A Literature Review on Energy Efficiency Standards and Labels for Household Electrical Appliances

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Abstract: This is a summarized previous works on energy efficiency standards and labels for household electrical appliances. It concerns mostly about international situation and other country experience about energy efficiency standard in residential sector. The possibilities of implementation of standards and labels for various household electrical appliances in Malaysia are also discussed. From the international review and other country experience shown that; there are many advantages for Malaysia to implement the standards and labels for household electrical appliances.

Keywords:
Eenergy efficiency, appliance standards; standards and labels.

I. INTRODUCTION

To day energy efficiency standards and labels is among the most popular strategy to educate the consumer to use energy efficiently. A great advantage is that energy efficiency standards are being introduced internationally, so it is possible 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 country. There are many publications on household electrical appliance efficiency, especially about developed countries but relatively very little information has been published on energy efficiency program in the developing countries.

Many countries have introduced energy efficiency standards with very successful result which other country can learn the experience. Some of the experiences it can be directly adopt for another country, but some must be modified in order to make it suitable for particular countries. For example, air conditioning the comfort temperature which is quit different among the population on the earth. An acceptable comfort ranges have 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 can be direct adoption for some other appliance efficiency standard like for TV, fluorescent lamp, fan etc.

II. ENERGY STANDARDS AND LABELS

A simple and effective strategy for providing guidance to residential consumers in their purchase of household appliances is standards and labels. Standards set a minimum efficiency level that appliance manufactures 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. The average energy performance of models on the market will improve gradually. Market pull and market push is complementary market transformation strategies. Establishing energy performance standards "pushes" the market by eliminating the least efficient models. Labels "pull" by encouraging customers to purchase higher efficiency models, and "pushes" by encouraging manufacturers to produces more energy efficient model [2]. Standards and labels benefit for national economies, local and international manufactures and the natural environment as well.

A. Energy Standards

Standards are a set of procedures and regulations that prescribe the energy performance of manufactured products, some times prohibiting less energy efficient than the minimum standard. Energy efficiency standards can be either mandatory or voluntary. They can be in the form of a 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 is an alternative option to energy efficiency standard. They have merit of being less controversial and hence some easier to enact [3].

There are two approaches widely used to set energy efficiency standards; (i) statistical and (ii) engineering/economic [4].

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The statistical approach requires fewer data and less analysis than the engineering/economic approach. The data required are those which give a current characterization of marketplace for the products of interest. This approach looks at the models available at a particular time and performs a regression analysis to determine the dependence of energy use on adjusted capacity. Using such 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 model are calculated and energy savings are aggregated until the total reaches the desired goal. The minimum efficiency line is defined as the line of maximum efficiency index. The efficiency index of a model is the percentage that the energy is above or below the reference line depends on efficiency indication. This approach has been utilized in the European Union (EU) and in Australia.

The second approaches is an engineering/economic analyses. This approach has been widely used by Lawrence Berkeley Laboratory (LBL) for the U.S. department of energy. An engineering analysis is carried out on each product type to determine manufacturing costs for improving the efficiency of particular model. Following seven steps performs 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 (vii) generation of cost-efficiency curves.

Nevertheless, whatever methodology in establishing efficiency standards, the following circumstances should be taken into consideration [5]:

(i) The level of the standard must have a positive effect on the environment.
(ii) Before implementing the standard, consumer 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, so that they do not end up static in their effort to make electricity consumption efficient. It is possible to maintain their dynamism by creating gradual standards that in certain ranges make increasing demands on electricity consumption.

B. Energy Labels

The purpose of introducing labels is to convince consumers to buy and manufactures to produce more efficient appliances. Labels should enable the comparison of energy efficiency or cost for similar appliances that compete with types having similar dimensions and characteristics. In considering a purchaser can see the price and choose the product with the lowest long-term costs. The indication energy label concept can be divided into three types [6]:

Labels with energy costs: this type of label is usually use for refrigerator, freezer, water heater, dishwasher, and washing machines. Energy cost for one year of operation are listed for the average price of energy and for the price offered by the local distribution company. An indication comparing the types and models is also mandatory, the minimum and maximum in corresponding category.

Labels with energy efficiency: this type of label is generally use for air conditioner, they compare 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.

Labels with general information: this type of label is usually use for ovens and small boiler. They primarily include information about efficient methods of home heating and ways to use heating devices. In order to achieve maximum energy efficiency.

