CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter contains an overview of other related studies, its approach development and its significance to this study in order to set up energy efficiency standard and label for TV sets in Malaysia. The review has found that there are numerous publications on household appliance efficiency and labeling program especially in the developed countries but relatively little information have been published about the situation in the developing countries. Most of the literature on energy efficiency standard and label did not examine TV sets in specific, but rather discuss household appliances as a whole. As a result, the theory on standard and label for TV sets in Malaysia could be adapted from the available theory provided that necessary improvements are made to suit the specific Malaysian condition. Apart from that, this chapter also provides an overview regarding countries that have established energy efficiency standard and label throughout the world. It eventually shows that these countries have realized the importance of standard and labelling program.

2.1 Overview of previous studies

Mahlia *et al.* (2002), presented a study on theory and methodology involved in developing energy efficiency standard and label for household appliances. The study is suitable for developing countries that has lack of available data and is considering to establish energy efficiency standards and labels for household appliances. The author stated that the initial step before setting a standard is to propose a test procedure followed by conducting appliance survey and testing data. The standard introduces two approaches, which are the engineering economic approach and the statistical approach. The study also discusses the methods for calculating energy, economical and environmental impacts of the standard and label. This will enable the energy efficiency standard for TV sets in Malaysia be established similar to the theory that have been developed by Mahlia *et al.* (2002). Furthermore the energy, economical and environmental impacts from implementing TV standard and label are calculated based on the theory developed by Mahlia *et al.* (2002).

Meanwhile, Rosen and Meier (2000) conducted a study to estimate the residential energy consumption of color televisions (TVs) and videocassette recorders (VCRs) in the USA. The study used three important factors for calculating TV and VCR energy consumption, which are number of units in the USA, typical usage patterns and average power levels. In our study, we intend to adapt the same three factors for calculating TV energy consumption in Malaysia. The total number of TVs in Malaysia is collected from the General Report of Population Census of

Malaysia (1970, 1991 and 2000). Meanwhile the TV usage pattern is derived from a survey conducted throughout Malaysia. The TV usage pattern is estimated from the approach similar to the one used by Rosen and Meier (2000), which is the sum of three different activities; watching broadcast television (inclusive of pay-TV), watching videocassettes (inclusive VCD and DVD), and playing video games. Since the Internet is gaining popularity in Malaysia, we included a fourth activity, which is logging on to the Internet with special type of hardware connected to a TV (web-TV). Besides that the third factor, which is the average power level, is collected from measurements, market survey conducted at electrical retail shops and data published by organizations such as Energy Star (2002) and GEEA (Group for Efficient Appliances, 2001).

Siderious (1999) on the other hand, reported that in Europe alone, TV energy use might grow by tens of terawatt hours if left unregulated. The study points to a large untapped energy saving potential, but equally an alarming increase in TV power demand. The author stated that it is possible to raise TV energy efficiency by the improvement of 3 design options, which are the components, hardware design and software design. However, the author reported that the most effective way to reduce TV power consumption is by improving the (main) *switched-mode power supply* component (SMPS). The convenience of the study conducted by Siderious to this study is that the design options stated by Siderious (1999) will serve as the basis to conduct the engineering/economic analysis.

Turiel *et al.* (1997) presented a study on theory and methodology of appliance standards. This study describes comprehensively the approaches to develop

appliance standard which include test procedure development, method to determine standard and conduct analysis. In this study, statistical approach, engineering/economic analysis and life cycle cost analysis is used. The purpose to carry out a life cycle cost analysis is to analyze the economic impact of the potential efficiency improvements on consumers once the engineering analysis is completed. In order to estimate this, the values of purchase price, annual operating expenses and life span of the appliance are required. Turiel *et al.* (1997) reported that survey of purchase price are limited because variability in retail price due to differences in features and among brands, retailers and region of sales (e.g. in the West Coast or East Coast). To overcome this, it is intended that the value of purchase price obtained from manufacturer's general catalogues are used. If the purchase price value is still unavailable, then the survey value or the retail price value available from retailers in Kuala Lumpur and the state of Selangor will be used. Meanwhile, the duration of TV lifetime which is 11 years, is adapted from Webber and Brown (1998). This is a reliable reference because Lawrence Berkeley National Laboratory is one of the leading research institutions on energy efficiency programs.

