A REVIEW ON ENERGY EFFICIENCY STANDARDS AND LABELS: PRESENT STATUS AND IMPLEMENTATION POSSIBILITIES IN MALAYSIA

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ABSTRACT

This article is a review on energy efficiency standards and labels for household electrical appliances around the world. Through the review of other country experiences on energy efficiency standards and labels, we attempt to identify savings possibilities in Malaysian households. The implementation possibilities of standards and labels for various household electrical appliances in Malaysia are also examined. It is found that various household appliances in Malaysia offer some potential in reducing electricity consumption. Finally, it is concluded that there are many advantages for Malaysia to implement the standards and labels for household electrical appliances as soon as possible in order to reduce electricity bills and energy consumption in Malaysian households.

1. INTRODUCTION

Energy efficiency standards and labels are among the most popular strategies to educate the consumer to use energy efficiently today. There is a great opportunity because energy efficiency standards are being introduced internationally, so it is beneficial to take advantage of the work already done and the knowledge already accumulated. However, each country's experience with appliance standards is different from another. Many countries have introduced energy efficiency standards with very successful results which other countries may be able to learn from. Some of the experiences can be directly adopted, but some must be modified in order to make them suitable for particular countries. For example, comfort temperature for air conditioning is quite different among the population on the earth. The acceptable comfort range has been found to vary from one country or population to another; generally an acceptable level being higher for acclimatized Asians and Africans as compared to the white populations of North America and Europe[1]. But there are direct adoptions for some other appliance efficiency standards like for TV, fluorescent lamp, fan etc.

In order to promote an energy efficiency program, the government of Malaysia has allocated a sum of RM 5.0 million (US $1.32 million) to the Department of Electricity and Gas Supply under the 7th Malaysian Plan to carry out a suitable program in the country. The program seeks to promote to consumers the use and manufactures the production of

energy efficiency appliances. The program will also ensure a more effective implementation of the energy efficiency measures. As preliminary result, the Department of Electricity and Gas Supply Malaysia has formulated and submitted the proposed electricity efficiency regulations to the government for final approval.

2. ENERGY STANDARDS AND LABELS

A simple and effective strategy for providing guidance to consumers in their purchase of household appliances is standards and labels. Standards set a minimum efficiency level that appliance manufacturers must meet in order to sell their products. On the other hand, labels stimulate consumer awareness and encourage manufacturers to improve the standards. Labels also encourage manufacturers to use efficiency as a feature of their sales campaigns. Energy efficiency standards are tools for market transformation of household appliances. By introducing standards and labels, the average energy performance of models on the market will improve gradually. Establishing energy efficiency standards pushes the market by eliminating the least efficient models. Labels pull by encouraging customers to purchase higher efficiency models, and pushes by encouraging manufacturers to produce more energy efficient models[2]. Standards and labels are beneficial to national economies, local and international manufacturers and the natural environment.

2.1 History of appliance standards and labels

Household appliance standards have a history of more than three-decades, but have become popular just after the oil price shock in the 1970s. The United States and European countries claim that they are the first countries which implemented efficiency standards and labels for household appliances. Egan[3] states that the United States is the nation with the oldest standards and label programs. However, Waide *et al*[4] has shown that European countries were among the first in introducing legislation to limit the energy consumption of domestic appliances during the 1960s and 1970s. France introduced mandatory minimum energy efficiency standards for refrigerators in 1966 and freezers in 1978. Russia introduced mandatory energy efficiency standards in 1976 while Poland is supposed to have had mandatory energy efficiency standards for a range of electrical appliances from as early as 1962, while in North America, the first energy efficiency standards for appliances were established in the state of California in 1977[5]. However, much of this early legislation was weak, poorly implemented and had little impact on appliances energy consumption. Appliance standards are actually a set of procedures and regulations that define the energy performance of a manufactured product, sometimes prohibiting the manufacture of products which are less energy efficient than the minimum standards. While labels are mandatory or voluntary stickers that are affixed to products or their packaging and which contain information on the energy efficiency or energy consumption of the products. Appliance standards have influenced manufacturers to invest more in designing products using less energy, which in turn reduces the need for new energy supplies.

