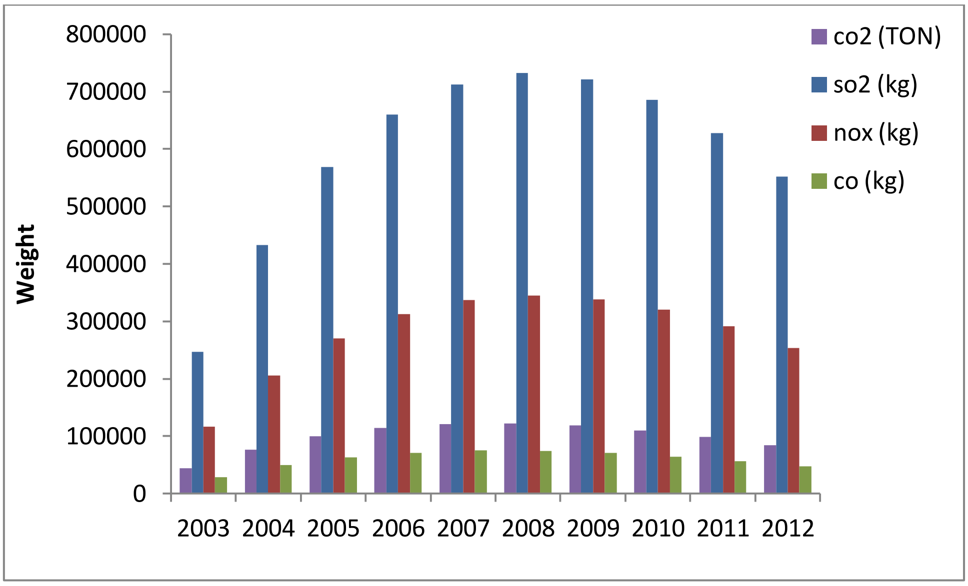

Figure 4.4 Annual mitigation of emissions due to electric rice cooker standards

4.3 Impact of the labels

Same as the impact of standards, the impact of the labels also are devided into three section, energy impacts, economic impact and environmental impact and will discussed in the following section.

4.3.1 Graded of electric rice cooker

The grades of the labels is divided to seven classes to make wider range of the appliances class. The wider range of class will give the consumer a wider range to choose and it will avoid a crowding of higher number category. The electric rice cooker grouped data with respect to energy consumption are shown in Table 4.10.

Table 4.11 Electric rice cooker graded data with respect to energy consumption data

Energy consumption	Letter grade	Number grade
≤92	A	1
93-98	B	2
99-104	C	3
105-110	D	4
111-116	E	5
117-122	F	6
123-128	G	7

4.3.2 Energy labels survey data

The data for the labels is obtained by conducting interview and the results are presented in the following section.

4.3.2.1 Respondents group

Interviews were conducted on 348 respondents in order to get input for energy labels. Out of the 348 respondents, 197 or 56.61 % are Malay, 86 or 24.71 % are Chinese, 54 or 15.52 % are Indian and 11 respondents or 3.16 % are from other races. The number and percentage of the respondents interviewed is presented in Figure 4.5.

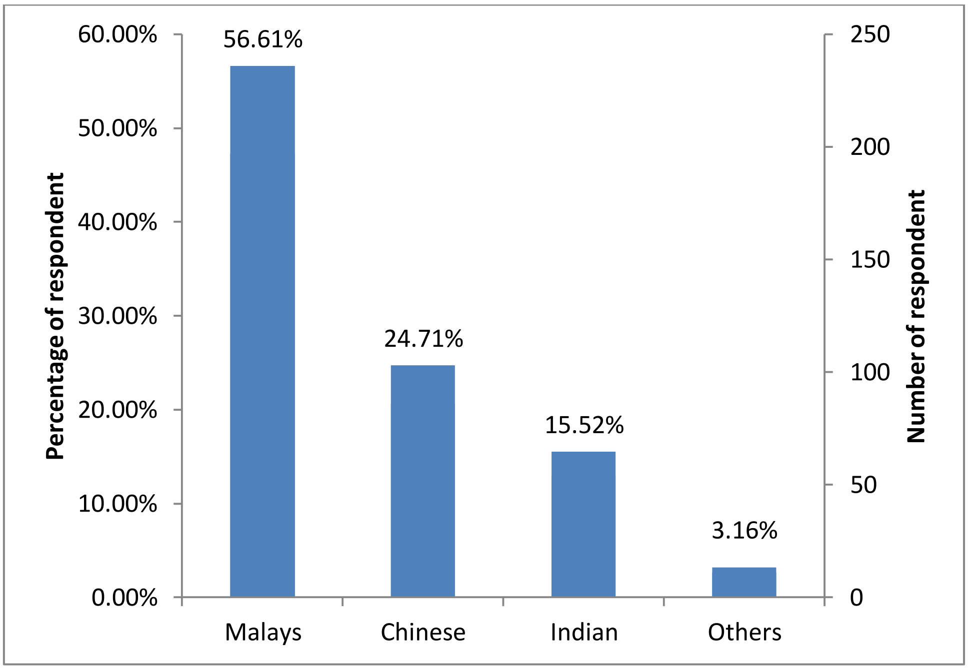

Figure 4.5 Respondent group

From the overall of the respondents, 246 of respondent live in uptown area and 102 are live in downtown area. Figure 4.6 shows the tabulated data for different living area which is uptown and downtown by the races.

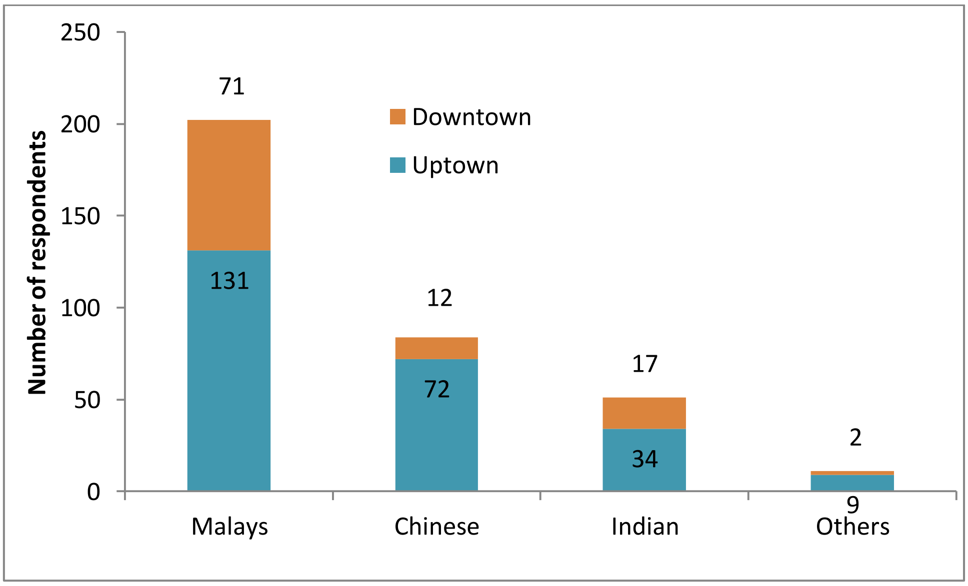

Figure 4.6 Respondent living areas

4.3.2.2 Labels selected by respondent based on frequency

From those three types of labels, most of respondents have selected labels type B which are about 185 of respondent or 53.16 %. Label type C were chosen by 88 of respondents or 25.29 %. The least favourite is label type A with 75 or 21.55 % of the total respondents. The number and percentage of the selected energy labels is shown in Figure 4.7.

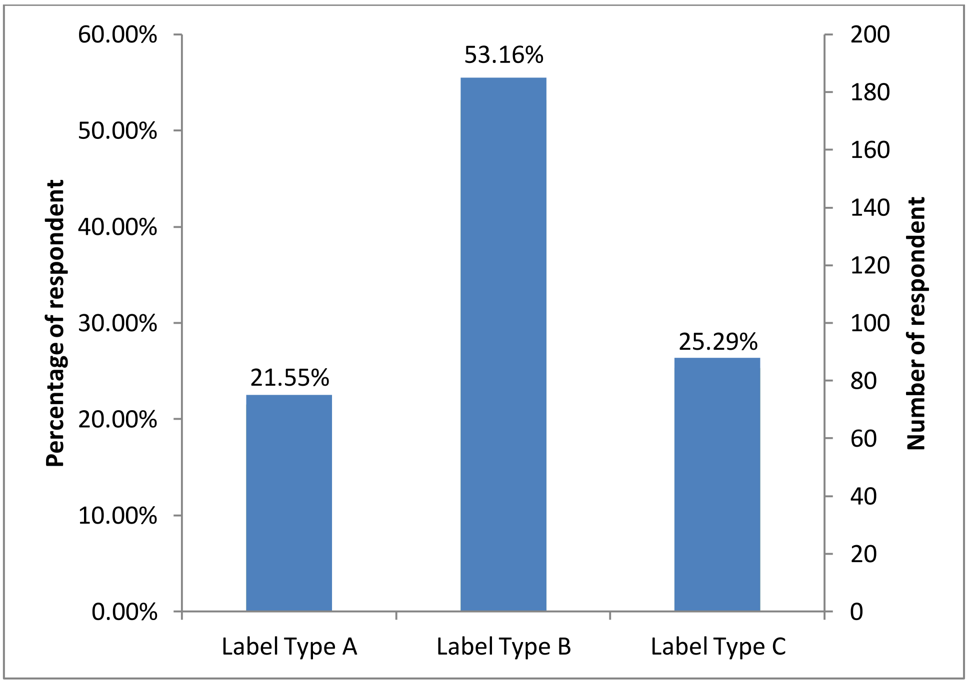

Figure 4.7 Labels selected by respondent based on frequency

4.3.2.3 Labels selected based on respondent understanding

After the labels were selected, it is necessary to ensure that the respondents understood of what they had chosen. The study found that only 261 out of the 348 respondents understood the labels which they had selected. Out of the 261 respondents, 165 or 63.22 % had selected the most efficient grade for labels type B correctly, 57 or 21.84 % of respondents selected the most efficient grade for labels type C correctly and only 39 or 14.94 % selected the most efficient grade for labels type B correctly. The number and percentages energy labels selected based on the respondent understanding are presented in Table 4.8.

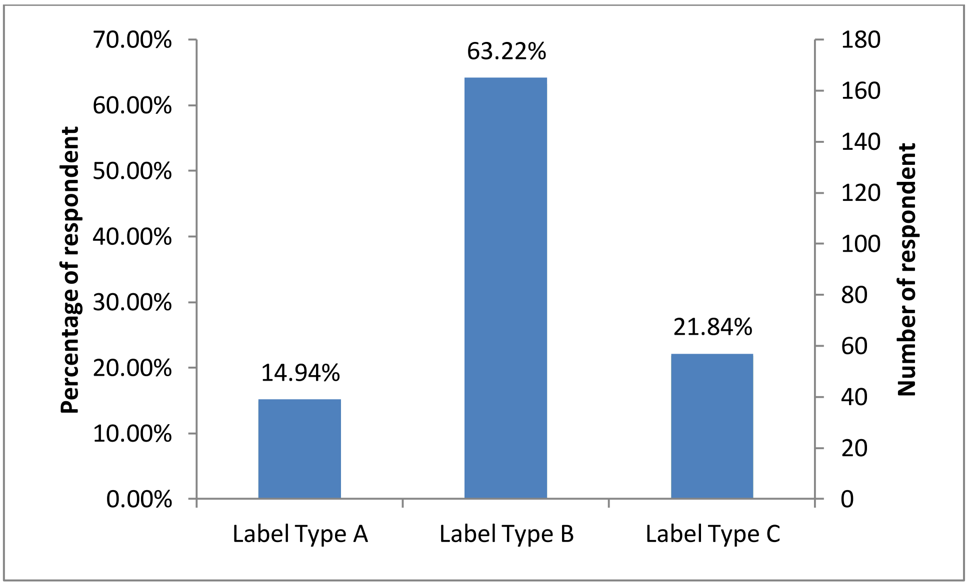

Figure 4.8 Labels selected based on respondent understanding

For labels type A, only 39 out of 75 or 52 % of the respondent who selected the labels understood the given information. For labels type B, 165 out of 185 or 89.19 % of the respondents understood the labels. For label C, only 57 out of 88 or 64.77 % of the respondents understood the labels. The number and percentage of respondents understanding for each energy label are presented in Figure 4.9.

