One-watt TV label implementation in Malaysia

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Abstract

Many countries, from the US to Australia, are now interested in implementing stand-by power energy label for household appliances, in stages, until the 1-W (watt) target is achieved. TV sets consuming 1-W power are widely available in the developed nations. In a developing country like Malaysia, however, the penetration of 1-W stand-by power TV is very low and unless a mandatory label programme is introduced, the degree of penetration is not likely to rise. This paper attempts to calculate the emission pollutants reduction and the energy savings by implementing the 1-W stand-by power label for TV sets in Malaysia. It is estimated that this effort will enable CO_2 (carbon dioxide) emissions reduction of 1477.7 kT (kilo tonnes), NO_x (oxides of nitrogen) reduction of 4673.0 tonnes, and CO (carbon monoxide) reduction of 763.7 tonnes in the country during the energy label period of 20 years. Additionally, Malaysia will benefit from energy savings of approximately, 2794.9 GWh (gigawatt hours).

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Nomenclature

AEI_s	Annual stand-by power efficiency improvement of TV sets (%)
AS_i	Applicable stock in year 'i' of TV sets
c, k	Constant values
Em_p^n	Emission 'p' for fuel type 'n' for unit electricity generation (kg/kWh)
ER_i	Emission reduction in year 'i' of TV sets (kg)
ES_i	Energy saving in year 'i' of TV sets (GWh)
L	Average life span of a TV set (year)
LEI_s	Label efficiency improvement of TV sets (%)
NA_i	Number of households with TV sets in year 'i'
NA_{i-1}	Number of households with TV sets in year 'i-1'
NA_{i-L}	Number of households with TV sets in year 'i-L'
P_{sb}	Average stand-by energy consumption of a TV set (W)
PE_i^n	Percentage of electricity generation in year 'i' of fuel type 'n' (%)
S	Year energy label programme enacted
S_i	TV saturation level per household in year 'i'
SF_i	Scaling factor in year 'i' of TV sets (%)
Sh_i	Shipments in year 'i' of TV sets
t_{sb}	Average duration of a TV set in stand-by mode (h/year)
UES_i	Initial unit energy saving in year 'i' of a TV set (kWh/year)
W_{sb}	Annual unit stand-by losses of TV set (Wh/year)
x	Year predicted; year start
y	Predicted value
Yse_s	Year energy label enacted for TV sets
Ysh_i	Year 'i' of shipment of TV sets

Introduction

Conventional power stations burn fossil fuels to produce electricity. This process releases pollutants such as CO_2 (carbon dioxide), NO_x (oxides of nitrogen), and CO (carbon monoxide) into the atmosphere. In Malaysia for example, approximately, 7.36 MT (million tonnes) of CO_2 was emitted due to the power generation in 1980. This figure shot up to approximately, 31.33 MT in 1996 (World Energy Council 2001). Meanwhile, electricity consumption in the residential sector increased from 8949 GWh (gigawatt hour) in 1997 (National Energy Balance 1997) to 12 564 GWh in 2001 (National Energy Balance 2001). This study calculates the potential energy savings and the potential CO_2, NO_x, and CO emissions reduction by implementing a mandatory energy label programme for 1-W stand-by power TV.

Data assessment

Survey data

A recent survey (in 2003) conducted on 262 households across Malaysia showed that in an average Malaysian household, the TV was in the stand-by mode for approximately, 4.3 h (hours) a day. It was also found that when a TV set was not utilized, it was either switched to the stand-by mode via a remote control (sometimes TVs were left idling for the whole day) or was switched off at the plug mounted on the wall (which draws 0 W). The TV saturation level in Malaysia was approximated at 1.5 per household and the average stand-by power of TV was found to be 4.5 W, after metering and conducting a market survey on nearly 500 TVs. Hence, from the above data, it was predicted that a significant amount of emissions pollution could be reduced as Malaysia had a high saturation level of TVs per household.

Household and electricity data

Three types of data were necessary for this study. These were the TV ownership data (Department of Statistics 1970; 1991; and 2000), percentage of electricity generation based on fuel-type data (Jaafar and Yusop 1998; Annas 2003), and the emissions for unit electricity generation data (Department of Electricity and Gas Supply 1999).

If the 1-W label programme is to be implemented from 2005 onwards, prediction has to be made on the basis of the data currently available on TV ownership and electricity generation based on the fuel type. This is done using the curve-fitting method. Predicted data are shown in Tables 1 and 2. Table 3 presents emissions for the unit electricity generation based on the energy sources data. For the curve-fitting method, a polynomial of the order 'k' in 'x' is expressed in the following form (Equation 1).

$$y = c_0 + c_1x + c_2x^2 + \dots + c_kx^k \tag{1}$$

Proposed energy label

The energy label proposed in this study is designed in line with the following criteria: it should be simple, easy to recognize, and should be clear in presenting to the consumers that a 1-W TV saves electricity (Figure 1). As for the legal status of the energy label, a mandatory status seems most suitable. This is essential to enforce emissions reduction in Malaysia as all TV manufacturers and vendors will per force have to abide by the 1-W specification.