Among the South East Asian nations, the Philippines and Thailand are leading the way towards the development of national energy efficiency standards and labels. The two countries have well-established programs for improving the efficiency of household appliances. Other countries that have applied either standards or labeling or both are Australia, Brazil, Canada, China, Japan, India, Korea, Mexico, Philippines, Taiwan, Thailand and the U.S.[2-8] An overview of appliance standards history is tabulated in Table 1. Standards and labels are one of the energy efficiency concepts that have been used worldwide. The status of standards and labeling around the world is shown in Table 2.

Table 1: An overview of appliances standard history.

Year Effective	Country	Legal Status	Appliances
1962	Poland	mandatory	several
1966	France	mandatory	R
1976	Russia	mandatory	several
1979	Japan	voluntary	RAC/LT/R/FR/TV
1978	Canada	mandatory	16 products
1989	China	mandatory	R
1980	United States	mandatory	R/AC/RAC/CW
1991	Taiwan	mandatory	RAC
1987	Australia	mandatory	R/RAC/AC/DW/CD/CW
1992	Korea	voluntary	R/FR/RAC/LT
1993	Philippines	mandatory	RAC
1994	Thailand	voluntary	R/RAC
1995	Hong Kong	voluntary	R/RAC/CW

Note: Refrigerator (R), Freezer (FR), Room Air Conditioner (RAC), Central Air Conditioner (AC), Clothes Washer (CW), Clothes Dryer (CD), Dishwasher (DW), Lighting (LT), Television (TV).
Sources: compiled from references [2-8].

Table 2: Standards and labeling around the world.

Product	China	Taiwan	Hong Kong	USA	Japan	Korea	Mexico	Philip-pine	Singa-pore	Thai-land	Canada
Air conditioner	S	S&L	L	S&L	S&L	S&L	S&L	S&L	S	L	S
Refrigerators	S	S&L	L	S&L	L	S&L	S&L	-	-	L	S&L
Central AC	S	S	-	S&L	-	S&L	-	-	-	-	S&L
Clothes washers	S	L	-	S&L	-	-	-	-	-	-	S&L
Clothes dryers	-	S	-	S&L	-	-	-	-	-	-	S&L
Dishwashers	-	S	-	S&L	-	-	-	-	-	-	S&L
Water heaters	-	S	-	S&L	-	-	-	-	-	-	S&L
Ranges/Oven	-	S	-	S&L	-	-	-	-	-	-	S&L
Fans	S	-	-	-	-	-	-	-	-	-	-
Rice cookers	S	-	-	-	-	-	-	-	-	-	-
Irons	S	-	-	-	-	-	-	-	-	-	-

Note: Standard (S) and Label (L).
Sources: compiled from references [2-8].

2.2 Energy standards

Standards are a set of procedures and regulations that prescribe the energy performance of manufactured products, sometimes prohibiting an energy efficiency less than the minimum standard. Energy efficiency standards can be either mandatory or voluntary. They can be in the form of minimum allowable energy efficiency or a maximum allowable energy use. A mandatory energy efficiency standard is generally the most effective means of rapidly improving the energy efficiency of appliances. While voluntary energy efficiency standards, negotiated between government and manufacturers, are an alternative option and have the advantage of being less controversial and hence easier to enact[3].

According to Turiel *et al*[9], the two approaches widely used to set energy efficiency standards are statistical and engineering/economic.