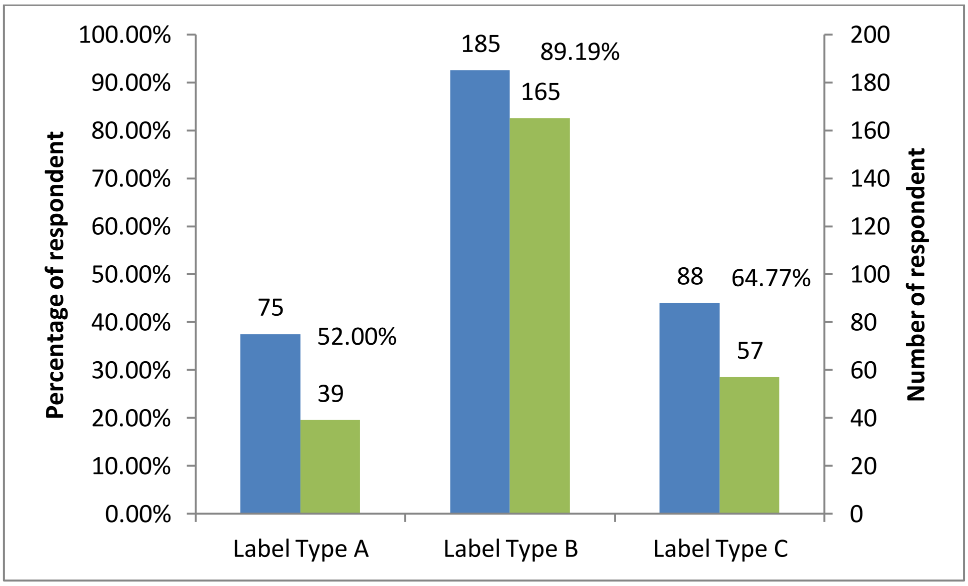

Figure 4.9 Respondent understanding for each labels

4.3.2.4 Respondent expectation from electric rice cooker at the time of purchase

Unlike the other appliances, energy efficiency in electric rice cookers is not priority and may not even be one of the most important factors when consumers choose the models. According from the respondents interview, the price of the appliances with 17.56 % is the most important factor followed by size with 13.01 %, brand with 12.36 %, ease of operation with 10.62 %, time required to cook with 8.67 % and energy efficiency with only 8.31 %. The data is illustrated in Figure 4.10. We can see that consumer choose the product based on the price compared to efficient product. So, by introducing this program, the consumers will pay higher prices for the appliances but get payable by lower electricity bills because of energy savings.

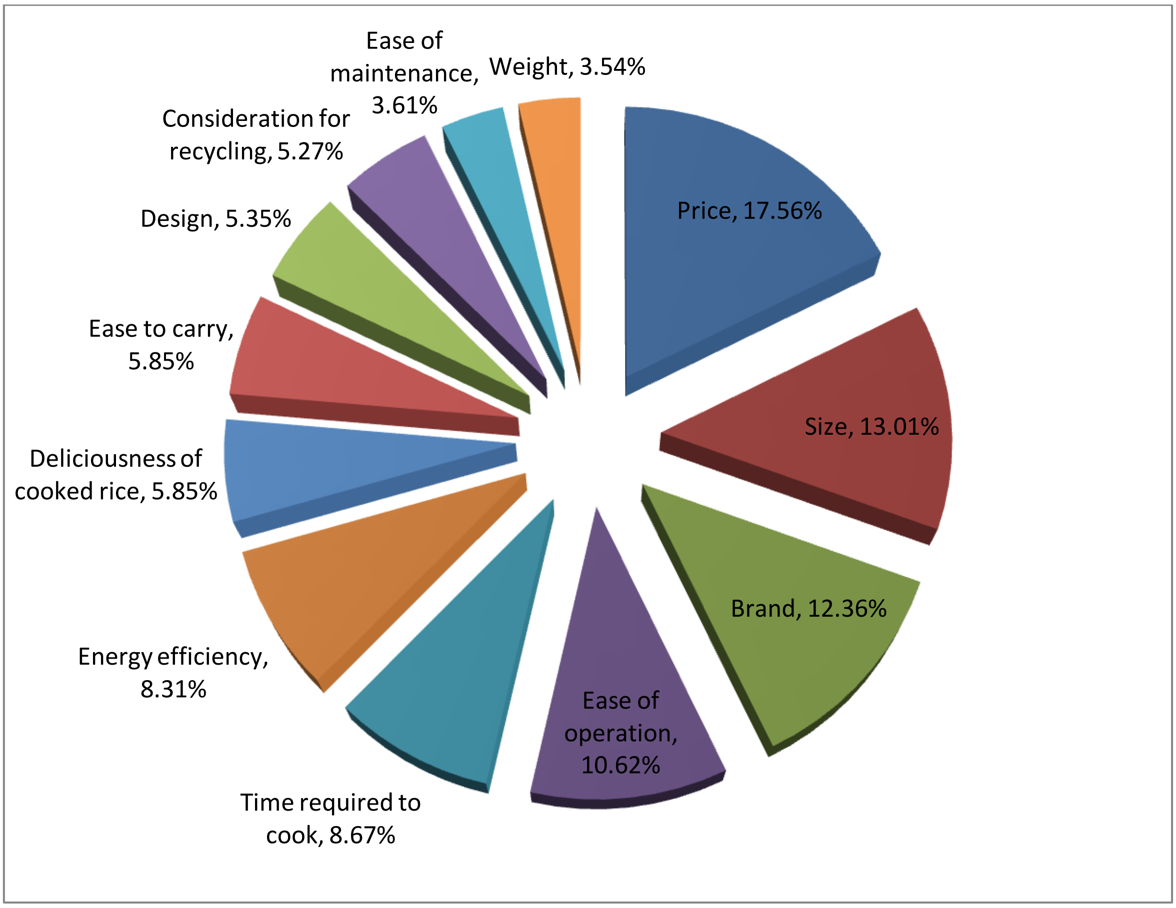

Figure 4.10 Respondent expectations at the time of purchase

4.3.3 Data collection and assessment

The technical data necessary for this study are the electricity data, electric rice cooker ownership data, the percentage of electricity generation based on fuel type and fossil fuel emissions for a unit electricity generation. These data are tabulated in Table 4.1, Table 4.2 and Table 4.3 respectively. Predicted electricity consumption, number of electric rice cooker and percentage fuel mix for electricity generation are tabulated in Table 4.4 using Equation 4.1, 4.2, 4.3, 4.4, 4.5 and 4.6 respectively.

Energy savings is calculated based on the difference between the energy consumption with and without labels. To calculate electric rice cooker impact, some input data have been identified which are presented in Table 4.12.

Table 4.12 Electric rice cooker input data

Description	Values
Baseline energy consumption	128 kWh/year
Labels energy consumption at grade A	92 kWh/year
Initial unit savings	36 kWh/year
Standards efficiency improvement	28.13 %
Increment cost	RM 0.8807 / kWh
Initial incremental cost	RM 31.7064 / year
Capital recovery factor	0.15
Cost of conserved energy	0.1352
Current electricity price	RM 0.3354 / kWh
Annual efficiency improvement	1.08 %
Year standards enacted	2003

4.3.4 Energy impact of the labels

Labels affect the shipments because all electric rice cookers are sold in year 2003 where the labels enacted. This is similar to the proposed standard enactment. The effective period of the labels depends on the standards which is shorter than 2/3 of the lifetime of electric rice cooker. As the results, the shipment survival factor is 100 %. The scenario is the nominal which is correlated to labels grade A. The potential of energy savings by implementing energy labels for electric rice cooker is presented in Table 4.13 and illustrated in Figure 4.11.

Table 4.13 Energy savings by the labels

Year	Shipment	Applicable Stock	Energy Savings (kWh)
2003	4278405	4278405	154022564
2004	4409628	8688033	312769176
2005	4543956	13231989	476351604
2006	4681389	17913378	644881611
2007	4821926	22735305	818470964
2008	4965568	27700873	997231428
2009	5112315	32813188	1181274769
2010	5262166	38075354	1370712753
2011	5415211	43490476	1565657144
2012	5571182	49061659	1766219710

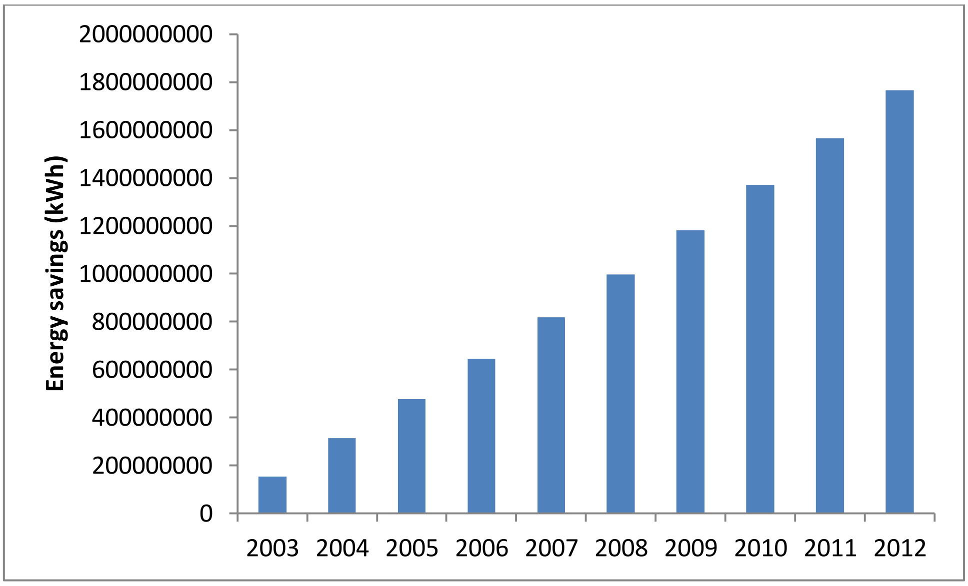

Figure 4.11 Energy savings by the labels

Table 4.14 Household energy consumption with and without labels

year	Household electricity consumption with standards (GWh)	Household electricity consumption with standards and labels (GWh)	Energy Savings (GWh)
2003	12881	12727	154
2004	13787	13475	313
2005	14745	14269	476
2006	15754	15109	645
2007	16812	15993	818
2008	17918	16920	997
2009	19070	17889	1181
2010	20267	18896	1371
2011	21507	19941	1566
2012	22788	21022	1766

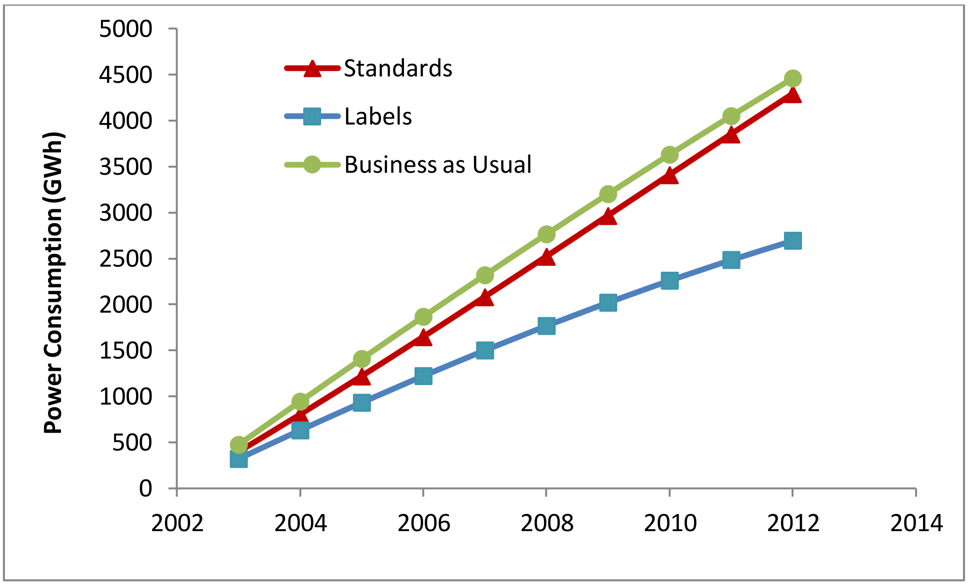

Figure 4.12 Household energy consumption with and without electric rice cooker standards and labels