For maximum effect of labeling, it is necessary to adhere to several fundamental conditions [5]:

(i) The label must be uniform, if labeling or information flyers are introduced in various ways, it can cause chaos in comparing appliances and 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 effective appliances without labels over effective appliances with labels.
(iii) The labels and information flyer must be as exact as possible while giving as much necessary information as possible.
(iv) Measures label should include informational flyer about the product for those customers who are willing to devote more time to considering the relative benefits of various appliances.
(v) Energy labels measures should allow of informational flyer to eliminate all obstacles hindering trade between member countries. The effort should be to support a unified market.

III. HISTORY OF APPLIANCE STANDARD

Household appliance standards have more than three-decade history, but it was become popular just after oil price shock in 1970s. United Stated and European countries

claimed that they are the first countries who implemented efficiency standard and labeling for household appliances. Kristina Egan [3], state that United States is the nation with the oldest standards and labeling programs. However, from the literature survey shown that European government was among the first introducing legislation to limit the energy consumption of domestic appliances during the 1960s and 1970s. France introduced mandatory minimum energy efficiency standard for refrigerator in 1966 [7] and freezers in 1978 [8]. Russia introduced mandatory energy efficiency standards in 1976 [9] and Poland alleged to have had mandatory energy efficiency standards for several of electrical appliances from as early as 1962 [10]. However, much of this early legislation was weak, poorly implemented and had little impact on appliance energy consumption [11].

Actually, appliance standards are a set of procedure and regulations that define the energy performance (minimum level of efficiency or maximum levels of energy consumption) of manufactured product, sometimes prohibiting the manufacture of products less energy efficient then the minimum standards [12]. While labels is mandatory or voluntary stickers that are affixed to products or their packaging and that contain information on the energy efficiency or energy consumption of the product [13]. Appliance standards have influenced manufacturers to invest more in design 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 standards for energy conservation. The two countries have well established and well-functioning 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 U.S. [3,13,14,15]. An overview of appliance standards history is shown in Table 1.

Table 1 An overview of the 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 product
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), Cloths Washer (CW), Cloths Dryer (CD), Dishwasher (DW), Lighting (LT), Television (TV).
Sources: compiled from references [3,11,13,14,15,16,17]

Standards and labels one of the energy efficiency concept that have been use worldwide. Status of standards and labeling around the world are shown in Table 2.

Table 2. Standards and labeling around the world

Product	China	Taiwan	Hong Kong	USA	Japan	Korea	Mexico	Philippine	Singapore	Thailand	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	-	-	-	-	-	-	-	-	-	-

Sources: compiled from References [3,13,16,]

IV. EFFICIENCY STANDARDS IN MALAYSIA

There are no standards, labeling, or energy testing for appliances in Malaysia to date, except, in 1989, the Ministry of Energy, Telecommunications and Posts issued efficiency standard for motors in Malaysia. However, draft energy efficiency regulations which have not yet publicly released are reputed to include mandates for establishing minimum energy performance standards for fan, room air conditioners and refrigerators and beginning a voluntary labeling program for TVs, computers, monitors, washing machines, and dish washers. SIRIM is also have requested by the Department of electricity and gas supply to draft the standards [18].

However, under existing Electricity Regulations 1994, certain electrical product and appliances classified under 'controlled items' are required to be approved by Department before they can be imported, manufactured, displayed, advertised or sold in the country. The criteria for approval of these items, beside safety also involve energy efficiency. As such, in order to prepare the manufactures

importers and distributors the implementation of the proposed "energy efficiency regulations", the department has conducted market surveys on schedule products in order to determine minimum standard for the products [18].

V. STANDARDS AND LABELS IMPLEMENTATION POSSIBILITIES

The ownership of electrical appliances, especially refrigerator, fan, television, rice cooker as well as lighting which are available in every electrified home have been increasing tremendously in Malaysian household. Assuring the acquisition of most efficient appliances could significantly reduce domestic electricity growth in this sector. Among the most interesting possibilities are the use of fluorescent instead of incandescent lighting, higher efficiency refrigerators, air conditioner, fan and washing machine. Latest technology are being developed that will improve the efficiency of those appliances even further.