Table 1 Predicted number of Malaysian households with TV sets

Year	*Households with TV sets*
2005	4 944 589
2006	5 140 298
2007	5 339 372
2008	5 541 811
2009	5 747 615
2010	5 956 783
2011	6 169 316
2012	6 385 214
2013	6 604 476
2014	6 827 103
2015	7 053 095
2016	7 282 451
2017	7 515 172
2018	7 751 258
2019	7 990 709
2020	8 233 524
2021	8 479 704
2022	8 729 249
2023	8 982 158
2024	9 238 432
2025	9 498 071

Table 2 Predicted percentage of electricity generation based on fuel types

Year	*Coal* (%)	*Oil* (%)	*Gas* (%)	*Hydro* (%)
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
2021	30.54	1.01	39.55	28.90
2022	32.16	1.04	39.20	27.60
2023	33.86	1.09	38.95	26.10
2024	35.64	1.16	38.80	24.40
2025	37.50	1.25	38.75	22.50

Table 3 Emissions per unit electricity generation based on different energy sources

	Emissions (kg/kWh)		
Fuel	*Carbon dioxide*	*Nitrogen oxide*	*Carbon monoxide*
Coal	1.1800	0.0052	0.0002
Oil	0.8500	0.0025	0.0002
Gas	0.5300	0.0009	0.0005
Hydro	0	0	0

Emission pollutants reduction calculations

The emission pollutants reduction is a function of the energy savings. Therefore, apart from contributing towards a cleaner environment, the energy label effort will also enable national energy savings. In this study, the method used for calculating the

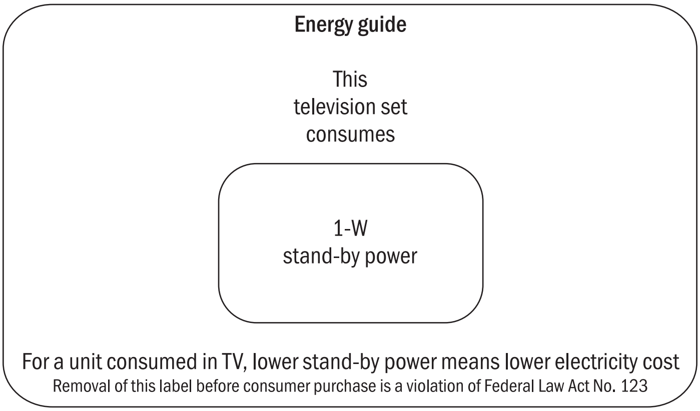

Figure 1 Proposed 1-watt energy label for TV

environmental impacts are adapted from Mahlia, Masjuki, and Choudhury (2002). The sample calculations following the mathematical expressions are calculated for the year 2005 (Table 4). Figure 2 shows the annual emissions reduction as a result of the 1-W label.

Annual unit stand-by loss

The annual unit stand-by losses can be described as a product of the average energy consumption of TVs in the stand-by mode

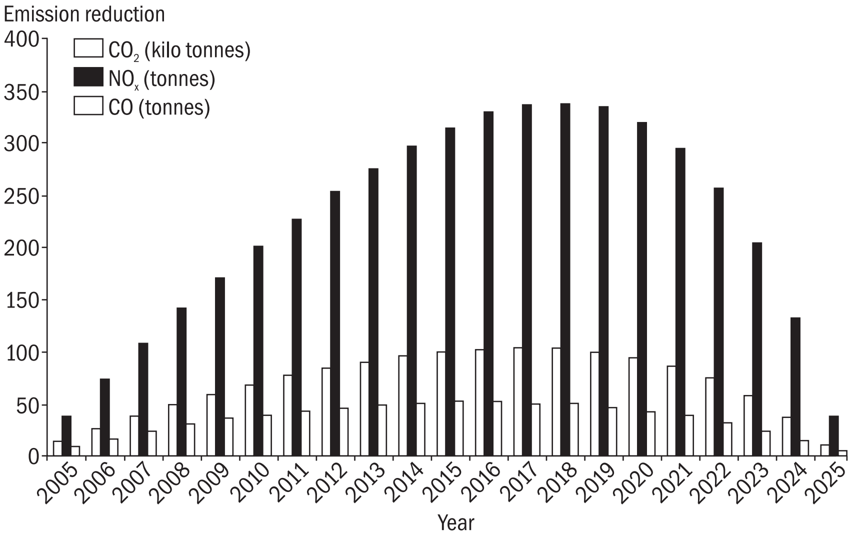

Figure 2 Annual emissions reduction from 1-watt energy label

and the average duration (in hours) of the TV in the stand-by mode in one year. The input data for this calculation is shown in the previous section (the section on the 'Survey data'). The annual unit stand-by losses are calculated for the TV sets in presence of the energy label (1-W TV) and in its absence (conventional TV) (Equation 2).