4.3.5 Economic impact of the labels

Table 4.15 Calculation results of economical impact of the labels

Year	Bill savings (RM)	Annualized net savings (RM)	Net savings (RM)	Present value of ANS (RM)
2003	51,659,168	34,702,567	-61,384,837	34,702,567
2004	104,902,782	70,469,502	-11,608,413	65,859,348
2005	159,768,328	107,325,986	39,707,914	93,742,673
2006	216,293,292	145,297,201	92,601,630	118,605,797
2007	274,515,161	184,408,329	147,110,220	140,684,231
2008	334,471,421	224,684,551	203,271,171	160,196,980
2009	396,199,558	266,151,049	261,121,970	177,347,682
2010	459,737,057	308,833,006	320,700,102	192,325,675
2011	525,121,406	352,755,602	382,043,053	205,306,972
2012	592,390,091	397,944,019	445,188,310	216,455,180

The economical impact of the labels is calculated using the standards as a baseline with the current average electricity price RM 0.3355/ kWh. The calculation results are total bill savings, total annualized net dollar savings, total net savings and cumulative present value with discount rate 7 %. The calculation results is illustrated in Figure 4.13

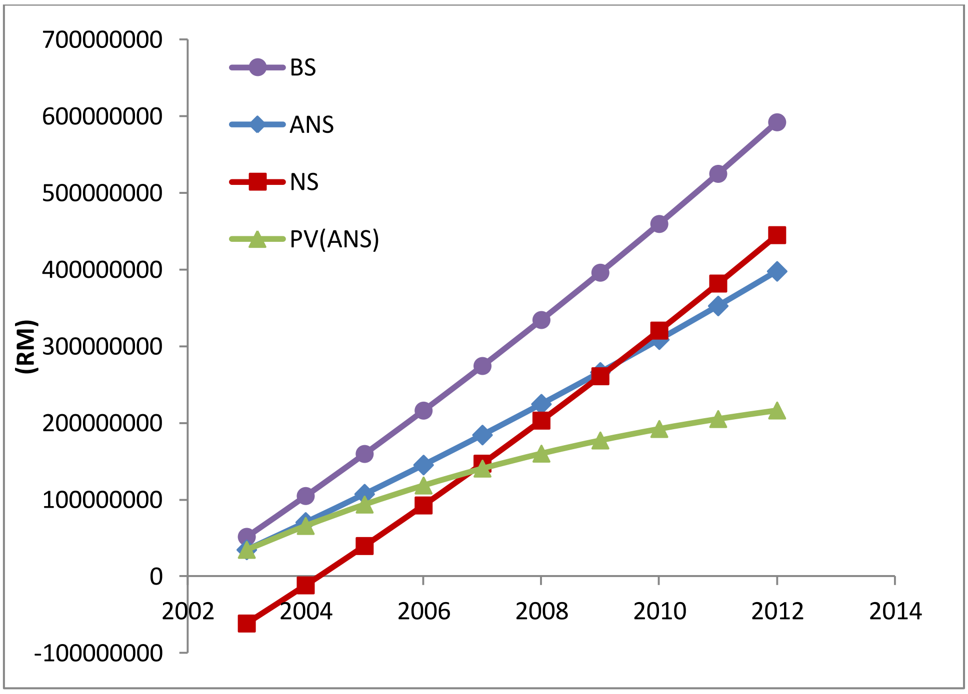

Figure 4.13 Economic impacts by labels

Based on the calculation result, the total bill savings is about RM 3,115 million, the annualized net dollar savings with RM 2,092 million, net savings with RM 1,818 million and cumulative present value with RM 1,405 million.

4.3.6 Environment impact of the labels

Similar to the standards, the environmental impacts of energy label are the potential reduction of carbon dioxide, sulfur dioxide, nitrogen oxide and carbon monoxide. The environmental impact is also a function of energy savings. The environmental impact of the labels is tabulated in Table 4.16 and illustrated in Figure 4.14.

Table 4.16 Calculation results of the environmental impact by labels

Year	**CO_2 (kg)**	**SO_2 (ton)**	**NO_x (ton)**	**CO (ton)**
2003	83851	469160	222858	54316
2004	166497	940247	446847	106842
2005	248608	1420123	674514	157791
2006	330896	1916072	908561	207394
2007	414120	2435811	1151851	255895
2008	499082	2987506	1407413	303557
2009	586635	3579794	1678450	350661
2010	677680	4221795	1968344	397507
2011	773172	4923131	2280661	444412
2012	874116	5693939	2619163	491716

The total of carbon dioxide reduction will be about 4,654,659 tonnes. The total of sulfur dioxide is about 28,587,578 kg, nitrogen oxide 13,358,660 kg while the total of carbon monoxide reduction about 2,770,091 kg.

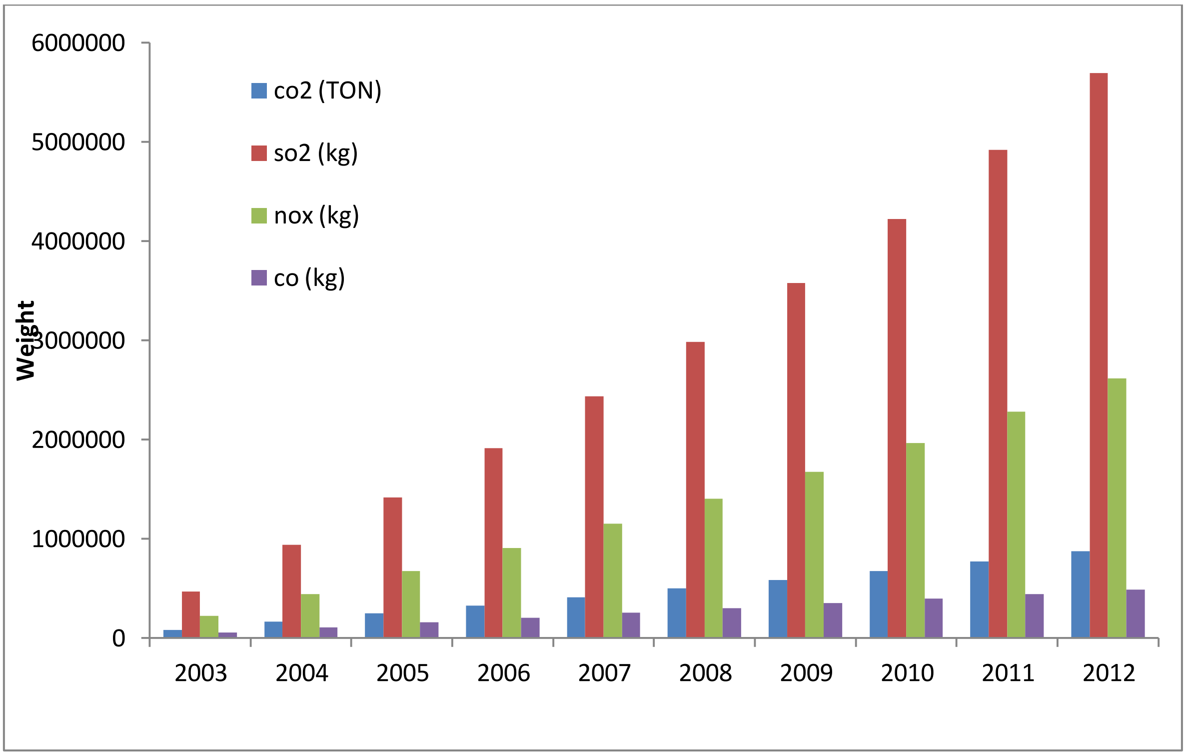

Figure 4.14 Environmental impacts by labels

4.4 Impact of the standards and labels in combination

The combination of the standards and labels energy impact is a summation of potential energy savings by the programs. The comparison of the energy consumption with and without electric rice cooker standards and labels as well as its potential savings is tabulated in Table 4.17.

Table 4.17 Household energy consumption with and without standards and labels

Year	Household electricity consumption (GWh)	Household electricity consumption with standards and labels (GWh)	Energy Savings (GWh)
2003	12962	12727	235
2004	13931	13475	457
2005	14936	14269	667
2006	15976	15109	867
2007	17051	15993	1058
2008	18162	16920	1242
2009	19308	17889	1419
2010	20490	18896	1593
2011	21707	19941	1765
2012	22959	21022	1937

From table 4.17 shown that implementation of energy efficiency standards and labels for electric rice cooker in 2003 will save about 11,241 GWh at the end of the year 2012.

The combination of the standards and labels economical impact is a summation of bill savings, annualized dollar savings, net savings and cumulative present value of the standards and labels for each year. The calculation results of potential bill savings, annualized dollar savings, net savings and cumulative present value is given in Table 4.18 and illustrated in Figure 4.15.

Table 4.18 Calculation result of economic impact by standards and labels

Year	Bill Savings (RM)	Annualized Net Savings (RM)	Net Savings (RM)	Present Value (Annualized Net Savings) (RM)
2003	78,780,231	51,140,946	105,481,668	5,1140,946
2004	153,216,771	98,465,383	-32,044,398	92,023,722
2005	223,729,538	142,436,453	37,618,829	124,409,514
2006	290,770,150	183,550,966	103,969,456	149,832,264
2007	354,823,507	222,340,979	167,502,211	169,622,868
2008	416,409,372	259,375,377	228,746,682	184,931,059
2009	476,083,952	259,261,453	288,268,903	196,745,173
2010	534,441,479	330,646,493	346,672,933	205,910,018
2011	592,115,793	366,219,353	404,602,436	213,142,998
2012	649,781,920	402,712,042	462,742,266	219,048,668

The total bill savings is about RM 3,770 million, the annualized net dollar savings is RM 2,352 million, the net savings is about RM 1,902 and the cumulative present value of annualized net savings with RM 1,606 when the standards and labels is implemented to the electric rice cooker.

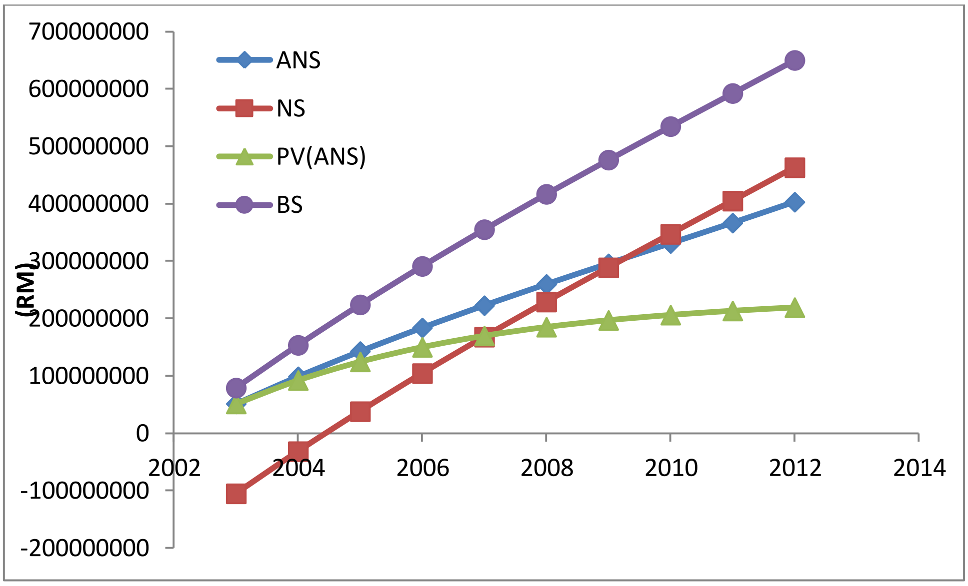

Figure 4.15 Calculation result of economic impact by standards and labels

The environmental impact of the energy efficiency standards and energy labels in combination is a summation of potential reduction of carbon dioxide, sulfur dioxide, nitrogen oxide and carbon monoxide of these programs for each year. The potential carbon dioxide, sulfur dioxide, nitrogen oxide and carbon monoxide reduction is given in Table 4.19 and illustrated in figure 4.16.