2.2.1 Statistical approach

The statistical approach requires fewer data and less analysis than the engineering/economic approach. The data required are ones that gives a current characterisation of the marketplace for the products of interest. This approach looks at the models available at a particular time and a regression analysis is done to determine the dependence of energy use with respect to capacity. Using such an approach, policy makers can decide on the percentage of models they are willing to eliminate or the desired overall energy savings from the standards. After calculation of the regression line, the least energy efficient model is found and replaced with a model of higher efficiency. The energy savings of replaced models are calculated and energy savings are accumulated until the total reaches the desired goal. This approach has been utilised in the European Union (EU) and Australia. This has been reported in detail by Marousek and Schwarzkopf[10].

2.2.2 Engineering/economic analyses

The second approach is an engineering/economic analysis. The approach has been widely used by Lawrence Berkeley Laboratory (LBL) for the U.S. Department of Energy. First, an engineering analysis is carried out on each product type to determine manufacturing costs for improving the efficiency of a particular model. The following seven steps form the basis for an engineering analysis: (i) selection of appliance classes, (ii) selection of particular units, (iii) selection of design options for each class, (iv) calculation of efficiency improvement from each design option, (v) combination of design options and calculation of efficiency improvements, (vi) developing cost estimates for each design option, and (vii) generation of cost-efficiency curves. Once an engineering analysis is completed, it is customary to analyse the economic impact of the potential efficiency improvement on consumers by carrying out a consumer life cycle cost analysis. The life cycle cost is the sum of purchase price and the annual operating cost discounted over the lifetime of the appliance. The engineering/economic approach is discussed in detail by Turiel *et al*[9].

Nevertheless, the following provisions should be taken into consideration in any methodology used in establishing efficiency standards[11]:

(i) The level of the standard must have a positive effect on the environment.
(ii) Before implementing the standard, consumers should be protected against the high rise in total costs over the life of the given appliance.
(iii) The standard should ensure energy efficiency in relation to performance and should not affect the quality of the appliance.
(iv) The standard should ensure market competitiveness.

Finally, it is necessary to ensure that the efficiency standards are dynamic, in order that they may remain responsive and effective. It is possible to maintain their dynamism by reviewing and updating the standards periodically.

2.3 Energy labels

The main purpose of introducing labels is to convince the consumers to buy and manufacturers to produce energy efficient appliances. Labels should enable the comparison of energy efficiency or cost for similar appliances that compete with types having similar dimensions and characteristics. A purchaser should be able to see the price and choose the product with the lowest long-term costs. According to Mahlia *et al*[11], for maximum effect of labeling, it is necessary to adhere to the following fundamental conditions:

(i) The label must be uniform. If labeling or information flyers are introduced in various ways, chaos can result from comparing appliances and thus lead the consumer to ignore information about energy consumption.
(ii) Label must be general, and all appliances of a given type must be labeled. If they are not, there is a danger that consumers would not want to know the operational cost. Thus they would give priority to less efficient appliances without labels over efficient appliances with labels.
(iii) Measures labels should include information about the product for those customers who are willing to devote more time to consider the relative benefits of various appliances.
(iv) The information in the labels must be as accurate as possible and give as much necessary information as possible.

There are about twenty-five labeling concepts for various household appliances used worldwide. However, the labels for energy consumption can be divided into three types which will be discussed in the following section[10].

2.3.1 Labels with energy costs

This type of label is usually used for refrigerators, freezers, water heaters, dishwashers, and washing machines. Energy costs for one year of operation are listed for the average price of energy and for the price offered by the local distribution company.

2.3.2 Labels with energy efficiency

Generally, this type of label is used for air conditioners. It compares energy efficiency or the price of energy for a certain number of hours of operation. The label must include a graph comparing the product to other types as well as information on how to use the product most efficiently.

2.3.3 Labels with general information

This type of label is usually used for ovens and small boilers for heating purposes. They primarily include information about efficient methods of home heating and ways to use heating devices in order to achieve maximum energy efficiency.