$$W_{sb} = P_{sb} \times t_{sb} \tag{2}$$

$$W_{sb\ (conventional)} = 4.5\ \text{W} \times (4.3\ \text{h/day} \times 365) = 7062.75\ \text{Wh/year}$$

where, $W_{sb\ (conventional)}$ is the annual stand-by loss from conventional TV, which is the TV set without the presence of one-watt label.

$$W_{sb(1\ watt)} = 1.0\ \text{W} \times (4.3\ \text{h/day} \times 365) = 1569.5\ \text{Wh/year}$$

where, W_{sb} is the annual unit stand-by loss of a TV set, P_{sb} is the average stand-by energy consumption of a TV set, T_{sb} is the average duration of a TV set is in stand-by mode in one year, and $W_{sb\ (conventional)}$ is the annual stand-by loss from conventional TV, which is the TV set without the presence of 1-W label.

Shipment

The mathematical expression of the shipment data can be written as below and the average life span of a TV is approximately, 11 years (Webber and Brown 2002) (Equation 3).

$$Sh_i = [(Na_i - Na_{i-1}) + Na_{i-L}] \times S_i \tag{3}$$

$$Sh_{2005} = [(4\ 944\ 589 - 4\ 752\ 244) + 3\ 013\ 855] \times 1.5$$

$$Sh_{2005} = 4\ 809\ 300$$

where, Sh_i is the shipments of TV sets in year 'i'; Na_i, Na_{i-1}, and Na_{i-l} are the number of households with TV sets in year; 'i', 'i-1', and 'i-l' respectively; and S_i is the TV saturation level per house hold in year 'i'.

Initial unit energy saving

The initial unit energy saving in this study is the difference between the annual unit stand-by losses of a TV in presence of

1-W label (1-W TV) and the annual unit stand-by losses of a conventional TV in absence of the energy label (Equation 4).

$$UES_s = W_{sb(conventional)} - W_{sb(1\ watt)} \quad (4)$$

$$UES_s = 7062.75 - 1569.5 = 5.5 \text{ kWh/year}$$

where, UES_s is the initial unit energy saving of TV sets in year 's' (kWh/year); s is the year the energy label programme was enacted, $W_{sb\ (conventional)}$ is the annual unit stand-by losses of a conventional TV set, and $W_{sb\ (1\ watt)}$ is the annual unit stand-by losses of the TV set in presence of 1-W label.

Scaling factor

The scaling factor would linearly scale down the unit energy savings because efficiency of the TV stand-by mode will be improving 6.7% per year even without the label programme. The rapid improvement in the stand-by power consumption is due to efforts of the developed countries to introduce the 1-W label programme by 2005. Currently, in Malaysia, there were a number of TV sets for which a low stand-by power of 1-W or less was being metered, although the average stand-by power for the TVs remained 4.5 W. The average stand-by power is not expected to improve unless a mandatory label programme is introduced. The scaling factor can be expressed in a mathematical form as given in Equation 5.

$$SF_i = 1 - [Ysh_i - Yse_s]\frac{AEI_s}{LEI_s} \quad (5)$$

$$SF_{2005} = 1 - [2005 - 2005]\frac{6.7\%}{78\%} = 1$$

where, SF_i is scaling factor in year 'i' of the TV sets, Ysh_i is the year of the shipment of the TV sets, Yse_s is the year the energy label was enacted for the TV sets; AEI_s is the annual stand-by power efficiency improvement of TV sets (%), and LEI_s is label efficiency improvement of TV sets (%).

Unit energy saving

The unit energy saving can be expressed as shown in Equation 6.

$$UES_i = SF_i \times UES_s \quad (6)$$

$$UES_{2005} = 1 \times 5.5 = 5.5 \text{ kWh/year}$$

where, UES_i is the initial unit energy saving of TV sets in year 'i' (kWh/year), UES_s is the initial unit energy saving of TV sets in year 's' (kWh/year), and SF_i is the scaling factor of TV sets in year 'i' (%).