Meanwhile, Meier and Huber (1997) presented results from investigations on leaking electricity in USA. The authors defined leaking electricity as the energy consumed by appliances when they are switched off or not performing their principal function. They stated that TVs have the highest amount of standby electricity consumption of 5.4 TWh per year. In their study, they metered sixty-five TV sets and found out that the standby power consumption ranges from 0.5 to 12.3 Watts with an average of 4.0 Watts. Then, they used this average figure to calculate the standby

electricity power loses in terms of watt-hour per year. In our study we also intend to calculate the yearly standby electricity power loses in Malaysia in a similar way. This figure will be used to estimate the amount of energy that can be saved if a more efficient standby power mode is introduced on TVs. Similar study on standby electricity consumption is also reported by Nakagami *et al.* (1997). This study estimates standby electricity consumption on several household appliances in Japan.

Koomey *et al.* (1998) on the other hand, presented a study entitled projected regional impacts of appliance efficiency standards for the U.S residential sector. This study assesses in a comprehensive fashion the energy, environmental and economic effect of the current minimum efficiency standards for American residential appliances. Moreover, they showed that minimum efficiency standard are able to reduce pollution and at the same time save cost. This is accomplished by computing energy savings, bill savings, net dollar savings and carbon emissions reduction at American national and state level. However the weakness of the study is that appliance such as TV, which is relevant in our study, is not included in the analysis.

National Energy Balance (NEB) Malaysia (1997) reported that the electricity consumption in the residential sector for the year 1997 was 770 ktoe (kilo Tonnes Oil Equivalent, where 1 ktoe = 41.84 TJ). In 2001, the electricity consumption for this sector increased to 1,081 ktoe (NEB, 2001). This figure is relatively high and is estimated to increase further due to the expected increase in household appliance ownership and number of households in Malaysia. Therefore, energy efficiency standard and label for household appliances seems to be the wise step to save energy in the residential sector. In this study, the data obtained from NEB will be used to

estimate the significance of energy efficiency standard and label implementation (for TV sets) in reducing electricity consumption in the residential sector.

Meanwhile, Population and Housing Census of Malaysia (1970) reported that in 1970, from 1,890,276 total households in Malaysia, 186,036 households had access to TV. This figure increased tremendously in 1991, whereby from 3,566,859 total households in Malaysia, 2,741,640 households had access to TV (Population and Housing Census of Malaysia, 1991). In our study, the data available from the Population and Housing Census of Malaysia (1970, 1991 and 2000) will be used to estimate the future ownership of TV sets in Malaysia. Furthermore, it will be used to compute energy savings and to set up energy efficiency standard and label for TVs in Malaysia.

2.2 History of appliance standard

Household appliance standard became popular at early 70s. Earlier standards were established in France in 1966 for refrigerator and Poland allegedly had established mandatory energy efficiency standard for a range of electrical appliances from as early as 1962 (Waide *et al*, 1997). However much of these earlier legislation was weak, poorly implemented and had little impact on appliance energy consumption (Mahlia, 2002).

Japan established its energy efficiency standard in 1979 for a number of appliances and followed by Canada, China, United States and Australia. Among

south East Asian countries, Philippines and Thailand have well established programs for improving the efficiency of household appliances since 1993 and followed by Malaysia in 1999. The overview of appliance standard history is presented in Table 2.1

Table 2.1 Overview of appliances standard history

Year Effective	Country	Legal Status	Appliances
1962	Poland	Mandatory	Several
1966	France	Mandatory	R
1979	Japan	Voluntary	RAC/LT/R/FR
1978	Canada	Mandatory	16 products
1989	China	Mandatory	R/TV
1980	United States	Mandatory	R/AC/RAC/CW
1987	Australia	Mandatory	R/RAC/AC/DW/CD/CW
1993	Philippines	Mandatory	RAC
1994	Thailand	Voluntary	R/RAC
1999	Malaysia	Mandatory	F/LT

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).
Source: Mahlia (2002).