3. ELECTRICITY PATTERN IN MALAYSIAN HOUSEHOLDS

In Malaysian households, the ownership of electrical appliances, especially refrigerators, fans, television, rice cookers as well as lighting has increased tremendously. Ensuring the acquisition of the most energy efficient appliances could significantly reduce electricity growth in this sector. Among the most interesting possibilities are the use of fluorescent instead of incandescent lighting and higher efficiency refrigerators, air conditioners, fans and washing machines. The appliances electricity share in the residential sector is shown in Figure 1 and the household appliances electricity pattern for a single household is shown in Figure 2.

4. PRESENT STATUS OF APPLIANCES ENERGY EFFICIENCY PROGRAM IN MALAYSIA

The Department of Electricity and Gas Supply of Malaysia has introduced the efficiency standard for ballasts and fans on 1st January 1999 and 1st January 2001, respectively. Other energy efficiency regulations which are still at the drafting stage are expected to include room air conditioners, refrigerators, TVs, computers and monitors, washing machines, and dish washers. The Standards and Industrial Research Institute of Malaysia (SIRIM) has been directed by The Department of Electricity and Gas Supply to draft the standards. In addition, to facilitate and ensure implementation of the energy efficiency programs, the Department has also introduced a set of electricity efficiency regulations addressing the following[12] areas: specified installations, energy efficiency officers, scheduled products, and energy using products. However, of the four programs, only scheduled products and energy using products relating to household electrical appliances are discussed in the following section.

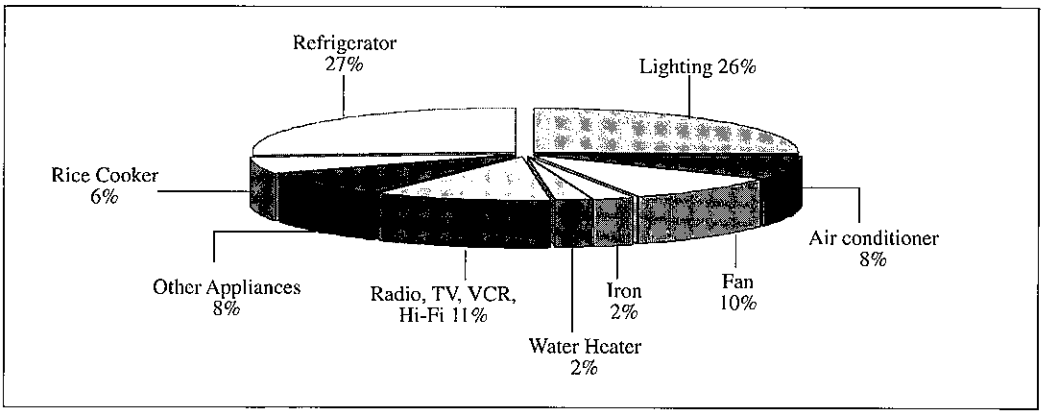

Figure 1: Household appliances electricity share in residential sector at national level.

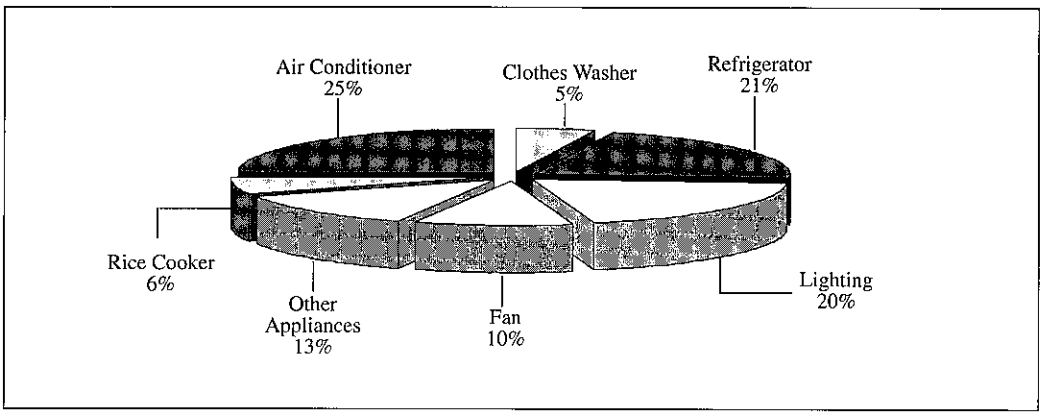

Figure 2: Household appliances electricity pattern for a single household.