Applicable stock

The applicable stock of 1-W TV in 2004 is taken to be zero. This is because it is assumed that 1-W TV sets will start penetrating the Malaysian market only after the label programme is established. The applicable stock is expressed in mathematical form as given in Equation 7.

$$AS_i = Sh_i + AS_{i-1} \tag{7}$$

$$AS_{2005} = 4\ 809\ 300 + 0 = 4\ 809\ 300$$

where, AS_i and AS_{i-1} are the applicable stocks of TV sets in the years 'i' and 'i-1', respectively, and Sh_i is the number of shipments of TV sets in the year 'i'.

Annual energy savings

The mathematical expression for annual energy savings can be written as given in Equation 8.

$$ES_i = (Sh_i \times SF_i + AS_{i-1}) \times UES_i \tag{8}$$

$$ES_{2005} = (4809\ 300 \times 1 + 0) \times 5.5 = 26.5 \text{ GWh}$$

where, ES_i is the energy saving of TV sets in year 'i' (kWh), Sh_i is the number of shipments of TV sets in year 'i', SF_i is the scaling factor of the TV sets in year 'i' (%); AS_{i-1} is the applicable stock of TV sets in year 'i-l'; and UES_i is the initial unit energy saving of TV sets in year 'i' (kWh/year).

Emission pollutants reduction

The mathematical expression for emissions reduction can be written as given in Equation 9.

$$ER_i^a = ES_i\,(PE_i^1 \times Em_p^1 + PE_i^2 \times Em_p^2 + \ldots + PE_i^n \times Em_p^n) \tag{9}$$

$$ER_{2005}^{CO_2} = 26.5 \times 10^9(15.5\% \times 1.18 + 3.25\% \times 0.85 + 58.75\% \times 0.53)$$

$$ER_{2005}^{CO_2} = 13.8 \text{ kilo tonnes}$$

$$ER_{2005}^{NO_x} = 26.5 \times 10^9(15.5 \times 0.0052 + 3.25 \times 0.0025 + 58.75 \times 0.0009)$$

$$ER_{2005}^{NO_x} = 37.5 \text{ tonnes}$$

where, ER_i^a is emission reduction of pollutant 'a' in year 'i'; ES_i is the energy savings of TV sets in year 'i' (kWh), PE_i^n is percentage of electricity generation in year 'i' of fuel type 'n', and Em_p^n is emission 'p' for fuel type 'n' for unit electricity generation (kg/kWh).

Results and discussion

Table 4 shows that the proposed 1-W label programme in 2005 will contribute towards the CO_2 emissions reduction of 1477.7 kT, NO_x of 4673.0 T, and CO reduction of 763.7 T at the end of 2025 in Malaysia. Besides this, the nation will also benefit from energy savings of approximately, 2794.9 GWh.

From Figure 2, it is clear that the energy label programme would be effective for only about 20 years. After that, it needs to be updated. Therefore, it is suggested that the energy label specification be updated to 0.5 W in 2025 because TVs with stand-by power below 1 W are already available in the developed countries.

Conclusion

The study highlights the importance of the 1-W stand-by power energy label for TV sets to mitigate emission pollutants in Malaysia and to contribute towards energy savings. The resources used to generate electricity can now be used more efficiently and most importantly, the emissions reduction will ensure a cleaner environment. Furthermore, if this effort is expanded to include all the household appliances, the impact will be greater. Overall, this study has proved that the introduction of the 1-W energy label for TV sets is of tremendous benefit both to the government and the environment.

Table 4 Energy savings and mitigation of emission pollutants in Malaysia due to 1-W TV label

Year	*ES* (GWh)	CO_2 (kT)	NO_x (T)	*CO* (T)
2005	26.5	13.8	37.5	8.8
2006	51.9	26.6	73.1	16.7
2007	76.0	38.5	107.0	23.8
2008	98.7	49.4	139.3	30.0
2009	119.7	59.4	170.0	35.5
2010	138.7	68.6	199.2	40.2
2011	155.8	76.9	226.9	44.2
2012	170.3	84.3	252.5	47.4
2013	182.1	90.6	275.9	49.8
2014	191.1	95.9	296.6	51.5
2015	196.9	100.0	314.0	52.4
2016	199.2	102.7	327.4	52.5
2017	197.9	103.9	335.9	51.8
2018	192.5	103.2	338.3	50.1
2019	182.8	100.3	333.2	47.5
2020	168.6	94.9	319.1	43.8
2021	149.4	86.5	294.3	39.0
2022	125.1	74.5	256.5	32.8
2023	95.1	58.5	203.5	25.2
2024	59.4	37.8	132.5	15.9
2025	17.4	11.5	40.5	4.7
Σ	2794.9	1477.7	4673.0	763.7

ES – energy savings; CO_2 – carbon dioxide; NO_x – oxides of nitrogen; CO – carbon monoxide

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