Table 4.19 Calculation results of the environmental impact by standard and labels

Year	**Carbon Dioxide (kg)**	**Sulfur Dioxide (ton)**	**Nitrogen Oxide (ton)**	**Carbon Monoxide (ton)**
2003	127873	715470	339859	82832
2004	243179	1373286	652647	156049
2005	348135	1988651	944547	220961
2006	444835	2575839	1221408	278806
2007	535269	3148397	1488820	330756
2008	621346	3719377	1752197	377922
2009	704917	4301576	2016870	421364
2010	787799	4907811	2288187	462099
2011	871812	5551218	2571626	501109
2012	958802	6245578	2872912	539354

The total carbon dioxide reduction is about 5,643,967 tones. The total sulfur dioxide reduction in the same period is about 34,527,204 kg and total nitrogen oxide reduction is about 16,149,072 kg, while total carbon monoxide reductions is about 3,371,253 kg.

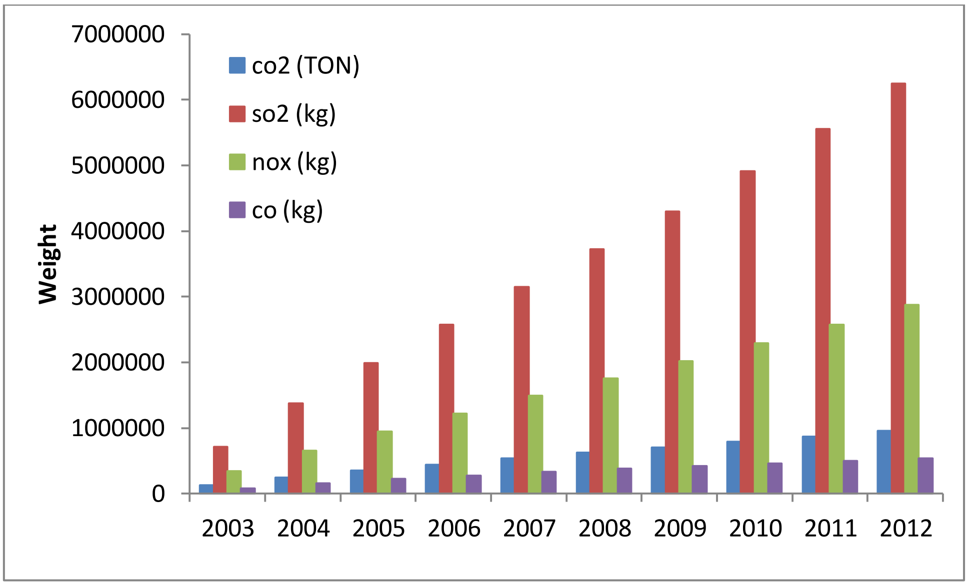

Figure 4.16 Calculation result of environmental impact by standards and labels

The summation of overall potential savings from energy efficiency standards and labels are presented in Table 4.20.

Table 4.20 Overall potential savings from energy efficiency standards and labels

Items	**Standards**	**Labels**	**Savings**
ES (GWh)	1953	9287	11240
BS (RM)	655,094,450	3,115,058,264	3,770,152,714
CO_2 (Ton)	989,309	4,654,659	5,643,967
SO_2 (kg)	5,939,626	28,587,578	34,527,204
NO_x (kg)	2,790,412	13,358,660	16,149,072
CO (kg)	601,162	2,770,091	3,371,253

Energy efficiency standards and labels usually come together. Standards are more towards technical setting of energy efficiency while labels provided a guideline to the consumers to select more efficient when purchase. Implementing the energy efficiency standards and labels for household electric rice cooker offer many benefit for consumers, government as well as the environment. The consumers might pay higher prices for electric rice cooker by adopting technological advances for the improvement of the product to meet the efficient product, but with this improvement, electricity bill reduce. As reducing the electricity consumption, more efficient product will contribute to the reduction of greenhouse gas emissions.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This study is concerned with an energy saving, economic and environmental analysis of electric rice cooker when implementing the standards and labels program in Malaysia. With the combination of standards and labels program to electric rice cooker, the results found that the energy consumption will save about 11,240 GWh for 10 years from 2003 to 2012. Bill savings with RM 3770 million. Beside that the air pollution will reduce about 5,643.967 ton of carbon dioxide, 34,527,204 kg of sulfur dioxide, 16,149,072 kg of nitrogen oxide and 3,371,253 kg of carbon monoxide.

Energy efficiency standards and labels can be the most effective long term energy efficiency policy any government can implement. Energy performance improvements in consumer products are an essential element in any government's portfolio of energy efficiency policies and climate change mitigation programs. For greatest effectiveness, a government should develop balanced programs, both voluntary and regulatory, that remove cost ineffective, energy wasting products from the marketplace and stimulate the development of cost effective, energy efficient technology.

Once the standard is established, manufacturers do the best efforts for the improvement of energy efficiency performance by the competition each other because they recognize that the products with higher efficiency performance are accepted by the consumers. By providing relevant information to consumers, this will encourage them to select energy efficient products. Popularization of energy efficient products will act as incentives for development of further energy efficient products.

In summary, the study showed that improving household electrical appliances efficiency is one of the most effective strategies to reduce electricity growth in this country in the future. Apart from consumers, standards and labels also provide great benefits to the national economy, natural environment and local manufacture. This is the main reason for the policy makers and energy planner to consider the programs as the top priority to gain an optimum energy, economical and environmental impacts which have been discussed early.

5.2 Recommendation

The findings of this study proved the viability of all these methods. However, it is recommended that future researches should continue for further studies of other energy saving measures for household appliances.

Malaysia needs to establish a framework to continually collect the data on household energy characteristics. It is crucial to have time-series data of the household appliance saturation levels, appliance unit energy consumption, lifetimes of appliance and appliance load shapes in order to obtain an exact figure of the energy consumption.

As consumers are crucial to the success of the labeling program, sustained information campaign is needed and the label's design should incorporate consumer feedback simultaneously and once standards and labels have been implemented, it is necessary to evaluate their effectiveness. The evaluation is important to identify the areas of weakness in the program design and implementation so that these can be strengthened.

Implementation of energy efficiency standards and labels is the responsibility of Energy Commission, however cooperation and coordination between relevant institutions such as SIRIM and PTM should be reinforced to increase the synergies between test procedure, energy efficiency standards and labels programs. For example, the development of new standards should be co-ordinate with the establishment of energy label to ensure a dynamic market transformation effect.

Finally, this study is just a starting point towards the implementation of energy efficiency standards and labels for household electrical appliances in Malaysia. It is hoped that the thesis can be used as a guideline for standards and labels implementation in this country and can encourage new researchers to be involved in this field.

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Appendix A

Questionnaires and survey data

A.1. Questionnaire

RICE COOKER SURVEY ON THE MALAYSIAN HOUSEHOLD

A. RESPONDENT DETAILS

Gender:

- ❑ Male
- ❑ Female

Age Group:

- ❑ 15-20
- ❑ 21-30
- ❑ 31-40
- ❑ 41-50
- ❑ 51 and above

Living Area:

- ❑ Uptown
- ❑ Downtown

Job:

- ❑ Student
- ❑ Private Sector
- ❑ Government Sector
- ❑ Own Business
- ❑ Others

Race:

- ❑ Malay
- ❑ Chinese
- ❑ Indian
- ❑ Others

B. RICE COOKER DATA

Brand: ___________________________

Made/Manufactured in: _________________________

Year of manufacture: __________________________

Capacity:

- ❑ 0.6L (3 cups)

- ☐ 1L (5.5 cups)
- ☐ 1.2L (6 cups)
- ☐ 1.8L (10 cups)

C. QUESTIONS

a. How many rice cookers in your house?________________

b. When did you buy? (year) ________________

c. How many times used a day? ________________

d. Capacity of cooking every day?

- ☐ 0.6L (3 cups)
- ☐ 1L (5.5 cups)
- ☐ 1.2L (6 cups)
- ☐ 1.8L (10 cups)

e. When buy rice cooker, what do you look for guideline?

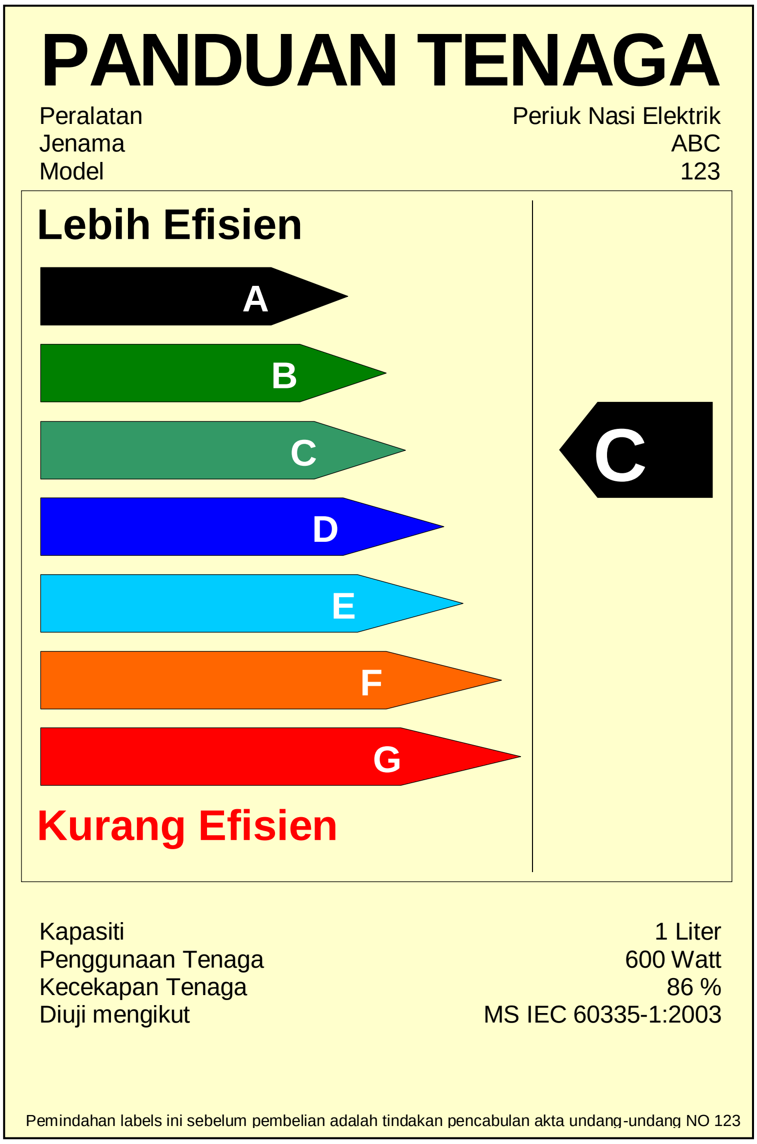
- ☐ Price
- ☐ Size
- ☐ Brand
- ☐ Time required to cook
- ☐ Energy efficiency
- ☐ Design
- ☐ Weight
- ☐ Ease of operation
- ☐ Ease to carry
- ☐ Ease of maintenance
- ☐ Deliciousness of cooked rice
- ☐ Consideration for recycling

f. Have you ever heard about standard and label program?