4.1 Scheduled products

The scheduled products regulation stipulates that no person should import, manufacture, display, sell or advertise any scheduled product unless[12]:

(i) the product complies with the prescribed energy efficiency standard and is issued with a valid certificate of compliance by the Director General of Electricity and Gas Supply, Malaysia; and

(ii) the product or package of the product is labeled in the prescribed form and manner as determined by the Director General of Electricity and Gas Supply, Malaysia.

At the initial stage, the list of scheduled products includes ballasts for fluorescent lamps, ceiling fans, table fans, wall fans, stand fans and box fans. Also included in the schedule are household refrigerators not exceeding 750 litres and room air conditioners not exceeding 3 kW.

4.2 Energy using products

The energy using product regulation states that, "unless exempted by the Director General of Electricity and Gas Supply of Malaysia, no person who imports, manufactures, advertises or sells any energy using products shall label, advertise, indicate and describe in any manner or in any way giving any impression or any indication or causing any person to believe that the product is using or consuming less energy compared with a product similar in function, usage type and capacity when used under similar conditions and environment", unless[12]:

(i) the product complies with the prescribed energy efficiency standard and is issued with a valid certificate of compliance by the Director General of Electricity and Gas Supply, Malaysia; and

(ii) the product or package of the product is labeled in the prescribed form and manner as determined by the Director General of Electricity and Gas Supply, Malaysia.

The list of energy using products includes lamps, clothes washers of capacity not exceeding 7 kg, storage water heaters of capacity not exceeding 150 litres, televisions, video monitors, and vacuum cleaners with input not exceeding 2 kW.

5. FURTHER POTENTIAL SAVINGS IN MALAYSIAN HOUSEHOLDS

The economic benefits of efficiency standards have never been so important as they are now, after the recent economic crisis. Efficiency reduces foreign exchange expenditures on power plant construction. Strategies to reduce growth in household electricity demand also benefit utilities and other sectors. Studies in developed countries indicate that household appliance efficiency standards can produce energy reductions of about 20 to 40 percent or more. In the following sections, we discuss the energy saving potential of some common electrical appliances used in Malaysian households.

5.1 Refrigerators

Refrigerators represent about 26.3% of residential electricity demand in Malaysia[13]. Significant improvements are possible by improving the efficiency of the motor and compressor used, improving the wall insulation of the refrigerator, increasing the thermal conductance of the evaporator and condenser tubes, and improving the gasket seals. The literature on improving household refrigerator efficiency is very extensive. Studies have shown that significant savings are also possible by better use of the refrigerator. The refrigerator electricity consumption can be reduced by around 5% to 20% by placing the refrigerator away from heat sources in the kitchen[14]. Cooling foods before storing them in the refrigerator is also helpful. Through campaigns on using the most efficient refrigerator, a significant amount of electricity can be saved. This can be reached by implementing standards and labels for the appliance. A laboratory test of the appliance is being developed at the University of Malaya under the financial assistance of the Ministry of Science Technology and Environment, Malaysia.

The Department of Electricity and Gas Supply of Malaysia is currently analysing the survey result on refrigerators. Discussions will be held with the relevant parties to come up with an acceptable minimum energy efficiency standard once the study is completed. The minimum standard will be used by the Department of Electricity and Gas Supply of Malaysia for the approval of refrigerators.

5.2 Lighting

Lighting accounts for the second largest electricity consumption in Malaysia. It accounts for about 25.3% of the total residential electricity use[13]. Most of the household lighting is done with incandescent bulbs especially in the rural areas. These bulbs are highly inefficient. Among the more common bulbs that reduce energy consumption are halogen lamps, fluorescent tubes, U-shape tubes, long-twin tubes, and high intensity discharge bulbs.