A. Refrigerators

Refrigerators represent about 26.3% of residential electricity demand in Malaysia [19]. Significant improvements are possible by improving the efficiency of the motor and compressor used, increasing the insulation walls of the refrigerator, increasing the thermal conductance of the evaporator and condenser tubes and improving the gasket seals. The literature on improved household refrigerator efficiency is very extensive. Significant savings can also be possible by better use of refrigerator. Studies in the USA have shown the importance of the kitchen temperature, pointing at the possibility of reducing refrigerator electricity consumption by around 5% to 20% by placing it away from heat sources in the kitchen [20]. Cooling foods before storing them in the refrigerator is also helpful. Through campaigning using the most efficient refrigerator it will save a significant amount of electricity. This can be reach by implementing standard and label for this appliance. The technical part, laboratory test, is being developed at the University of Malaya under the financial assistant of the Ministry of Science, Malaysia.

B. Lighting

Lighting is the second largest electricity consumption in Malaysia. It is accounted about 25.3% of the total residential electricity use [19]. Most of household lighting is done with incandescent bulbs especially in the rural area. These types of bulbs are highly inefficient when compared with newer technologies lamp. Compact fluorescent lamps (CFL) are an alternative to incandescent bulbs in Malaysian households. Among the more common bulb that reduces wattage are incandescent, halogen, fluorescent tubes, U-shape, long-twin tube, and high intensity discharge bulbs.

Pushing manufactures to adopt more efficient lighting technologies could decrease the growth of residential electricity demand. For example, substituting compact fluorescent light bulbs could save 60 to 75 percent of electricity used per light bulbs replaced. Latest technologies can also contribute to reduce lighting electricity demand if they are made available at a competitive price. Incandescent lamps life spans about 750 to 1000 hours comparable to CFLs that is twelve times longer. But the price of CFLs is quit high to purchase in Malaysian market. With government intervention or subsidies the price may be affordable by the customers.

C. Fan

Fan is the third largest electricity consumption in this country, it is account about 11.13% of the total residential electricity use [19]. There many types of fans usually used in the household, these are 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 conventional ceiling fan [21]. So by setting mandatory energy efficiency standard for the fan can save a significant amount of electricity in Malaysia's domestic sector.

D. Air Conditioner

Household's air conditioners in Malaysia mean room air conditioner, because central air conditioner is uncommon in this country. Air conditioner is accounting about 8.3% of overall domestic electricity share [19]. In energy demand viewpoint, this appliance is unique because its energy consumption depends much on the climate of the country and region. Efficiency of air conditioner expresses as Coefficient of Performance (COP) or Energy Efficiency Ratio (EER) which is the ratio of cooling capacity to power input. The air conditioners in the market now are so advanced in technology that some of them have reached EER 13. This is about 40% more efficient than common product. So setting energy efficiency standards for this appliance also can contribute a significant impact on electricity consumption in residential sectors in this country.

However as environment and surroundings dependent appliances, further savings potential of air conditioner still depend on room condition. Increasing insulating walls, painting roofs, and walls with high reflectivity color can do further savings.

E. Other End-Uses

Besides above, other appliances that are possible for saving are TV, VCR, and Hi-fi. These appliances are considered as miscellaneous. These three entertainment appliances consume about 11.1% of electricity consumption in this country. By setting minimum stand-by leaking electricity for these appliances can save a significant amount of electricity in residential sectors.

Rice cooker consumes about 6% of domestic sector electricity consumption. Iron and water heater each

consumes 2.5% and 2% of electricity consumption share. Other appliances just consume about 8.4% of total residential electricity consumption in this country [19]. For iron it can be save by adopting new efficient product. While water heater can be save by adopting solar water heater as an alternative of electric water heater. Malaysia as a tropical country has a plentiful sunshine which is a good alternative to use

VI. CONCLUSIONS

Many sectors in Malaysia will get tremendous benefits of implementing the energy efficiency standard for household appliances. The consumers will pay higher purchase prices for appliances, but will get lower electricity bill. An applicability of energy efficiency is strictly depends on correlation between those two factors. The economic benefits of efficiency standards have never been so needed as they are now, after the economics crisis. Energy efficiency standard is also reduces foreign exchange expenditures on power plant construction.

Strategies to reduce growth in residential electricity demand are probably one of greater benefit for the country. Studies in developed countries indicate that household appliance efficiency standard can produce energy reductions about 20 to 40 percent or more. Base on other country experience it is concluded that; it is a big advantage for Malaysia to implement the standards as soon as possible.

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