- ☐ Yes
- ☐ No

LABELS

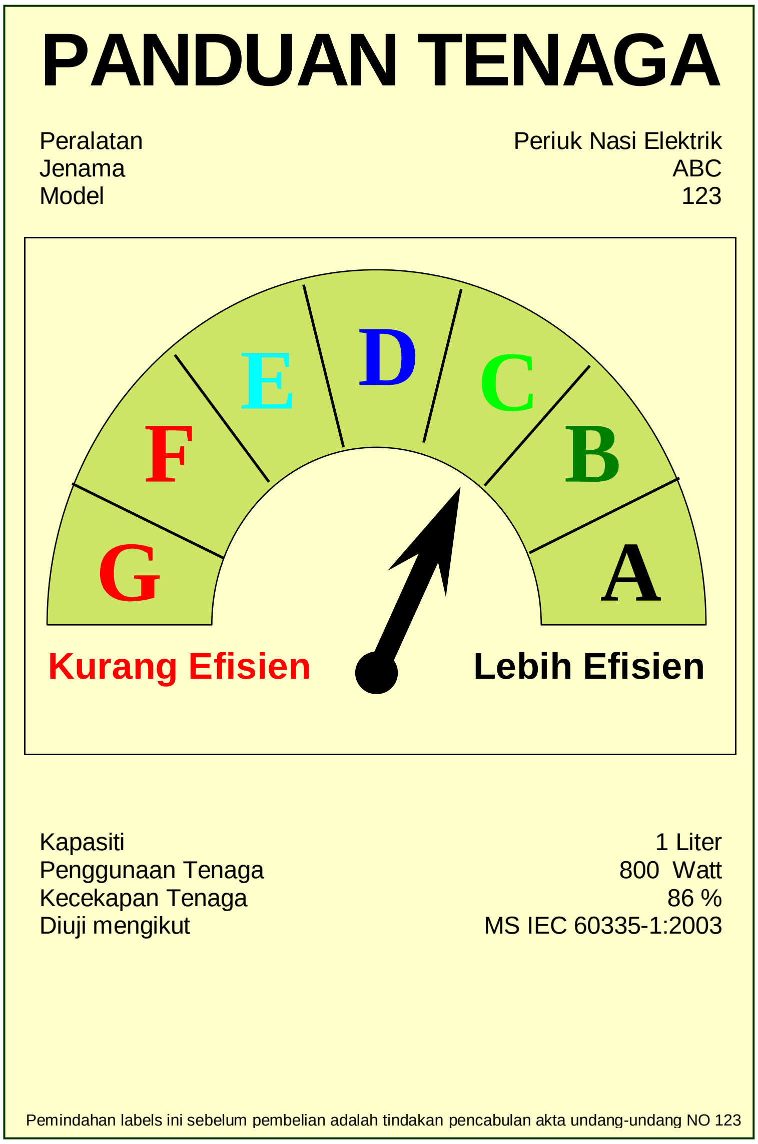
These labels are will be used for energy guide for electrical appliances in Malaysia.



Label type A


1
2
3
4
5
6
7
SEMAKIN
BANYAK BINTANG
SEMAKIN EFISIEN
PANDUAN TENAGA
Peralatan
Periuk Nasi Elektrik
Jenama
ABC
Model
123
Kecekapan tenaga untuk peralatan
ini ialah pada peringkat:
5
Kapasiti
1 Liter
Penggunaan Tenaga
800 Watt
Kecekapan Tenaga
86 %
Diuji mengikut
MS IEC 60335-1:2003
Pemindahan labels ini sebelum pembelian adalah tindakan pencabulan akta undang-undang NO 123

Label type B



Label type C

g. Which labels is easier one to understand and you recommended to be used in Malaysia?

- ☐ Label type A
- ☐ Label type B
- ☐ Label type C

h. From these three labels, which one is the most efficient?

- ☐ Label type A
- ☐ Label type B
- ☐ Label type C

☐ Right

☐ Wrong

i. What are the improvements for the labels in order to make easier understanding for consumer?

Comment/Suggestion:

A.2. Household survey data

No.	Brand	Year Manufac tured	Max Cooking Capacity (L)	Power (W)	Usage hour (hr/day)	Energy consump tion (Wh/day)	Energy consu mption (kWh/ year)
1	PANASONIC	2008	0.6	200.00	0.50	100.00	36.50
2	ADVANCE	2011	1.0	450.00	1.25	562.50	205.31
3	ADVANCE	2011	1.0	450.00	1.25	562.50	205.31
4	AMWAY	2000	1.2	485.00	1.00	485.00	177.03
5	AMWAY	2000	1.2	485.00	1.00	485.00	177.03
6	AMWAY	2000	1.2	485.00	1.00	485.00	177.03
7	ANSHIN	2010	1.8	365.00	1.00	365.00	133.23
8	BLAZE	2009	1.8	750.00	0.50	375.00	136.88
9	BLAZE	2009	1.8	750.00	0.50	375.00	136.88
10	BLAZE	2009	1.8	750.00	0.50	375.00	136.88
11	BRIGHTWE LL	2011	1.8	700.00	1.00	700.00	255.50
12	CORNELL	2009	1.0	500.00	0.50	250.00	91.25
13	CORNELL	2009	1.0	500.00	0.50	250.00	91.25
14	CORNELL	2009	1.0	500.00	0.50	250.00	91.25
15	CORNELL	2010	1.8	800.00	0.50	400.00	146.00
16	CORNELL	2010	1.8	800.00	0.50	400.00	146.00
17	CORNELL	2010	1.8	800.00	0.50	400.00	146.00
18	ELBA	2007	1.2	500.00	0.50	250.00	91.25
19	ELBA	2007	1.2	500.00	0.50	250.00	91.25
20	ELBA	2007	1.2	500.00	0.50	250.00	91.25
21	ELBA	2009	1.2	500.00	0.75	375.00	136.88
22	ELBA	2009	1.2	500.00	0.75	375.00	136.88
23	ELBA	2009	1.2	500.00	0.75	375.00	136.88
24	ELBA	2009	1.2	500.00	1.00	500.00	182.50
25	ELBA	2009	1.2	500.00	1.00	500.00	182.50
26	ELBA	1997	1.2	500.00	1.00	500.00	182.50
27	ELBA	2010	1.2	500.00	1.00	500.00	182.50
28	ELBA	2009	1.2	500.00	1.00	500.00	182.50
29	ELBA	2009	1.2	500.00	1.00	500.00	182.50
30	ELBA	1997	1.2	500.00	1.00	500.00	182.50
31	ELBA	2010	1.2	500.00	1.00	500.00	182.50
32	ELBA	2009	1.2	500.00	1.00	500.00	182.50
33	ELBA	2009	1.2	500.00	1.00	500.00	182.50
34	ELBA	1997	1.2	500.00	1.00	500.00	182.50
35	ELBA	2010	1.2	500.00	1.00	500.00	182.50
36	ELBA	2002	1.8	700.00	0.75	525.00	191.63
37	ELBA	2002	1.8	700.00	0.75	525.00	191.63
38	ELBA	2002	1.8	700.00	0.75	525.00	191.63
39	ELBA	2008	1.8	700.00	1.00	700.00	255.50
40	ELBA	2010	1.8	700.00	1.00	700.00	255.50
41	ELBA	2010	1.8	700.00	1.00	700.00	255.50
42	ELBA	2008	1.8	700.00	1.00	700.00	255.50

43	ELBA	2010	1.8	700.00	1.00	700.00	255.50
44	ELBA	2010	1.8	700.00	1.00	700.00	255.50
45	ELBA	2010	1.8	700.00	1.00	700.00	255.50
46	ELBA	2010	1.8	700.00	1.00	700.00	255.50
47	FABER	2011	1.0	400.00	0.50	200.00	73.00
48	FABER	2011	1.0	400.00	0.50	200.00	73.00
49	FABER	2011	1.0	400.00	0.50	200.00	73.00
50	FABER	2011	1.0	400.00	0.50	200.00	73.00
51	FABER	2011	1.0	400.00	0.50	200.00	73.00
52	FABER	2011	1.0	400.00	0.50	200.00	73.00
53	FABER	2010	1.8	700.00	0.50	350.00	127.75
54	FABER	2010	1.8	700.00	0.50	350.00	127.75
55	FABER	2010	1.8	700.00	0.50	350.00	127.75
56	FABER	2010	1.8	700.00	0.50	350.00	127.75
57	FABER	2010	1.8	700.00	0.50	350.00	127.75
58	FABER	2010	1.8	700.00	0.50	350.00	127.75
59	KHIND	2010	0.6	350.00	0.50	175.00	63.88
60	KHIND	2010	0.6	350.00	0.50	175.00	63.88
61	KHIND	2010	0.6	350.00	0.50	175.00	63.88
62	KHIND	2010	1.2	365.00	0.50	182.50	66.61
63	KHIND	2010	1.2	365.00	0.50	182.50	66.61
64	KHIND	2010	1.2	365.00	0.50	182.50	66.61
65	KHIND	2010	1.2	365.00	0.50	182.50	66.61
66	KHIND	2010	1.2	365.00	0.50	182.50	66.61
67	KHIND	2010	1.2	365.00	0.50	182.50	66.61
68	KHIND	1997	0.6	245.00	1.00	245.00	89.43
69	KHIND	1997	0.6	245.00	1.00	245.00	89.43
70	KHIND	1997	0.6	245.00	1.00	245.00	89.43
71	KHIND	2011	0.6	350.00	1.00	350.00	127.75
72	KHIND	2008	0.6	350.00	1.00	350.00	127.75
73	KHIND	2011	0.6	350.00	1.00	350.00	127.75
74	KHIND	2008	0.6	350.00	1.00	350.00	127.75
75	KHIND	2011	0.6	350.00	1.00	350.00	127.75
76	KHIND	2008	0.6	350.00	1.00	350.00	127.75
77	KHIND	2008	1.2	365.00	1.00	365.00	133.23
78	KHIND	2011	1.2	365.00	1.00	365.00	133.23
79	KHIND	2008	1.2	365.00	1.00	365.00	133.23
80	KHIND	2008	1.2	365.00	1.00	365.00	133.23
81	KHIND	2011	1.2	365.00	1.00	365.00	133.23
82	KHIND	2008	1.2	365.00	1.00	365.00	133.23
83	KHIND	2008	1.2	365.00	1.00	365.00	133.23
84	KHIND	2011	1.2	365.00	1.00	365.00	133.23
85	KHIND	2008	1.2	365.00	1.00	365.00	133.23
86	KHIND	2004	1.8	480.00	1.00	480.00	175.20
87	KHIND	2004	1.8	480.00	1.00	480.00	175.20
88	KHIND	2004	1.8	480.00	1.00	480.00	175.20
89	KHIND	2008	1.2	365.00	1.50	547.50	199.84
90	KHIND	2006	1.2	365.00	1.50	547.50	199.84

91	MASTER CHEF	2009	1.8	800.00	1.00	800.00	292.00
92	MASTER CHEF	2009	1.8	800.00	1.00	800.00	292.00
93	NATIONAL	2002	0.6	200.00	0.50	100.00	36.50
94	NATIONAL	2002	0.6	200.00	0.50	100.00	36.50
95	NATIONAL	2002	0.6	200.00	0.50	100.00	36.50
96	NATIONAL	2001	0.6	200.00	1.00	200.00	73.00
97	NATIONAL	2001	0.6	200.00	1.00	200.00	73.00
98	NATIONAL	2001	0.6	200.00	1.00	200.00	73.00
99	NATIONAL	2008	1.2	450.00	0.50	225.00	82.13
100	NATIONAL	1989	1.2	450.00	0.50	225.00	82.13
101	NATIONAL	2000	1.2	450.00	0.50	225.00	82.13
102	NATIONAL	2010	1.2	450.00	0.50	225.00	82.13
103	NATIONAL	2008	1.2	450.00	0.50	225.00	82.13
104	NATIONAL	1989	1.2	450.00	0.50	225.00	82.13
105	NATIONAL	2000	1.2	450.00	0.50	225.00	82.13
106	NATIONAL	2010	1.2	450.00	0.50	225.00	82.13
107	NATIONAL	2008	1.2	450.00	0.50	225.00	82.13
108	NATIONAL	1989	1.2	450.00	0.50	225.00	82.13
109	NATIONAL	2000	1.2	450.00	0.50	225.00	82.13
110	NATIONAL	2010	1.2	450.00	0.50	225.00	82.13
111	NATIONAL	2005	1.0	310.00	1.00	310.00	113.15
112	NATIONAL	1999	1.0	310.00	1.00	310.00	113.15
113	NATIONAL	1997	1.0	310.00	1.00	310.00	113.15
114	NATIONAL	2009	1.0	310.00	1.00	310.00	113.15
115	NATIONAL	2005	1.0	310.00	1.00	310.00	113.15
116	NATIONAL	1999	1.0	310.00	1.00	310.00	113.15
117	NATIONAL	1997	1.0	310.00	1.00	310.00	113.15
118	NATIONAL	2009	1.0	310.00	1.00	310.00	113.15
119	NATIONAL	2005	1.0	310.00	1.00	310.00	113.15
120	NATIONAL	1999	1.0	310.00	1.00	310.00	113.15
121	NATIONAL	1997	1.0	310.00	1.00	310.00	113.15
122	NATIONAL	2009	1.0	310.00	1.00	310.00	113.15
123	NATIONAL	2000	1.2	450.00	1.00	450.00	164.25
124	NATIONAL	2000	1.2	450.00	1.00	450.00	164.25
125	NATIONAL	2000	1.2	450.00	1.00	450.00	164.25
126	NATIONAL	1990	1.8	650.00	1.00	650.00	237.25
127	NATIONAL	2010	1.8	650.00	1.00	650.00	237.25
128	NATIONAL	1990	1.8	650.00	1.00	650.00	237.25
129	NATIONAL	2010	1.8	650.00	1.00	650.00	237.25
130	NATIONAL	1990	1.8	650.00	1.00	650.00	237.25
131	NATIONAL	2010	1.8	650.00	1.00	650.00	237.25
132	NATIONAL	2010	1.2	450.00	1.75	787.50	287.44
133	NATIONAL	2010	1.2	450.00	1.75	787.50	287.44
134	NATIONAL	2010	1.2	450.00	1.75	787.50	287.44
135	NONA	2010	0.6	250.00	0.50	125.00	45.63
136	PANASONIC	2010	0.6	200.00	0.50	100.00	36.50