Pushing the manufacturers to adopt more efficient lighting technologies could decrease the growth of residential electricity demand. For example, by substituting for compact fluorescent light bulbs, up to 60 to 75 percent of electricity used per light bulb replaced can be saved. The latest technologies can also contribute to reduce lighting electricity demand if they are made available at a competitive price. Incandescent lamps have a life span of about 750 to 1000 hours. Compare this with compact fluorescent lamps (CFLs) whose life span is twelve times longer. However, the price of CFLs is quite high in Malaysia. With government intervention or subsidies, the price may be made affordable to consumers.

Unlike many other initiatives, energy efficiency standards have advantages because their benefits are comparatively simple to quantify. The Department of Electricity and Gas Supply has issued a directive on the minimum energy efficiency standard for ballasts. The minimum standard is shown in Table 3.

According to Annas[12], about 75% of all types of ballasts sold in the country can comply with the standard set for 1999, whereas 60% can comply for the year 2000. Since the energy efficiency standard for ballasts is already in place, the authority should implement energy labelling for this appliance as a pair of standards. Energy labelling for ballasts can produce further savings.

Table 3: The minimum energy efficiency standard for ballast.

Fluorescent ballast rating (Watt)	**Maximum allowable power loss for ballast (Watt)**	**Effective date**
18/20W & 36/40W	10 W	1 January 1999
18/20W & 36/40W	8 W	1 January 2000
18/20W & 36/40W	6 W	1 January 2001

5.3 Fans

Fans account for the third largest electricity consumption in this country. It accounts for about 11.13% of the total residential electricity use[13]. There are many types of fans used in households, and they are commonly called ceiling fan, box fan and stand fan, table fan and wall fan. A new breakthrough in fan technology saves up to 40% electricity when compared with the conventional ceiling fan[15]. Therefore, by setting a mandatory energy efficiency standard for fans, a significant amount of electricity in Malaysia's domestic sector can be saved. The Department of Electricity and Gas Supply has issued a directive on the minimum energy efficiency standard to be complied with before the department can approve any fan. The minimum standard is shown in Table 4.

Since the energy efficiency standard for fans is already in place, the authority should implement energy labelling for this appliance in addition to the standard in order to gain more savings.

Table 4: The minimum energy efficiency standard for fans

Type of fan, diameter (inches)	**Minimum COP (m^3/min/W)**	**Effective date**
Ceiling Fan (48"-60")	3.5	1 January 2001
Stand Fan, Table Fan and Wall Fan (10"-16")	1.0	1 January 2001
Box Fan (10"-14")	0.5	1 January 2001

5.4 Air conditioners

Household air conditioners in Malaysia are mainly room air conditioners, because central air conditioners are uncommon in this country. Air conditioners account for about 8.3% of the overall domestic electricity share[13]. From an energy demand viewpoint, this appliance is unique because its energy consumption depends much on the climate of the country and region. Efficiency of air conditioners is expressed as Coefficient of Performance (COP) or Energy Efficiency Ratio (EER), which is the ratio of cooling capacity to power input. Air conditioners in the market now are so advanced in technology that some of them have reached an EER of 13. This is about 40% more efficient than the common product. Therefore an energy efficiency standard for this appliance can have a significant impact on electricity consumption in the residential sector in this country.

However, with environment and surroundings dependent appliances like air conditioners, the energy saving potential depends on the room condition. Further savings can be obtained by introducing insulating walls and painting roofs and walls to make them highly reflective. The Department of Electricity and Gas Supply, Malaysia, is currently analysing survey results on room air conditioners. Discussions will be held with the relevant parties to come up with an acceptable minimum energy efficiency standard once the study is completed.