2.3 Energy standard and label programs for TV sets throughout the world

TV is one of the major energy consuming electrical appliance in the household ambience. However, to date only eight European countries and six other

nations have been known to have minimum energy efficiency standard and label for residential TV. Nakagami and Litt (1997) stated that Japan's standard is represented by the TV's annual energy consumption equation for various types of TV. The standard assumes that the TV is on for 4.5 hours and off for 19.5 hours daily and provides method for measuring TV energy consumption. The standard has been updated in 1999 to further improve the energy performance of TVs in Japan (EECJ, 2002).

Russia and China's standard are yet to be translated in English. However Biermayer *et al.* (2000) stated that the Russia's standard is regarding TV on mode power consumption only. Meanwhile the current US's TV label states that in order vendors to obtain the Energy Star® label, standby power consumption for analog TV should be 1 Watt or less whereas digital TV should consume 3 Watts or less in the standby mode (Energy Star®, 2002). TV combination units (TV/VCR, TV/DVD etc.) on the other hand, should consume 4 Watts or less in the standby mode to be granted the Energy Star® label. However effective July 2005, all types of TV should consume 1 Watt or less in the standby mode to meet the Energy Star® specifications (Energy Star®, 2002).

Following US's TV label, Australia has come up with a similar policy to reduce TV standby power. The policy which is also assessed by Energy Star®, is aimed to reduce TV (inclusive of TV/VCR and TV/DVD) standby power consumption by stages to 1 Watts or less by July 2005 (Energy Star® Australia, 2003). Meanwhile Biermayer *et al.* (2000) stated that Sri Lanka's standard is

regarding TV receivers testing, to measure electrical, acoustical and optical properties.

Eight European countries (comprises of Austria, Denmark, Finland, France, Germany, the Netherlands, Sweden and Switzerland) formed GEEA (Groups for Efficient Appliances) to promote energy efficient appliances. Beginning from January 2002, the energy efficiency index, which takes into account both active and standby mode was the criterion used to classify TVs. Siderius (2001) stated that in order manufacturers to be granted the GEEA-label, the energy efficiency index of a TV should be less than 0.75. Korea's standard is not exactly a standard but rather a voluntary partnership between Korea government through Korea Energy Management Corporation (KEMCO) and TV manufacturers (IEA, 2003). Under this partnership, manufacturers producing energy saving TV sets can attach KEMCO label on their products. The complete list of countries with energy efficiency standard and label for TV sets are presented in Table 2.2.

In Malaysia on the other hand, energy efficiency regulations for residential TVs are still at the drafting stage. Standards and Industrial Research Institute of Malaysia (SIRIM) has been directed by The Department of Electricity and Gas Supply (JBEG) to draft the standard. In addition to facilitate and ensure implementation of the energy efficiency program, JBEG has introduced the electricity efficiency regulations, where one of the policy including energy efficiency standard and label (Annas, 1999).

Table 2.2 Countries with energy efficiency standard and label for residential TVs

Country	Standard/Label	Comment
China	GB 12021.7-89	not yet in English
Japan	JIS C 6101-88*	- represented by annual energy consumption equation - provides method to measure energy consumption
Russia	GOST 18198-89	not yet in English: on mode consumption only
USA/Aust.	Label	Standby mode Analog TV < 1W, Digital TV < 3W, TV/VCR, TV/DVD and TV/VCR/DVD < 4W
Korea	(voluntary agreement)	Scope Color TV with cathode-ray tube (CRT), liquid crystal display (LCD), or other display device
European Union	Label	energy efficiency index should be less than 0.75
Sri Lanka	SLS 694	regarding TV receivers testing, to measure electrical, acoustical and optical properties

*- Updated again in 1999