137	PANASONIC	2009	0.6	200.00	0.50	100.00	36.50
138	PANASONIC	2008	0.6	200.00	0.50	100.00	36.50
139	PANASONIC	2009	0.6	200.00	0.50	100.00	36.50
140	PANASONIC	2009	0.6	200.00	0.50	100.00	36.50
141	PANASONIC	2008	0.6	200.00	0.50	100.00	36.50
142	PANASONIC	2010	0.6	200.00	0.50	100.00	36.50
143	PANASONIC	2009	0.6	200.00	0.50	100.00	36.50
144	PANASONIC	2008	0.6	200.00	0.50	100.00	36.50
145	PANASONIC	2009	0.6	200.00	0.50	100.00	36.50
146	PANASONIC	2009	0.6	200.00	0.50	100.00	36.50
147	PANASONIC	2010	0.6	200.00	0.50	100.00	36.50
148	PANASONIC	2009	0.6	200.00	0.50	100.00	36.50
149	PANASONIC	2009	0.6	200.00	0.50	100.00	36.50
150	PANASONIC	2009	0.6	200.00	0.50	100.00	36.50
151	PANASONIC	2009	1.0	310.00	0.50	155.00	56.58
152	PANASONIC	2009	1.0	310.00	0.50	155.00	56.58
153	PANASONIC	2009	1.0	310.00	0.50	155.00	56.58
154	PANASONIC	2009	1.0	310.00	0.50	155.00	56.58
155	PANASONIC	2009	1.0	310.00	0.50	155.00	56.58
156	PANASONIC	2009	1.0	310.00	0.50	155.00	56.58
157	PANASONIC	2008	1.2	450.00	0.50	225.00	82.13
158	PANASONIC	2006	1.2	450.00	0.50	225.00	82.13
159	PANASONIC	2008	1.2	450.00	0.50	225.00	82.13
160	PANASONIC	2008	1.2	450.00	0.50	225.00	82.13
161	PANASONIC	1990	1.2	450.00	0.50	225.00	82.13
162	PANASONIC	2009	1.2	450.00	0.50	225.00	82.13
163	PANASONIC	2008	1.2	450.00	0.50	225.00	82.13
164	PANASONIC	2009	1.2	450.00	0.50	225.00	82.13
165	PANASONIC	2010	1.2	450.00	0.50	225.00	82.13
166	PANASONIC	2000	1.2	450.00	0.50	225.00	82.13
167	PANASONIC	2008	1.2	450.00	0.50	225.00	82.13
168	PANASONIC	2006	1.2	450.00	0.50	225.00	82.13
169	PANASONIC	2008	1.2	450.00	0.50	225.00	82.13
170	PANASONIC	2008	1.2	450.00	0.50	225.00	82.13
171	PANASONIC	1990	1.2	450.00	0.50	225.00	82.13
172	PANASONIC	2009	1.2	450.00	0.50	225.00	82.13
173	PANASONIC	2008	1.2	450.00	0.50	225.00	82.13
174	PANASONIC	2009	1.2	450.00	0.50	225.00	82.13
175	PANASONIC	2010	1.2	450.00	0.50	225.00	82.13
176	PANASONIC	2000	1.2	450.00	0.50	225.00	82.13
177	PANASONIC	2008	1.2	450.00	0.50	225.00	82.13
178	PANASONIC	2008	1.2	450.00	0.50	225.00	82.13
179	PANASONIC	2008	1.2	450.00	0.50	225.00	82.13
180	PANASONIC	1990	1.2	450.00	0.50	225.00	82.13
181	PANASONIC	2009	1.2	450.00	0.50	225.00	82.13
182	PANASONIC	2008	1.2	450.00	0.50	225.00	82.13
183	PANASONIC	2009	1.2	450.00	0.50	225.00	82.13
184	PANASONIC	2010	1.2	450.00	0.50	225.00	82.13

185	PANASONIC	2000	1.2	450.00	0.50	225.00	82.13
186	PANASONIC	2011	0.6	200.00	1.50	300.00	109.50
187	PANASONIC	2011	0.6	200.00	1.50	300.00	109.50
188	PANASONIC	2011	0.6	200.00	1.50	300.00	109.50
189	PANASONIC	2008	1.0	310.00	1.00	310.00	113.15
190	PANASONIC	2009	1.0	310.00	1.00	310.00	113.15
191	PANASONIC	2008	1.0	310.00	1.00	310.00	113.15
192	PANASONIC	2008	1.0	310.00	1.00	310.00	113.15
193	PANASONIC	2008	1.0	310.00	1.00	310.00	113.15
194	PANASONIC	2009	1.0	310.00	1.00	310.00	113.15
195	PANASONIC	2008	1.0	310.00	1.00	310.00	113.15
196	PANASONIC	2008	1.0	310.00	1.00	310.00	113.15
197	PANASONIC	2008	1.0	310.00	1.00	310.00	113.15
198	PANASONIC	2009	1.0	310.00	1.00	310.00	113.15
199	PANASONIC	2008	1.0	310.00	1.00	310.00	113.15
200	PANASONIC	2008	1.0	310.00	1.00	310.00	113.15
201	PANASONIC	2011	1.8	650.00	0.50	325.00	118.63
202	PANASONIC	2011	1.8	650.00	0.50	325.00	118.63
203	PANASONIC	2008	1.8	650.00	0.50	325.00	118.63
204	PANASONIC	2009	1.8	650.00	0.50	325.00	118.63
205	PANASONIC	2008	1.8	650.00	0.50	325.00	118.63
206	PANASONIC	2011	1.8	650.00	0.50	325.00	118.63
207	PANASONIC	2011	1.8	650.00	0.50	325.00	118.63
208	PANASONIC	2008	1.8	650.00	0.50	325.00	118.63
209	PANASONIC	2009	1.8	650.00	0.50	325.00	118.63
210	PANASONIC	2008	1.8	650.00	0.50	325.00	118.63
211	PANASONIC	2011	1.8	650.00	0.50	325.00	118.63
212	PANASONIC	2011	1.8	650.00	0.50	325.00	118.63
213	PANASONIC	2008	1.8	650.00	0.50	325.00	118.63
214	PANASONIC	2009	1.8	650.00	0.50	325.00	118.63
215	PANASONIC	2009	1.2	450.00	1.00	450.00	164.25
216	PANASONIC	2000	1.2	450.00	1.00	450.00	164.25
217	PANASONIC	2008	1.2	450.00	1.00	450.00	164.25
218	PANASONIC	2010	1.2	450.00	1.00	450.00	164.25
219	PANASONIC	2009	1.2	450.00	1.00	450.00	164.25
220	PANASONIC	1990	1.2	450.00	1.00	450.00	164.25
221	PANASONIC	2010	1.2	450.00	1.00	450.00	164.25
222	PANASONIC	2009	1.2	450.00	1.00	450.00	164.25
223	PANASONIC	2000	1.2	450.00	1.00	450.00	164.25
224	PANASONIC	2007	1.2	450.00	1.00	450.00	164.25
225	PANASONIC	2010	1.2	450.00	1.00	450.00	164.25
226	PANASONIC	2009	1.2	450.00	1.00	450.00	164.25
227	PANASONIC	1990	1.2	450.00	1.00	450.00	164.25
228	PANASONIC	2010	1.2	450.00	1.00	450.00	164.25
229	PANASONIC	2009	1.2	450.00	1.00	450.00	164.25
230	PANASONIC	2000	1.2	450.00	1.00	450.00	164.25
231	PANASONIC	2010	1.2	450.00	1.00	450.00	164.25
232	PANASONIC	2009	1.2	450.00	1.00	450.00	164.25

233	PANASONIC	1990	1.2	450.00	1.00	450.00	164.25
234	PANASONIC	2010	1.2	450.00	1.00	450.00	164.25
235	PANASONIC	2009	1.0	310.00	1.50	465.00	169.73
236	PANASONIC	2009	1.0	310.00	1.50	465.00	169.73
237	PANASONIC	2009	1.0	310.00	1.50	465.00	169.73
238	PANASONIC	2006	1.8	650.00	1.00	650.00	237.25
239	PANASONIC	1997	1.8	650.00	1.00	650.00	237.25
240	PANASONIC	2009	1.8	650.00	1.00	650.00	237.25
241	PANASONIC	1995	1.8	650.00	1.00	650.00	237.25
242	PANASONIC	2008	1.8	650.00	1.00	650.00	237.25
243	PANASONIC	2009	1.8	650.00	1.00	650.00	237.25
244	PANASONIC	2006	1.8	650.00	1.00	650.00	237.25
245	PANASONIC	1997	1.8	650.00	1.00	650.00	237.25
246	PANASONIC	2009	1.8	650.00	1.00	650.00	237.25
247	PANASONIC	1995	1.8	650.00	1.00	650.00	237.25
248	PANASONIC	2008	1.8	650.00	1.00	650.00	237.25
249	PANASONIC	2009	1.8	650.00	1.00	650.00	237.25
250	PANASONIC	2006	1.8	650.00	1.00	650.00	237.25
251	PANASONIC	1997	1.8	650.00	1.00	650.00	237.25
252	PANASONIC	2009	1.8	650.00	1.00	650.00	237.25
253	PANASONIC	1995	1.8	650.00	1.00	650.00	237.25
254	PANASONIC	2008	1.8	650.00	1.00	650.00	237.25
255	PANASONIC	2009	1.8	650.00	1.00	650.00	237.25
256	PANASONIC	2009	1.2	450.00	1.50	675.00	246.38
257	PANASONIC	2009	1.2	450.00	1.50	675.00	246.38
258	PANASONIC	2009	1.2	450.00	1.50	675.00	246.38
259	PANASONIC	2010	1.8	650.00	1.25	812.50	296.56
260	PANASONIC	2010	1.8	650.00	1.25	812.50	296.56
261	PANASONIC	2010	1.8	650.00	1.25	812.50	296.56
262	PANASONIC	2009	1.8	650.00	1.50	975.00	355.88
263	PANASONIC	2009	1.8	650.00	1.50	975.00	355.88
264	PANASONIC	2009	1.8	650.00	1.50	975.00	355.88
265	PENSONIC	2010	1.0	400.00	0.50	200.00	73.00
266	PENSONIC	2003	1.0	400.00	0.50	200.00	73.00
267	PENSONIC	2008	1.0	400.00	0.50	200.00	73.00
268	PENSONIC	2010	1.0	400.00	0.50	200.00	73.00
269	PENSONIC	2003	1.0	400.00	0.50	200.00	73.00
270	PENSONIC	2008	1.0	400.00	0.50	200.00	73.00
271	PENSONIC	2010	1.0	400.00	0.50	200.00	73.00
272	PENSONIC	2003	1.0	400.00	0.50	200.00	73.00
273	PENSONIC	2008	1.0	400.00	0.50	200.00	73.00
274	PENSONIC	2005	1.2	500.00	0.50	250.00	91.25
275	PENSONIC	2008	1.2	500.00	0.50	250.00	91.25
276	PENSONIC	2007	1.2	500.00	0.50	250.00	91.25
277	PENSONIC	2005	1.2	500.00	0.50	250.00	91.25
278	PENSONIC	2008	1.2	500.00	0.50	250.00	91.25
279	PENSONIC	2007	1.2	500.00	0.50	250.00	91.25
280	PENSONIC	2005	1.2	500.00	0.50	250.00	91.25