5.5 Other end-uses

Other appliances that have energy saving potential are TVs, VCRs, and Hi-Fi systems. These entertainment appliances are considered as miscellaneous and account for about 11.1% of the electricity consumption in this country. By setting minimum stand-by leaking electricity for these appliances, significant amounts of electricity in the residential sector can be saved.

Rice cookers account for about 6% of the electricity consumption in the residential sector. Irons and water heaters account for 2.5% and 2% of electricity consumption share respectively. Other appliances account for about 8.4% of the total residential electricity consumption[13]. For irons, energy saving can be achieved by adopting new energy efficient products. While water heaters energy saving can be achieved by adopting solar water heaters as an alternative to electric water heaters. Malaysia as a tropical country has plentiful sunshine, which is a good alternative source of energy.

6. PROCESS OF SETTING STANDARDS AND LABELS

Relatively little information has been published on the theory and methodology of setting appliance standards. However, some essential information has been published[9,10,16]. The methodologies introduced in the cited references mostly relate to countries that already have set standards and labels. Not all the approaches recommended by the above studies are appropriate to Malaysia. This is because the necessary data are incomplete or unavailable in developing countries such as Malaysia, and the structure of standards and labels development may not be directly applicable. For example, the pyramid structure of energy efficiency programs proposed by Meier and Hill[16] consist of four steps for the appliances. These steps from the base of the pyramid to the apex are: (i) test procedures, (ii) labels, (iii) standards, and (iv) incentive programs. This sequence of steps may be appropriate for developed countries where the program has already been established. However, the same sequence may not be applicable to developing countries because the label must display the minimum efficiency for the particular appliance. Without setting the minimum energy efficiency standard, a display is impossible. Based on that reason, the methodology developed should be modified with respect to requirements of the particular country. The proposed hierarchy of test procedures, standards, labels and incentive programs for Malaysia and other developing countries is shown in Figure 3.

For developing countries, the following essential steps should be carried out in order to establish appliance energy efficiency standards and labels:

(i) establish a legal authority;
(ii) establish a universally agreed test procedure by which energy consumption and energy efficiency of an appliance can be measured;
(iii) establish label to educate consumers;
(iv) conduct statistical or engineering analyses;
(v) analyse the impact of the standards and labels; and
(vi) finally, after all of the analysis are completed, recommend the program or proceed to re-evaluation, or perform standard evaluations at periodic intervals.