281	PENSONIC	2008	1.2	500.00	0.50	250.00	91.25
282	PENSONIC	2007	1.2	500.00	0.50	250.00	91.25
283	PENSONIC	2009	1.2	500.00	1.00	500.00	182.50
284	PENSONIC	2009	1.2	500.00	1.00	500.00	182.50
285	PENSONIC	2009	1.2	500.00	1.00	500.00	182.50
286	PENSONIC	2010	1.0	400.00	1.50	600.00	219.00
287	PENSONIC	2009	1.0	400.00	1.50	600.00	219.00
288	PENSONIC	2010	1.0	400.00	1.50	600.00	219.00
289	PENSONIC	2009	1.0	400.00	1.50	600.00	219.00
290	PENSONIC	2010	1.0	400.00	1.50	600.00	219.00
291	PENSONIC	2009	1.0	400.00	1.50	600.00	219.00
292	PENSONIC	2010	1.8	700.00	1.00	700.00	255.50
293	PENSONIC	2010	1.8	700.00	1.00	700.00	255.50
294	PENSONIC	2010	1.8	700.00	1.00	700.00	255.50
295	PENSONIC	2007	1.8	700.00	1.25	875.00	319.38
296	PENSONIC	2006	1.8	700.00	1.25	875.00	319.38
297	PENSONIC	2007	1.8	700.00	1.25	875.00	319.38
298	PENSONIC	2006	1.8	700.00	1.25	875.00	319.38
299	PENSONIC	2007	1.8	700.00	1.25	875.00	319.38
300	PENSONIC	2006	1.8	700.00	1.25	875.00	319.38
301	PHILIPS	2002	1.8	825.00	0.50	412.50	150.56
302	RICE COOKER	2007	1.8	800.00	1.00	800.00	292.00
303	RICE COOKER	2007	1.8	800.00	1.00	800.00	292.00
304	RICE COOKER	2007	1.8	800.00	1.00	800.00	292.00
305	SANYO	2002	1.0	450.00	1.00	450.00	164.25
306	SANYO	2002	1.0	450.00	1.00	450.00	164.25
307	SANYO	2002	1.0	450.00	1.00	450.00	164.25
308	SANYO	2009	1.2	500.00	1.00	500.00	182.50
309	SANYO	2009	1.2	500.00	1.00	500.00	182.50
310	SANYO	2009	1.2	500.00	1.00	500.00	182.50
311	SEC	2011	1.8	800.00	0.50	400.00	146.00
312	SHARP	2009	0.6	245.00	0.50	122.50	44.71
313	SHARP	2009	0.6	245.00	0.50	122.50	44.71
314	SHARP	2009	0.6	245.00	0.50	122.50	44.71
315	SHARP	2005	1.2	485.00	0.50	242.50	88.51
316	SHARP	2010	1.2	485.00	0.50	242.50	88.51
317	SHARP	2005	1.2	485.00	0.50	242.50	88.51
318	SHARP	2010	1.2	485.00	0.50	242.50	88.51
319	SHARP	2005	1.2	485.00	0.50	242.50	88.51
320	SHARP	2010	1.2	485.00	0.50	242.50	88.51
321	SHARP	2006	1.2	485.00	1.00	485.00	177.03
322	SHARP	2006	1.2	485.00	1.00	485.00	177.03
323	SHARP	2006	1.2	485.00	1.00	485.00	177.03
324	SHARP	2003	1.2	485.00	1.50	727.50	265.54
325	SHARP	2001	1.2	485.00	1.50	727.50	265.54
326	SHARP	2006	1.2	485.00	1.50	727.50	265.54

327	SHARP	2001	1.2	485.00	1.50	727.50	265.54
328	SHARP	2001	1.2	485.00	1.50	727.50	265.54
329	SHARP	2009	1.8	800.00	1.00	800.00	292.00
330	SHARP	2009	1.8	800.00	1.00	800.00	292.00
331	SHARP	2009	1.8	800.00	1.00	800.00	292.00
332	SHARP	2003	1.8	800.00	1.50	1200.00	438.00
333	SHARP	2002	1.8	800.00	1.50	1200.00	438.00
334	SINGER	2000	1.8	700.00	1.00	700.00	255.50
335	SINGER	2000	1.8	700.00	1.00	700.00	255.50
336	SINGER	2000	1.8	700.00	1.00	700.00	255.50
337	SONY	2010	1.0	250.00	0.50	125.00	45.63
338	SONY	2010	1.0	250.00	0.50	125.00	45.63
339	STABILO	2009	1.2	500.00	0.75	375.00	136.88
340	STABILO	2009	1.2	500.00	0.75	375.00	136.88
341	TOSHIBA	2005	1.8	880.00	0.50	440.00	160.60
342	TOSHIBA	2002	1.8	880.00	0.50	440.00	160.60
343	TOSHIBA	2005	1.8	880.00	0.50	440.00	160.60
344	TOSHIBA	2002	1.8	880.00	0.50	440.00	160.60
345	TOSHIBA	2005	1.8	880.00	0.50	440.00	160.60
346	TOSHIBA	2002	1.8	880.00	0.50	440.00	160.60
347	TRIO	2007	1.8	650.00	0.75	487.50	177.94
348	WALLABY	2011	1.8	800.00	1.00	800.00	292.00
	Average		1.3	484.51	0.83	405.22	147.90
	Min		0.6	200.00	0.50	100.00	36.50
	Max		1.8	880.00	1.50	1200.00	438.00

A.4 Survey data for maximum rice cooking capacity 1 L

No.	Brand	Year Manufac tured	Max Cooking Capacity (L)	Power (W)	Usage hour (hr/day)	Energy consump tion (Wh/day)	Energ y consu mption (kWh/ year)
1	PANASONIC	2009	1.0	310.00	1.00	310.00	113.15
2	PANASONIC	2008	1.0	310.00	1.00	310.00	113.15
3	PANASONIC	2009	1.0	310.00	1.00	310.00	113.15
4	PANASONIC	2009	1.0	310.00	1.00	310.00	113.15
5	FABER	2011	1.0	400.00	0.75	300.00	109.50
6	FABER	2011	1.0	400.00	0.75	300.00	109.50
7	PANASONIC	2008	1.0	310.00	1.00	310.00	113.15
8	PANASONIC	2009	1.0	310.00	1.00	310.00	113.15
9	PENSONIC	2010	1.0	400.00	0.75	300.00	109.50
10	NATIONAL	2005	1.0	310.00	1.00	310.00	113.15
11	PANASONIC	2008	1.0	310.00	1.00	310.00	113.15
12	CORNELL	2009	1.0	505.00	0.50	252.50	92.16
13	PENSONIC	2010	1.0	400.00	0.75	300.00	109.50
14	PENSONIC	2003	1.0	400.00	0.75	300.00	109.50
15	ADVANCE	2011	1.0	450.00	1.25	562.50	205.31
16	SANYO	2002	1.0	466.00	0.75	349.50	127.57
17	NATIONAL	1999	1.0	310.00	1.00	310.00	113.15
18	NATIONAL	1997	1.0	310.00	1.00	310.00	113.15
19	NATIONAL	2009	1.0	310.00	1.00	310.00	113.15
20	PENSONIC	2008	1.0	400.00	0.75	300.00	109.50
21	PENSONIC	2009	1.0	400.00	0.75	300.00	109.50
22	PANASONIC	2009	1.0	310.00	1.00	310.00	113.15
23	PANASONIC	2008	1.0	310.00	1.00	310.00	113.15
24	PANASONIC	2009	1.0	310.00	1.00	310.00	113.15
25	PANASONIC	2009	1.0	310.00	1.00	310.00	113.15
26	FABER	2011	1.0	400.00	0.75	300.00	109.50
27	FABER	2011	1.0	400.00	0.75	300.00	109.50
28	PANASONIC	2008	1.0	310.00	1.00	310.00	113.15
29	PANASONIC	2009	1.0	310.00	1.00	310.00	113.15
30	PENSONIC	2010	1.0	400.00	0.75	300.00	109.50
31	NATIONAL	2005	1.0	310.00	1.00	310.00	113.15
32	PANASONIC	2008	1.0	310.00	1.00	310.00	113.15
33	CORNELL	2009	1.0	505.00	0.50	252.50	92.16
34	PENSONIC	2010	1.0	310.00	1.00	310.00	113.15
35	PENSONIC	2003	1.0	310.00	1.00	310.00	113.15
36	SANYO	2002	1.0	450.00	0.75	337.50	123.19
37	NATIONAL	1999	1.0	310.00	1.00	310.00	113.15
38	NATIONAL	1997	1.0	310.00	1.00	310.00	113.15
39	NATIONAL	2009	1.0	310.00	1.00	310.00	113.15
40	PENSONIC	2008	1.0	250.00	1.25	312.50	114.06
41	PENSONIC	2009	1.0	310.00	1.00	310.00	113.15
42	SONY	2010	1.0	250.00	1.25	312.50	114.06

43	PANASONIC	2009	1.0	310.00	1.00	310.00	113.15
44	PANASONIC	2008	1.0	310.00	1.00	310.00	113.15
45	PANASONIC	2009	1.0	310.00	1.00	310.00	113.15
46	PANASONIC	2009	1.0	310.00	1.00	310.00	113.15
47	FABER	2011	1.0	400.00	0.75	300.00	109.50
48	FABER	2011	1.0	400.00	0.75	300.00	109.50
49	PANASONIC	2008	1.0	310.00	1.00	310.00	113.15
50	PANASONIC	2009	1.0	310.00	1.00	310.00	113.15
51	PENSONIC	2010	1.0	400.00	0.75	300.00	109.50
52	NATIONAL	2005	1.0	310.00	1.00	310.00	113.15
53	PANASONIC	2008	1.0	310.00	1.00	310.00	113.15
54	CORNELL	2009	1.0	505.00	0.50	252.50	92.16
55	PENSONIC	2010	1.0	310.00	1.00	310.00	113.15
56	PENSONIC	2003	1.0	310.00	1.00	310.00	113.15
57	ADVANCE	2011	1.0	310.00	1.00	310.00	113.15
58	NATIONAL	2002	1.0	310.00	1.00	310.00	113.15
59	NATIONAL	1999	1.0	310.00	1.00	310.00	113.15
60	NATIONAL	1997	1.0	310.00	1.00	310.00	113.15
61	NATIONAL	2009	1.0	310.00	1.00	310.00	113.15
62	PENSONIC	2008	1.0	310.00	1.00	310.00	113.15
63	PENSONIC	2009	1.0	310.00	1.00	310.00	113.15
	Average						110.9
	Min						92.16
	Max						127.57

A.3. Predicted electricity consumption and household data

Year	Total (GWh)	Residential (GWh)	Household	Electric Rice Cooker
1970	2175	326	1,890,282	1890282
1971	3920	663	1,937,678	1937678
1972	2953	498	1,988,182	1988182
1973	2185	369	2,041,791	2041791
1974	1615	275	2,098,504	2098504
1975	1244	216	2,158,322	2158322
1976	1071	193	2,221,244	2221244
1977	1097	205	2,287,271	2287271
1978	1321	253	2,356,403	2356403
1979	1743	336	2,428,639	2428639
1980	2364	455	2,503,980	2503980
1981	3183	609	2,582,425	2582425
1982	4200	798	2,663,975	2663975
1983	5416	1023	2,748,630	2748630
1984	6830	1283	2,836,389	2836389
1985	8443	1579	2,927,253	2927253
1986	10254	1910	3,021,221	3021221
1987	12263	2277	3,118,294	3118294
1988	14471	2679	3,218,472	3218472
1989	16877	3116	3,321,754	3321754
1990	19481	3589	3,428,141	3428141
1991	22284	4098	3,537,632	3537632
1992	25285	4642	3,650,228	3650228
1993	28485	5221	3,765,929	3765929
1994	31883	5835	3,884,734	3884734
1995	35479	6486	4,006,644	4006644
1996	39274	7171	4,131,658	4131658
1997	43267	7892	4,259,777	4259777
1998	47459	8649	4,391,001	4391001
1999	51849	9440	4,525,329	4525329
2000	56437	10268	4,662,761	4662761
2001	61224	11131	4,803,299	4803299
2002	66209	12029	4,946,941	4946941
2003	71392	12962	5,093,687	5093687
2004	76774	13931	5,243,539	5243539
2005	82355	14936	5,396,494	5396494
2006	88133	15976	5,552,555	5552555
2007	94110	17051	5,711,720	5711720
2008	100286	18162	5,873,989	5873989
2009	106659	19308	6,039,364	6039364
2010	113232	20490	6,207,842	6207842
2011	120002	21707	6,379,426	6379426
2012	126971	22959	6,554,114	6554114
2013	134138	24247	6,731,906	6731906

2014	141504	25571	6,912,803	6912803
2015	149068	26930	7,096,805	7096805
2016	156831	28324	7,283,912	7283912
2017	164792	29754	7,474,123	7474123
2018	172951	31219	7,667,438	7667438
2019	181308	32719	7,863,858	7863858
2020	189864	34255	8,063,383	8063383

A.4. Predicted percentage fuel mix for electricity generation

Year	Coal (%)	Petroleum (%)	Gas (%)	Hydro (%)
2000	15.00%	5.00%	70.00%	10.00%
2001	14.94%	4.61%	67.55%	12.90%
2002	14.96%	4.24%	65.20%	15.60%
2003	15.06%	3.89%	62.95%	18.10%
2004	15.24%	3.56%	60.80%	20.40%
2005	15.50%	3.25%	58.75%	22.50%
2006	15.84%	2.96%	56.80%	24.40%
2007	16.26%	2.69%	54.95%	26.10%
2008	16.76%	2.44%	53.20%	27.60%
2009	17.34%	2.21%	51.55%	28.90%
2010	18.00%	2.00%	50.00%	30.00%
2011	18.74%	1.81%	48.55%	30.90%
2012	19.56%	1.64%	47.20%	31.60%
2013	20.46%	1.49%	45.95%	32.10%
2014	21.44%	1.36%	44.80%	32.40%
2015	22.50%	1.25%	43.75%	32.50%
2016	23.64%	1.16%	42.80%	32.40%
2017	24.86%	1.09%	41.95%	32.10%
2018	26.16%	1.04%	41.20%	31.60%
2019	27.54%	1.01%	40.55%	30.90%
2020	29.00%	1.00%	40.00%	30.00%

Appendix B

Sample calculation

SAMPLE CALCULATION

E.1 Data assessment

E.1.1 Total energy consumption

$E_{2003}^{T} = 99.192(2003 - 1970)^2 - 1264(2003 - 1970) + 5084.4 = 71392GWh$ …(E.1)

E.1.2 Energy consumption in residential sector

$E_{2003}^{R} = 17.718(2003 - 1970)^2 - 218.06(2003 - 1970) + 863.37 = 12962GWh$ …(E.2)

E.1.3 Number of house

$N_{2003}^{H} = 1552.3(2003 - 1970)^2 + 45847.08(2003 - 1970) + 1890279.09 = 5093687$ …(E.3)

E.1.4 Number of room air conditioners

$N_{2003}^{H} = 1552.3(2003 - 1970)^2 + 45847.08(2003 - 1970) + 1890279.09 = 5093687$ …(E.4)

E.1.5 Percentage of coal

$P_{2003}^{coal} = 0.0004(2003 - 2000)^2 - 0.001(2003 - 2000) + 0.15 = 15.06\%$ …(E.5)

E.1.6 Percentage of petroleum

$P_{2003}^{petroleum} = 0.0001(2003 - 2000)^2 - 0.004(2003 - 2000) + 0.05 = 3.89\%$ …(E.6)

E.1.7 Percentage of gas

$P_{2003}^{gas} = 0.0005(2003 - 2000)^2 - 0.025(2003 - 2000) + 0.70 = 62.95\%$ …(E.7)

E.1.8 Percentage of hydropower

$P_{2003}^{hydro} = -0.001(2003 - 2000)^2 - 0.03(2003 - 2000) + 0.10 = 18.10\%$ …(E.8)

E.2 Energy impact of the standards and labels

E.2.1 Impact of the standards

E.2.1.1 Energy impact of the standards

a) Baseline energy consumption

$BEC_s^{rc} = 110.90\ kWh/year$ …(E.9)

b) Standards energy consumption

$SEC_s^{rc} = 92.00\ kWh/year$ …(E.10)

c) Initial unit energy savings

$UES_s^{rc} = 110.90 - 92.00 = 18.90\ kWh/year$ …(E.11)

d) Shipment

$Sh_{2003}^{rc} = (Na_{2003}^{rc} - Na_{2002}^{rc}) + Na_{1996}^{rc}$

$Sh_{2003}^{rc} = 5093687 - 4946941 + 4131658 = 4278405$ …(E.12)

e) Standards efficiency improvement

$SEI_{2003}^{rc} = \frac{18.90}{110.90} \times 100\% = 17.04\%$ …(E.13)

f) Scaling factor

$SF_{2003}^{rc} = 1 - \left[(2003 - 2003) \times \frac{1.08\%}{17.04\%}\right] = 100\%$ …(E.14)

g) Unit energy savings

$UES_{2003}^{rc} = 100\% \times 18.9 = 18.9\ kWh/year$ …(E.15)

h) Shipment survival factor

$SSF_{2003}^{rc} = 1 - \left[\frac{(2012-2003)-{}^{2}/_{3}\times 9}{({}^{4}/_{3}-{}^{2}/_{3})\times 9}\right] = 100\%$ …(E.16)

Note: All the shipments are affected by standards because all of electric rice cooker sold in the year which the standards affected them, which is in 2003, that is the same as the proposed standards enactment. The standards effective period is also shorter 2/3 of lifetime of electric rice cooker. As a result, the shipment survival factor is 100%.

i) Applicable stock

$AS_{2004}^{rc} = 4409628 + 4278405 = 8688033$ …(E.17)

j) Energy savings

$ES_{2003}^{rc} = 4278405 \times 100\% \times 18.9 = 80861846\ kWh$ …(E.18)

k) Business as usual

$BAU_{2003}^{rc} = 4278405 \times 100\% \times 100\% \times 110.9 = 474475065\ kWh$ …(E.19)

E.2.1.2 Economic impact of the standards

a) Initial incremental cost

$IIC_{2003}^{rc} = 18.9 \times 0.8807 = RM16.6459$ …(E.20)

b) Capital recovery factor

$CRF_{2003}^{rc} = \frac{7\%}{1-(1+7\%)^{-9}} = 0.126$ …(E.21)

c) Cost of conserved energy

$CCE_{2003}^{rc} = 16.6459 \times \frac{0.15}{18.9} = 0.1352$ …(E.22)

d) Bill savings

$BS_{2003}^{rc} = 80861846 \times 0.3354 = RM\ 27\ 121\ 063$ …(E.23)

e) Net savings

$ANS_{2003}^{rc} = 27121063 - 4278405 \times 0.15 \times 100\% \times 16.6459$

$= RM16\ 438\ 379$ …(E.24)

$NS_{2003}^{rc} = 27121063 - 4278405 \times 100\% \times 16.6459$

$= RM - 44096831$ …(E.25)

f) Cumulative present value

$PV(ANS)_{2003}^{rc} = \frac{16438379}{(1+7\%)^{(2003-2003)}} = RM16\ 438\ 379$ …(E.26)

E.2.1.3 Environmental impact of the standards

a) Carbon dioxide reduction

$CO2_{2003}^{rc} = 80861846 \times (15.06\% \times 1.18 + 3.89\% \times 0.85 + 62.95\% \times 0.53)$

$= 44022000\ kg$ …(E.27)

b) Sulfur dioxide reduction

$$SO2_{2003}^{rc} = 80861846 \times \begin{pmatrix} 15.06\% \times 0.0139 + 3.89\% \times 0.0164 \\ +62.95\% \times 0.0005 \end{pmatrix}$$

$$= 246309\ kg \qquad \ldots(E.28)$$

c) Nitrogen oxide reduction

$$NOx_{2003}^{rc} = 80861846 \times \begin{pmatrix} 15.06\% \times 0.0152 + 3.89\% \times 0.0025 \\ +62.95\% \times 0.0009 \end{pmatrix}$$

$$= 117001\ kg \qquad \ldots(E.29)$$

d) Carbon monoxide reduction

$$CO_{2003}^{rc} = 80861846 \times \begin{pmatrix} 15.06\% \times 0.0002 + 3.89\% \times 0.0002 \\ +62.95\% \times 0.0005 \end{pmatrix}$$

$$= 28516\ kg \qquad \ldots(E.30)$$

E.2.2 Impact of the labels

E.2.2.1 Energy impact of the labels

a) Baseline energy consumption

$$BEC_l^{rc} = 128\ kWh/year \qquad \ldots(E.31)$$

b) Labels energy consumption

$$LEC_l^{rc} = 92\ kWh/year \qquad \ldots(E.32)$$

c) Initial unit energy savings

$$UES_l^{rc} = 128 - 92 = 36\ kWh/year \qquad \ldots(E.33)$$

d) Shipment

Similar to (E.12)

e) Shipment survival factor

Similar to (E.16)

f) Applicable stock

Similar to (E.17)

g) Annual energy savings

$ES_{2003}^{rc} = 4278405 \times 36 = 154022564\ kWh$ …(E.34)

E.2.2.2 Economic impact of the labels

a) Initial incremental cost

$IIC_{2003}^{rc} = 36 \times 0.8807 = RM\ 31.7064$ …(E.35)

b) Capital recovery factor

Similar to (E.21)

c) Cost of conserved energy

$CCE_{2003}^{rc} = 31.7064 \times \frac{0.15}{36} = RM\ 0.1352/kWh$ …(E.36)

d) Bill savings

$BS_{2003}^{rc} = 154022564 \times 0.3354 = RM\ 51659168$ …(E.37)

e) Annualized dollar and Net savings

$ANS_{2003}^{rc} = 51659168 - 4278405 \times 0.15 \times 26.422 = RM34702567$ …(E.38)

$NS_{2003}^{rc} = 51659168 - 4278405 \times 26.422 = RM - 61384837$ …(E.39)

f) Cumulative present value

$PV(ANS)_{2003}^{rc} = \frac{34702567}{(1+7\%)^{(2003-2003)}} = RM34702562$ …(E.40)

E.2.2.3 Environmental impact of the labels

a) Carbon dioxide reduction

$CO2_{2003}^{rc} = 154022564 \times (15.06\% \times 1.18 + 3.89\% \times 0.85 + 62.95\% \times 0.53)$

$= 83851000\ kg$ …(E.41)

b) Sulfur dioxide reduction

$$SO2_{2003}^{rc} = 154022564 \times (15.06\% \times 0.0139 + 3.89\% \times 0.0164 + 62.95\% \times 0.005)$$

$$= 469160\ kg \quad \ldots(E.42)$$

c) Nitrogen oxide reduction

$$NOx_{2003}^{rc} = 154022564 \times (15.06\% \times 0.0052 + 3.89\% \times 0.0025 + 62.95\% \times 0.0009)$$

$$= 222858\ kg \quad \ldots(E.43)$$

d) Carbon monoxide reduction

$$CO_{2003}^{rc} = 154022564 \times (15.06\% \times 0.0002 + 3.89\% \times 0.0002 + 62.95\% \times 0.0005)$$

$$= 54316\ kg \quad \ldots(E.44)$$