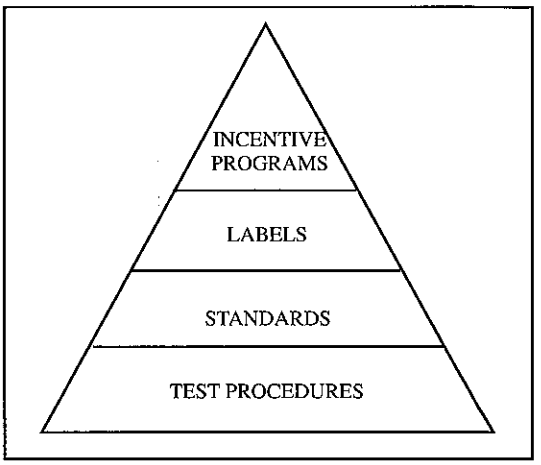

Figure 3: Relationship between test procedures, standards and labels

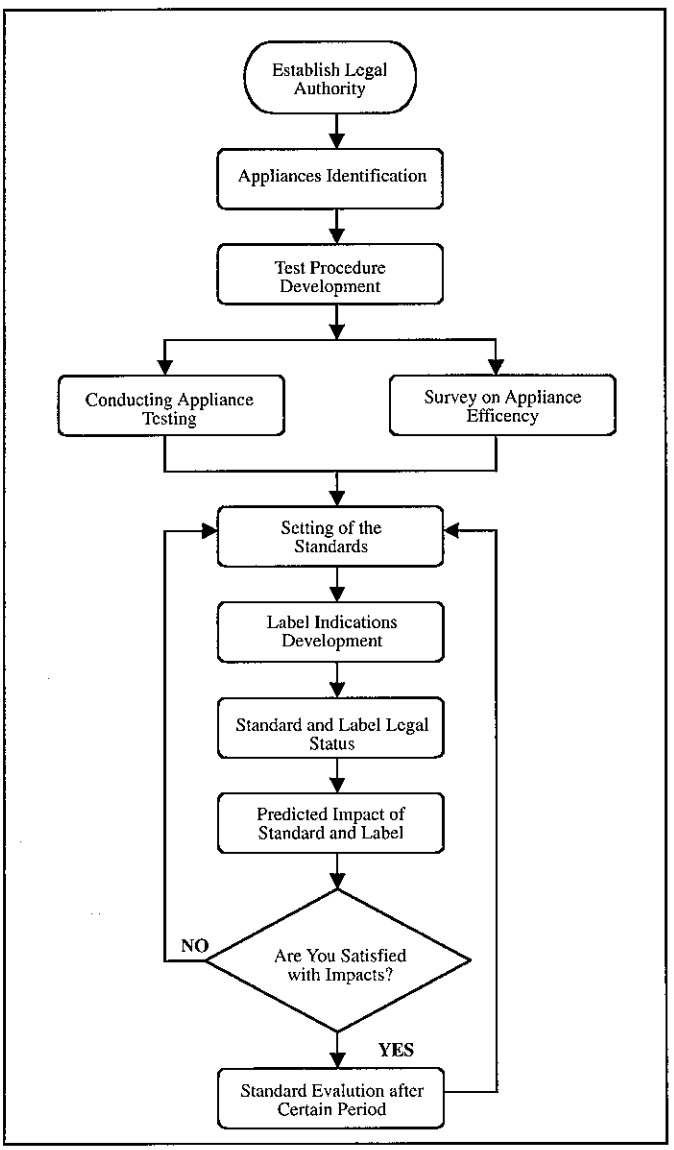

Figure 4: Flowchart for setting standard and labels.

The proposed flowchart of setting standards and labels for Malaysia and other developing countries is shown in Figure 4.

7. CONCLUSIONS

After the economic downturn in July 1997, the government of Malaysia had postponed the 2000 MW Bakun hydroelectric electricity generation project. This decision might contribute to a shortage of electricity in the coming years. Energy conservation in the residential sectors can help reduce the electricity consumption nationally. Introducing standards and labels for household appliances may reduce electricity consumption and demand in this country. Furthermore, many sectors in Malaysia will benefit from implementing this strategy. Although consumers will pay higher prices for appliances, they will get lower electricity bills. The manufacturer will be compelled to pay attention to improving the efficiency of the product. This will increase the competitiveness of the appliances in international trade. Standards and labels have also proved to have positive impact to the environment by reducing greenhouse gas emissions from electricity generation[17]. This study has found that there are numerous publications on the experience of household appliance efficiency programs in developed countries but relatively little information has been published about the situation in developing countries. Furthermore, Figures 1 and 2 show that room air conditioners and refrigerators are major energy consuming equipment in Malaysian households. Therefore, introducing energy efficiency standards and labels for these appliances can save a significant amount of electricity in the residential sectors and offer great benefits for the consumers, government as well as the environment. This is in agreement with Meier and Hill[16] who support testing the programs for key appliances such as refrigerators and air conditioners as important first step to assessing the energy efficiency of appliances. Egan[2] too has claimed that air conditioners are given a priority because, while only penetrating a small fraction of households, they represent one of the most dramatic areas of increased demand for electricity in the residential sector. Therefore, as a starting point, it is imperative to concentrate on room air conditioners and refrigerators in order to reduce the electricity consumption in this sector. This work aims to give an initiative for Malaysia and other developing countries to implement energy standard and labelling programs as soon as possible.

8. ACKNOWLEDGMENTS

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